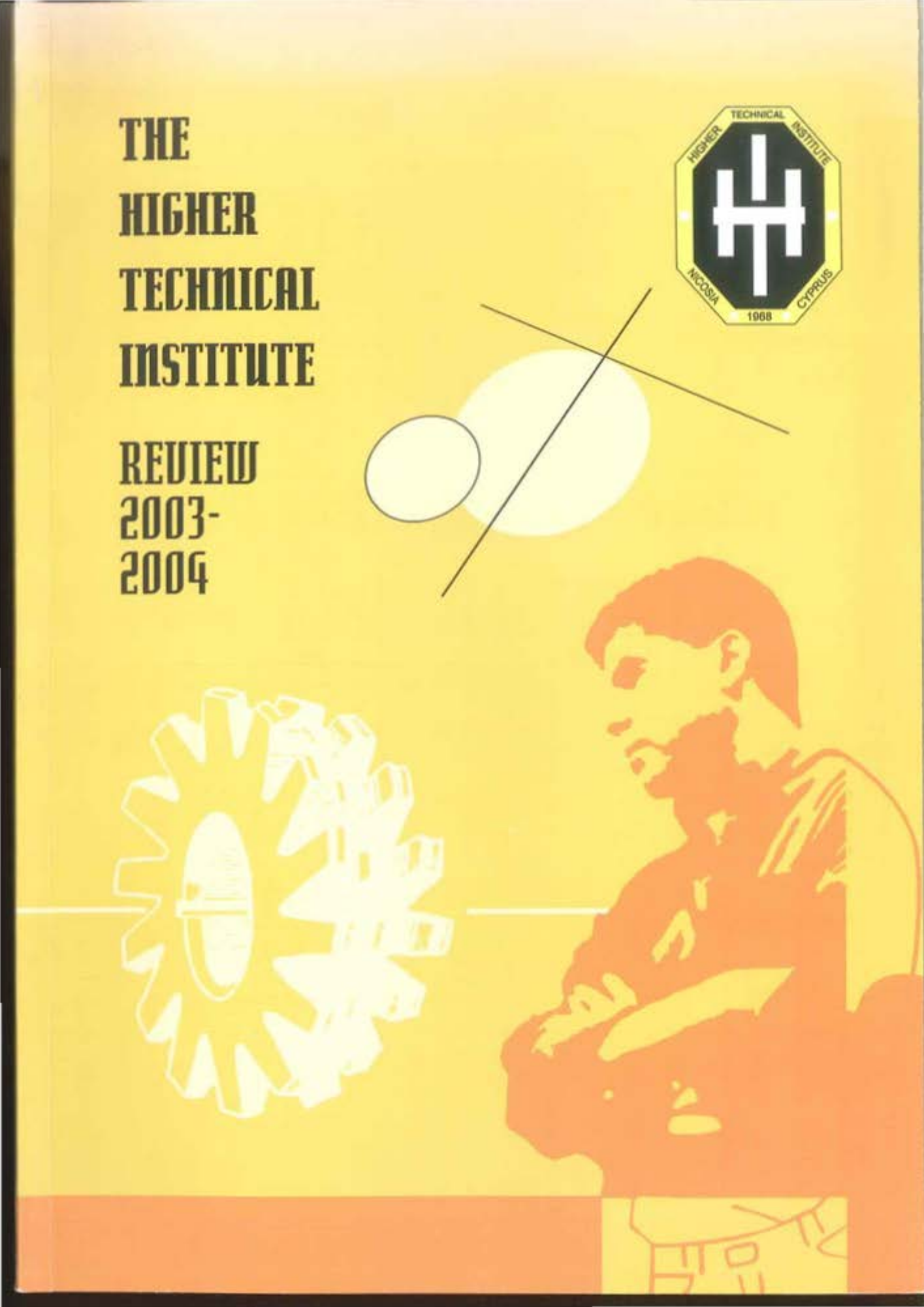
THE HIGHER TECHNICAL INSTITUTE

REVIEW 2003-2004



THE HIGHER TECHNICAL INSTITUTE REVIEW 2003 - 2004

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From the editors' desk...

Welcome to the HTI Review of 2003 - 2004

We would like to welcome all our readers to the latest issue of the HTI Review, a publication which has become a tradition since 1971.

In this issue we have included an impressive collection of scientific and research articles, ranging from the technical to the more academic.

One of the premier objectives of HTI has always been the promotion and development of research. For this reason there has been extensive activity on applied research among HTI staff, both at National and European levels.

In this issue, you will find notable articles concerning areas of the environment, energy, building design, radiography and technology, technical writing, economy and others.

We have also included an update of our staff's participation in various courses/seminars/visits abroad. HTI has been actively involved in a number of educational European programmes such as the Socrates-Erasmus, the Leonardo Da Vinci and an array of others involving staff exchanges between Tertiary Education Institutions.

As always we welcome feedback on articles that are featured in the HTI Review 2003-2004 as well as any suggestions you may have for future publications. We have most certainly enjoyed putting it together and we wholeheartedly hope you will enjoy reading through it.

The Editors

TAILOR-MADE NANOSTRUCTURED TUNGSTEN HEAVY ALLOY POWDERS

Dr. Nicos Angastiniotis

The article below highlights the work of the Nanomaterials Laboratory at the Higher Technical Institute. It represents a Technology Offer (TO) that has been accepted (complied with the quality criteria) and promoted by the IRC network under the Reference Code Heph2003-040. The TO has also been inserted on the CORDIS Database under the description Exploitable Research Results with Record Control Number 30211. As of July 25, 2004 Chemring Countermeasures (UK) and Metal-Tech (Israel) have declared their commitment in exploiting the results.

CORDIS RTD-RESULTS / European Communities

Record Control Number: ***30211***

Quality Validation Date: 2003-08-01

Update Date: 2003-08-08

Abstract: A Cyprus Technical Institute has developed a novel manufacturing technology for the large-scale production of tailor-made nanostructured tungsten heavy alloy powders. End-users from the defense, aerospace and hot metal working industry, as well as vibration dumping and radiation shielding manufacturers are being sought for the utilization of the aforementioned powders (licensing agreement).

Owner of a patented methodology, the Institute, which focuses on the synthesis of nanostructured powders, has developed a novel method that yields bulk quantities of tailor-made nanostructured Copper-Tungsten (Cu-W) powders. The Institute is seeking partners for licensing agreement.

Some of the applications include:

- Balance weights on flight control surfaces and helicopter rotor blades
- Vibration dampening (crankshafts, pistons, turbine blades, etc.)
- Medical devices for radioactive isotope containment
- Heavy-duty electrical contacts
- Hot metal working processes
- Kinetic energy penetrators
- Heat sinks
- Electrodes

The approach entails two inherently scalable processing steps, i.e. the synthesis of chemically homogeneous precursor powders with compositional constituents mixed at an atomic level followed by the thermo chemical conversion of the precursor powders to Cu-W powders that are characterized by a unique phase distribution where each individual particle consists of tailor-made nanocrystalline tungsten and copper phases. The methodology is in a position to produce commercial quantities of tailor-made nanostructured Cu-W powders.

Main Advantages:
The tailor-made nanostructured Cu-W powders can be utilized for the fabrication of dense nanostructured net-shaped or thermally spayed components suitable for the above-mentioned applications.

Due to the high surface area and unique microstructure of the particles these powders are anticipated to exhibit excellent pressure ability followed by sintering activity at exceptionally low temperatures without the presence of sintering aids, which degrade the electrical/thermal conductivity of Cu-W. Thus the components are characterized by complete retention of copper in the tungsten framework (absence of copper bleed-out) and uniform distribution of tungsten and copper phases. Most importantly the component properties like the electrical/thermal conductivity and arc erosion resistance could be adjusted in accordance with the tailor-made nanometre grain size. Furthermore, these Cu-W components are expected to have excellent operability, enabling highly complex machining.

The Cu-W powders could also be deagglomerated, thus becoming ideally suitable for injection molding applications. The deagglomerated powder could also be spray-dried with an organic binder (removable by dewaxing) to produce near-spherical, flowable particles. The latter should be suitable for the net-shape fabrication of parts for use in microprocessor applications, microwave communication systems and high-performance electrical components.

Innovative Aspects: The conventional technology for making Cu-W materials involves the infiltration of a tungsten template with liquid copper. This technology yields large-size slugs that require extensive machining. Fabrication of comparable net-shape parts by powder metallurgy (P/M) has not been feasible due to the lack of commercially available powders that match the microstructural characteristics of infiltrated tungsten.

The present methodology provides a new manufacturing technology for the large-scale production of tailor-made nanostructured Cu-W powders, which are characterized by such a nanometre grain size control that render the infiltrated counterparts obsolete.

Subject Class: Energy; IT, telecommunications; Materials, industrial manufacturing technologies

Subject Descriptors: Ceramics, glasses; Composites; Metals, alloys; Polymers; Powders

Subject Index : Materials Technology

Market Applications: Nuclear fission; Manufacturing technologies; Industrial chemicals; Machine tools; Pottery, china, glass products; Road, rail vehicles

Stage of Development: Experimental development stage (laboratory prototype)

Remarks: IRC Data: Heph2003-040

Property Rights: Secret know-how

Collaboration Sought: License agreement

Collaboration Detail: End-users from the defense, aerospace and hot metal working industry, as well as vibration dumping and radiation shielding manufacturers are being sought for the utilization of the aforementioned powders.

TEMPERATURE INSENSITIVE LONG PERIOD GRATING SENSORS IN PHOTONIC CRYSTAL FIBRE

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Abstract

Presented are long-period gratings (LPGs) fabricated in pure silica photonic crystal fibre (PCF) using an electric arc. Two different varieties of PCF have been investigated, an endlessly single mode PCF and a large-mode area PCF. The LPGs have been characterised for their sensitivity to a variety of external measurands. The LPGs in both fibres have been found to have negligible temperature sensitivity whilst exhibiting good sensitivity to bending and strain.

1. Introduction

A variety of diffracting structures can now be produced inside optical fibres, including Bragg gratings, long period gratings, chirped gratings, Moiré gratings, π-shifted gratings and blazed gratings. Many of these structures have properties which are dependent on the environment of the fibre and this has lead researchers to explore their potential as sensing devices. Although grating based sensing systems are at present a long way from being low cost, for certain applications they have a number of features which make them look attractive, such as their small size, dielectric nature, electrical passivity and large multiplexing capability.

The most mature of these technologies is the fibre Bragg grating and commercial systems have been available for a few years, with the price for an interrogation system recently falling below ¤10,000. However research into these devices continues and recently considerable effort has been devoted to the long period grating (LPG) [1]. In this paper we will compare the properties of the LPG with those of the FBG in order to justify our interest in these devices. We shall describe how the sensitivity of LPGs to various parameters is dependent on the fibre composition and geometry and then go on to present our latest work with LPGs written in photonic crystal fibre (PCF), where we have produced LPG sensors with negligible temperature sensitivities.

2.LPG Properties

A LPG consists of a periodic modulation of the waveguiding properties of a single mode optical fibre, typically on a scale of a few hundred microns. The modulation can take the form of a variation in the refractive index or geometry of the fibre and can be produced in a number of ways. Direct photoinscription is a popular approach and relies on the intrinsic sensitivity of some fibres to UV light [2]; photoinscription modifies the refractive index of the fibre core and is the approach used to write FBGs. Because of the much larger period of LPGs in comparison with FBGs, it is also possible to produce these structures by modifying the fibre geometry using an electric arc [3], a CO_2 laser [4] or, for temporary devices, by applying a mechanical perturbation (microbending) [5].

The periodic modulation couples light from the core into a forward travelling cladding mode; these modes are quite heavily attenuated so that little of the coupled light will reach the far end of the fibre. Consequently, when illuminated by a suitable broadband source and viewed in transmission, the presence of an LPG is revealed by an attenuation band in the transmitted spectrum; in fact since coupling can occur to a series of cladding modes, there are usually a number of attenuation bands visible in the transmission spectrum.

Figure 1 shows the K-vector diagrams for diffraction from an LPG and an FBG. The former involves coupling to a cladding mode which has a similar propagation constant to the core mode; consequently the grating vector is much smaller that in the case of FBG diffraction where the coupling is between counter-propagating core modes. The much smaller grating vector in the case of the LPG translates into the much larger grating period required for these devices.

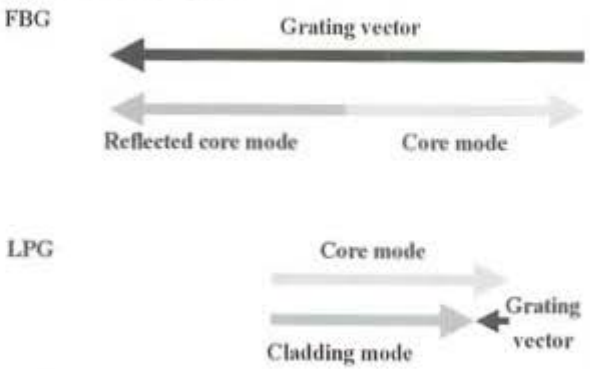

Fig. 1. K-vector diagram for diffraction from FBG (top) and LPG (Bottom).

The condition for resonant coupling between the core mode and a given cladding mode can be described by

$$\lambda = \Lambda(n_{co} - n_{cl}) \qquad (1)$$

where λ is the free space resonant wavelength, Λ is the grating period and n_{cl} and n_{co} the effective indices of the relevant cladding and core modes, respectively. In general, the resonant wavelength is sensitive to strain, temperature, curvature and the index surrounding the cladding; these measurands may affect some or all of the terms on the RHS of equation 1.

3.COMPARISON OF LPGS and FBGS

LPG Disadvantages	LPG Advantages
Detected only in transmission	Ease of fabrication
Broader attenuation bands	Can have higher sensitivity
Complex spectra	Sensitivity to index/curvature
Sensitivity to more measurands	Multi-parameter sensing
	Dependence of sensitivity on core and cladding properties

Table 1. Advantages and disadvantages of LPGs in comparison with FBGs

The differences between FBGs and LPGs are summarised in Table 1. The size of the LPG period increases the number of techniques that can be used for fabrication, since producing the structure point-by-point is far easier than for FBGs. LPGs can only be detected in transmission, this reduces the options available when designing the optical system. LPGs tend to have a broader resonance, which will generally make the determination of the central wavelength less precise, though this is countered by the fact that LPGs can offer greater sensitivity to the various measurands than FBGs. Because there can be coupling to many cladding modes, LPGs have more complex spectra consisting of many attenuation bands; coupled with the larger attenuation bands and high sensitivity this may limit the number of devices that can be wavelength division multiplexed from a single source. On the positive side, the different attenuation bands can have radically different sensitivities to the various measurands, thereby permitting two measurands to be recovered by monitoring two different bands from the same LPG. Unlike FBGs, LPGs can also be used to directly measure refractive index and curvature.

Last but definitely not least is the fact that the sensitivity of a given LPG attenuation band to a measurand is strongly dependent on the LPG period, the material properties of the core and cladding and the geometry of the fibre. By altering these parameters the sensitivity to a particular measurand can be varied considerably, both in magnitude and sign. Table 2 lists representative values that have been measured for FBGs and LPGs, both in conventional single mode fibre and also in fibres with other geometries, such as multiclad fibre or D-shaped fibre. It is this flexibility that we feel is the most important feature of LPGs and motivates our research. Ultimately, it should be possible to design a fibre to optimise the sensitivity to the desired measurand(s) whilst minimising, or removing completely, undesirable cross-sensitivities. As yet we have not met this goal, but we have investigated experimentally and theoretically the response of LPGs in a range of fibre types [6,7].

Feature	SMF telecoms optical fibre		LPGs in other fibre types	
	FBG	LPG	Maximum	Minimum
Period	0.5 μm	300 μm	-	-
Length	5 mm	5 cm	-	-
Width of attenuation bands	0.5 nm	8 nm	15 nm	3 nm
Number of attenuation bands	1 + harmonics	many	many	many
Temperature sensitivity @ 1550 nm	0.014 nm/°C	-0.41 nm/°C	+0.68 nm/°C	-0.56 nm/°C
Strain sensitivity @ 1550 nm	1.2 pm/με	+0.9 pm/με	+4.0 pm/με	-6.1 pm/με
Bend sensitivity @ 1550 nm	No	+9.5 nm/m	+9.5 nm/m	-7.4 nm/m
Index sensitivity @ 1550 nm	No	-465 nm	+5000 nm	-2400 nm

Table 2. Comparison of measurand sensitivities of FBGs and LPGs.

Recently we have extended this study from fibres with a more or less conventional core/cladding structure, to photonic crystal fibre (PCF). The motivation here is that the dispersion properties of PCF are strongly dependent on the microstructured geometry and it is possible to produce a wide variety of geometries using the usual stack-and-draw fabrication technique; consequently we feel that PCF may offer an attractive route towards producing fibre that would enable LPG sensors to be optimised for specific applications.

4.Fabrication

LPGs are most commonly fabricated by exposing the optical fibre to UV laser radiation [2], either through an amplitude mask or by point-by-point inscription. In these fabrication techniques the fibre either has to be designed to be highly photosensitive or the fibre has to be slightly doped with germanium and hydrogen loaded to increase the photosensitivity and consequently the change in refractive index. If the fibre has been hydrogenated, post exposure thermal annealing needs to be undertaken to stabilise the gratings by removing the residual hydrogen. The electric arc technique does not require the fibre to be photosensitive or hydrogen loaded in order for LPGs to be fabricated. It has been shown by A. Malkdi et al. [8] that the writing mechanism of the electric arc technique is to induce a weak reduction in diameter and a slight induced anisotropy in the fibre. This is a result of the areas of the fibre exposed to the arc experiencing densification of the glass structure. The anisotropy is likely to be due to the asymmetry of the electric arc discharge.

The LPGs in this paper were fabricated by exposing a stripped section of the PCF to an electric arc, provided by a commercial splicer. The period of the LPG was controlled by applying the arc at set intervals, defined by a translation stage (TS), with the fibre under no tension, see Fig 2.

The characterisation of the attenuation bands was carried out by launching light from a broadband light source (BBS) into the fibre and monitoring the transmitted spectrum using an optical spectrum analyser (OSA), with an accuracy of 0.08nm. Two different types of PCF were investigated: endlessly single mode fibre from Blaze Photonics and large mode area fibre from Crystal Fiber.

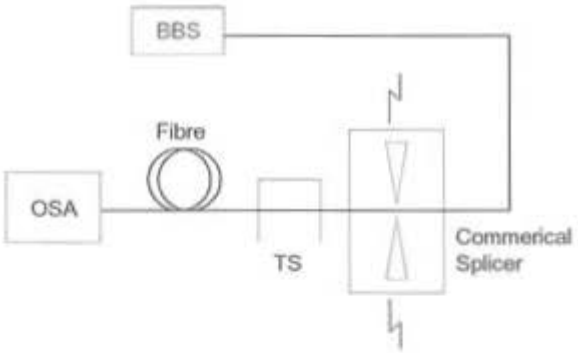

Fig. 2. Schematic of the electric arc fabrication technique.

5. Endlessly Singlemode PCF

In standard step index telecommunications fibre the number of guided modes in the core is determined by the V value

$$V=\left(\frac{2\pi a}{\lambda}\right)\left(n^2_{core}-n^2_{clad}\right)^{1/2}, \qquad (2)$$

where a is the fibre radius, ncore is the refractive index of the core and ncladd is the refractive index of the cladding. The V number must be less than 2.405 for the fibre to be single mode. Consequently, ostensibly singlemode optical fibre can be multimode at lower wavelengths. Endlessly singlemode (ESM) PCF is designed to have singlemode operation for all wavelengths of light [9]. This is possible because at shorter wavelengths the light intensity distribution in the fibre becomes more concentrated in the silica region, avoiding the holes. Since the effective refractive indices are wavelength dependant due to the material and waveguide dispersion of the fibre, at shorter wavelengths the effective refractive index of the cladding increases. This dispersion counteracts the dependence of V on the wavelength extending the single-mode range.

The particular ESM PCF used for this work (Blaze Photonics ESM-1550-01) had a core diameter of 12_m surrounded by 54 air holes, with the space between adjacent holes being 8_m, see Fig.3.

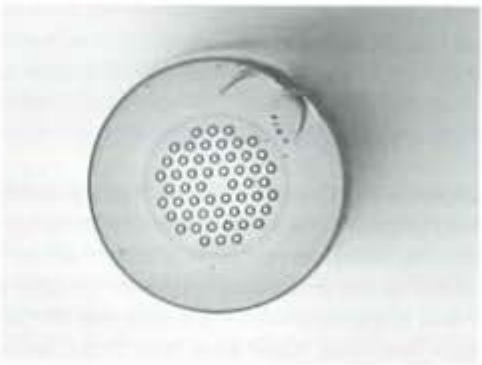

Fig. 3. Cross-section of the endlessly single mode PCF taken using a microscope with x 20 objective.

Several periods of LPG were fabricated, their transmission spectra being shown in Fig. 4. The location of attenuation bands of LPGs in standard telecommunications fibre e.g. SMF 28, increase in wavelength with an increase in grating period [10]. However, as can be seen in Fig 4, for the ESM PCF as the grating period increases the location of the attenuation bands decreases in wavelength. This is due to the effective refractive index of the cladding becoming lower at higher wavelengths due to the light intensity spreading into the air holes. From equation (1) it can be seen that this effect increases (nco-ncladd) significantly with increasing wavelength, which results in the attenuation bands shifting to longer wavelengths for shorter grating periods [11].

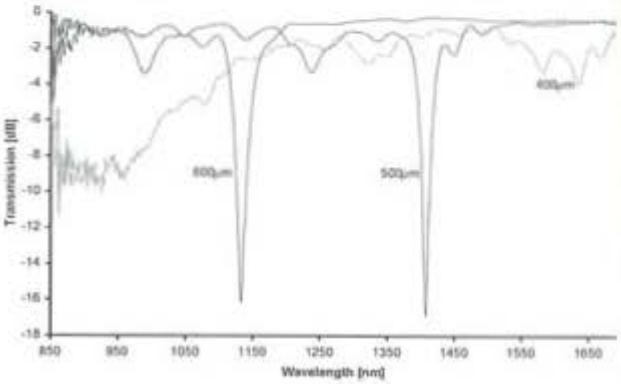

Fig. 4. Attenuation bands of different LPGs fabricated using the electric arc technique in ESM PCF. Dark Grey line 600mm; Black line 500µm; Light Grey line 400µm.

No significant attenuation bands are seen in the spectrum of the 400µm period LPG due to the attenuation bands being higher in wavelength than the optical range of the OSA. The 500µm period LPG, which had a length of 25.5mm, was investigated for its spectral sensitivity to external measurands. Although a small band is seen at 1239nm, the 1409nm attenuation band was investigated due to this band being significantly stronger.

5.1 Spectral Temperature Charcteristics

The temperature sensitivity was investigated by placing the LPG on an insulated Peltier heater. The temperature was varied from 20.0°C to 90.5°C, which produced no measurable change in the central wavelength of the attenuation band. From the measurement accuracy we have deduced a temperature sensitivity of $d\lambda/dT=0 \pm 10$ pm/°C. This may be compared with the results of Humbert et al. [12] who quote a temperature sensitivity of 9 pm/°C in the range of 25-160°C for a similar structured PCF which varied from this PCF only by slightly differing core and hole dimensions. By way of further comparison, the temperature sensitivity of electric arc-induced LPGs in standard single mode fibre is 70 pm/°C [13]. The difference between the fibre types occurs because standard single mode fibre has a germanium doped core which has a higher change in refractive index with temperature, dn/dT, than pure silica.

5.2 Spectral Bending Charcteristics

The bend sensitivity measurements were made by clamping the LPG midway between two blocks, one on a translation stage that was moved inwards, thereby bending the fibre; see Fig. 5.

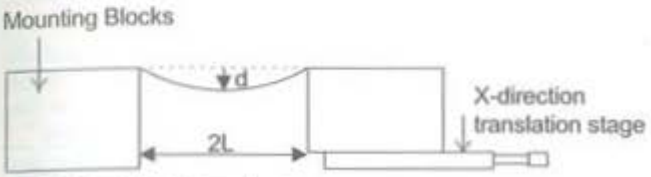

Fig. 5. Schematic of the bending rig.

When the LPG is midway between the two blocks, the resulting curvature, R, of the sensor is given by [14]

$$R = \frac{2d}{d^2 + L^2} \quad , \qquad (3)$$

where d is the bending displacement and L is half the distance between the fibre clamping points. The resulting change in the transmission spectrum is shown in Fig. 6.

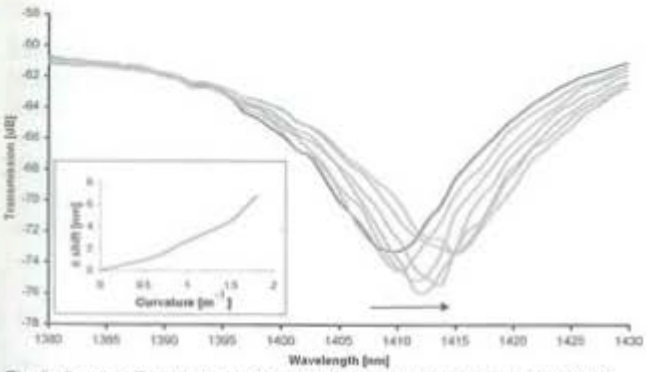

Fig. 6. Spectral Response of 500 μm LPG to curvature in range 0-1.81m^{-1} Bold curve corresponds to straight fibre. Inset: Wavelength shift as a result of induced curvature

With increasing curvature a red wavelength shift of the central wavelength was observed. The inset to Fig. 6 shows the relationship between the central wavelength shift and the curvature of the LPG; at a curvature of 1 m^{-1} the bend sensitivity is dλ/dR=3.7± 0.1 nm.m.

5.3 SPECTRAL STRAIN CHARCTERISTICS

The strain sensitivity of the 1409 nm attenuation band was determined by fixing one end of the grating on a block and the other to a translation stage. The effect of the strain on the attenuation band is shown in Fig. 7. The resulting wavelength shift gives a strain sensitivity of dλ/dσ = -2.0 ± 0.1 pm/με. The negative value of the sensitivity indicates a wavelength shift towards the blue with increasing strain. The shift of the attenuation band to lower wavelengths with applied strain is expected since the strain causes a temporary increase in the grating period. As previously shown, increasing the grating period in PCF causes the location of the LPG attenuation bands to shift to lower wavelengths.

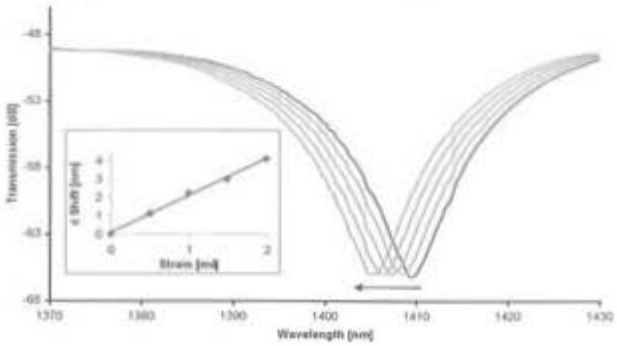

Fig. 7 Spectral response of LPG to strain in range 0–1.98 m_ Unstrained curve in bold. Inset: Wavelength shift as a result of applied strain, showing straight line fit with dλ/dσ = -2.0 ± 0.1 pm/με.

6. Large-mode Area PCF

The second PCF investigated was a Large-Mode Area (LMA) PCF (Crystal Fiber, LMA 10). As with the previous fibre this too is designed to be endlessly single mode but with the difference that this fibre has a large effective mode field area, approximately 40μm^2. This PCF had a core diameter of 11μm and was surrounded by 90 air holes with a separation distance of 7.1μm, see Fig. 8.

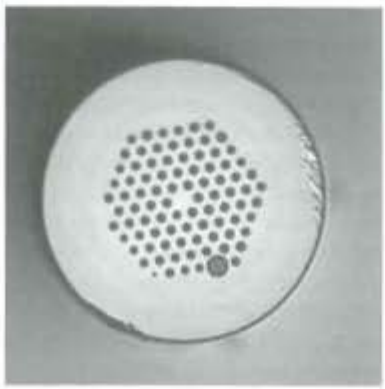

Fig. 8. Cross-section of the large-mode area PCF taken using a microscope with x 20 objective.

Once again several grating periods were fabricated (see Fig. 9) and as seen with the ESM PCF, increasing grating period decreased the location of the attenuation bands. Since the 600μm and 500μm LPGs did not have attenuation bands in a high enough wavelength range, the 400μm LPG was investigated for its sensitivity to external measurands.

The 400μm LPG had a length of 37.6mm and a transmission spectrum containing four attenuation bands located at 1668nm, 1511nm, 1434nm and 1389nm. These bands were investigated for their spectral sensitivity to external measurands.

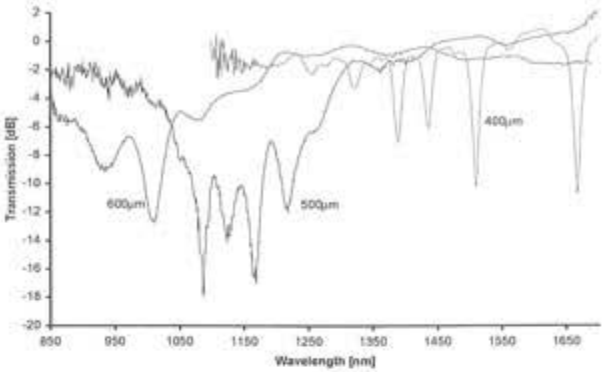

Fig. 9. Attenuation bands of different LPGs fabricated using the electric arc technique on LMA PCF. Dark Grey line 600µm; Black line 500µm; Light Grey line 400µm.

6.1 Spectral Temperature Charcteristics

The temperature sensitivity was investigated again by placing the LPG on an insulated Peltier heater. The temperature was varied from 20.0°C to 90.2°C, which again produced no measurable change in the central wavelengths of any of the attenuation bands, from which we deduce a temperature sensitivity of $d\lambda/dT=0 \pm 10$ pm/°C.

6.2 Spectral Bending Charcteristics

The bend sensitivity was investigated using the same method as used with the previous PCF. However, in addition two rotational stages were fixed to the blocks and the fibre placed in the stages so that curvatures in different axes of the fibre could be investigated. The fibre was consequently bent with the rotational stages set at 0 degrees and the experiment repeated with the stages rotated by 180 degrees. This was done to investigate if the fibre had any directional curvature dependence. The attenuation bands were found to be directionally sensitive with red and blue shifts in the central wavelength observed for the two orientations, see Fig. 10. With the rotational stages set at 0 degrees the attenuation bands at 1668nm and 1511nm experienced a blue wavelength shift while the bands at 1434nm and 1389nm experienced a red shift. With the rotational stages set at 180 degrees all shifts were in the opposite sense. It should be noted that the attenuation band at 1511nm experienced very small shifts and also decreased in amplitude.

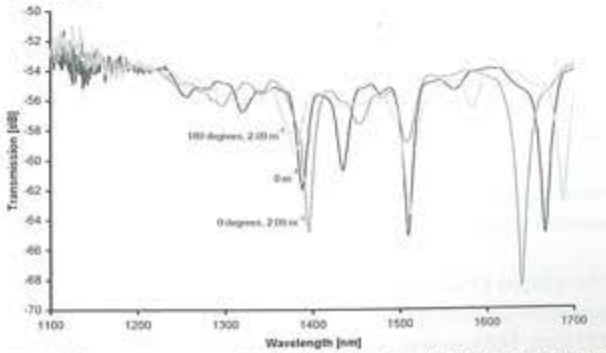

Fig. 10. Spectral response of the LPG to bending. Black line, LPG with no curvature; dark grey line, curvature of 2.09m^{-1} in the 0 degrees position and light grey line curvature of 2.09m^{-1} in the 180 degrees position.

The spectral sensitivity of all the attenuation bands was investigated and the band centred at 1668nm was found to have the maximum sensitivity to bending with a value of $d\lambda/dR = 9.6 \pm 1.0$ nm.m with the fibre in the 180 deg rotational state and a sensitivity of $d\lambda/dR = -12.4 \pm 1.2$ nm.m when in the 0 deg position; shown by the trend lines in Fig. 11.

The results for all the attenuation bands can be seen in Table 3. The negative signs indicate blue wavelength shifts.

	Atten. Band 1668nm	Atten. Band 1511nm	Atten. Band 1434nm	Atten. Band 1389nm
0 degree rotation	-12.4 ± 1.2 nm.m	-1.1 ± 0.1 nm.m	6.5 ± 0.3 nm.m	4.5 ± 0.4 nm.m
180 degree rotation	9.6 ± 1.0 nm.m	0.7 ± 0.1 nm.m	-4.0 ± 0.5 nm.m	-4.3 ± 0.5 nm.m

Table 3. Table showing the spectral responses of all the attenuation bands to the induced curvature

The spectral investigation of the band at 1668nm was taken up to a curvature of 2.09m^{-1}, whereas the attenuation bands at 1511nm, 1434nm and 1389nm were taken up to 1.45m^{-1}. This was because at larger curvatures it became increasingly difficult to determine the location of the bands at 1434nm and 1511nm due to their reduction in size. To the best of our knowledge these two rotational positions provide the maximum sensitivity to bending.

6.2 Spectral Surrounding Refractive Index (SRI) Charcteristics

The spectral sensitivity to surrounding refractive index (SRI) was investigated by placing the LPG in a V-groove and immersing the grating in certified refractive index (CRI) liquids (supplied by Cargille laboratories Inc), which have a quoted accuracy of ±0.0002. Before immersion in each of the CRI liquids, to prevent contamination the LPG and V-groove were cleaned using methanol, then deionised water and finally dried.

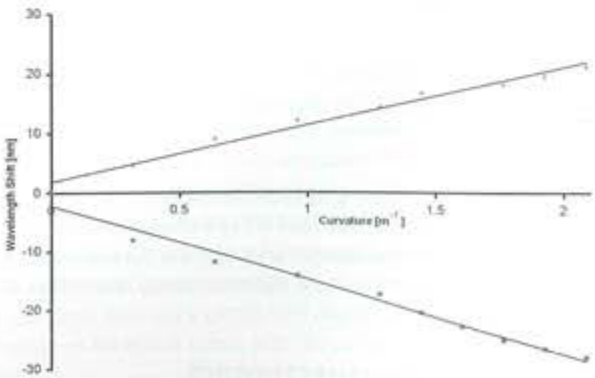

Fig. 11. Spectral sensitivity of the attenuation band at 1668nm to bending.

The V-groove was created in an aluminium plate, which had been machined flat to minimise the fibre bending. The plate was clamped to the optical table to ensure no movement. After each cleaning and subsequent repositioning of the fibre, it was ensured that the fibre was under the same tension each time by comparing the spectrum on the OSA with a saved trace of the original starting

position. Several different CRI liquids were compared in the range n=1.325 to n=1.514. Since the refractive index of silica is 1.47 this ensured the response of the grating to refractive indices lesser and greater than that of the fibre. Fig. 12 shows the effect of the SRI changes on the transmission spectrum of the grating with CRI liquids of index less than that of silica. As can be seen, all attenuation bands experience a red wavelength shift with increasing index.

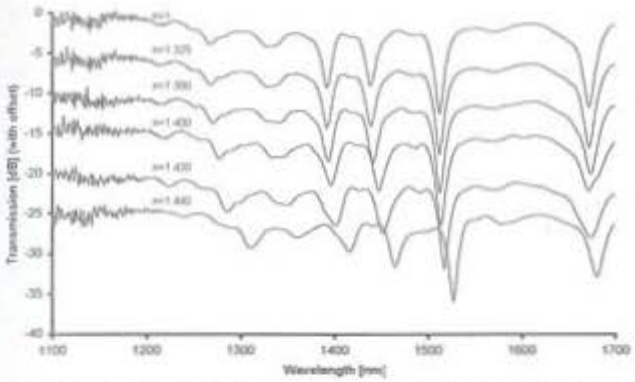

Fig. 12. The effect of SRI on the attenuation bands of the LPG.

The wavelength shift as a function of the SRI for each attenuation band is shown in Fig. 13. The figure shows that the peak initially centred at 1434nm has the greatest wavelength shift followed by the peak at 1389nm then 1511nm and finally 1668nm.

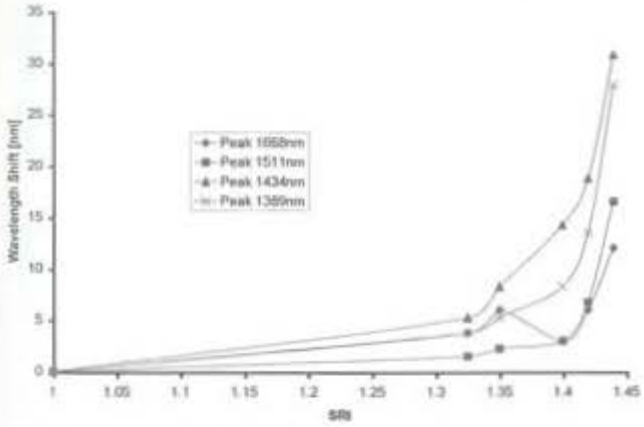

Fig. 13. The wavelength shift of the four attenuation bands as a function of the SRI (less than silica).

For refractive indices greater than that of silica, the spectrum of the LPG changes with only three attenuation bands present, see Fig. 14. This plot also shows that as the SRI is increased the amplitude of the attenuation bands grow and the fourth attenuation band starts to reappear.

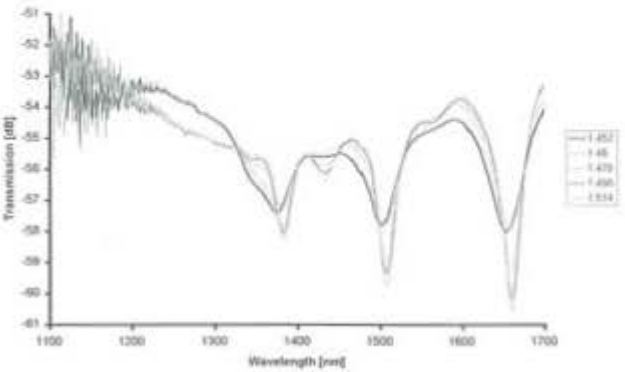

Fig. 14. The wavelength shift of the attenuation bands as a function of the SRI (greater than silica).

6.4 Spectral Strain Charcteristics

The strain sensitivity of this LPG was investigated in the same way as the Blaze PCF. A linear blue wavelength shift of the central wavelength of all the attenuation bands was observed, see Fig. 15 for details of the band at 1668 nm. The attenuation band centred at 1668nm has a strain sensitivity of $d\lambda/d\sigma = -2.5 \pm 0.04$ pm/με. The other attenuation bands were also investigated and experienced roughly the same strain sensitivity, except for the band centred at 1389nm which had a sensitivity of $d\lambda/d\sigma = -1.8 \pm 0.2$pm/με.

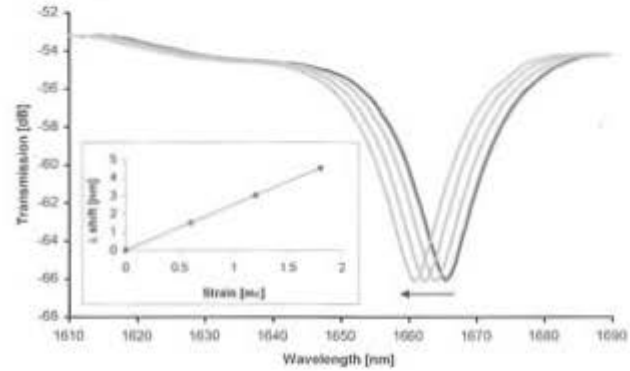

Fig. 15. Spectral response of LPG band at 1668 nm to strain in range 0–1.8mε. Unstrained curve in bold. Inset: Wavelength shift as a result of applied strain

7. Conclusions

LPGs in two different types of PCF have been investigated. Both fibres have shown negligible temperature sensitivity whilst having significant sensitivity to other measurands. This is an important factor, since one of the persistent problems of using LPGs as sensors is their cross-sensitivity to temperature, which results in discriminatory schemes needing to be employed to separate the effect of temperature from the desired measurands. Since the electric-arc-induced LPGs studied here have been shown to possess attenuation bands with negligible temperature sensitivity,

this eliminates the need for such schemes. Furthermore, since the fabrication process does not involve photoinscription, photosensitive fibre is not required and the cost of the resulting sensing system has the potential to be significantly reduced, as does the fabrication time itself.

The LPG fabricated in the Crystal Fiber PCF was found to have a maximum strain sensitivity of $d\lambda/d\sigma = -2.5 \pm 0.04$ pm/με, which is comparable to the Blaze Photonics PCF, which had a strain sensitivity of $d\lambda/d\sigma = -2.0 \pm 0.1$ pm/με. Both fibres were found to have a similar damage threshold breaking after a strain of 1.98 mε for the Blaze Photonics PCF compared to after a strain of 1.8 mε for the Crystal Fiber PCF. The Crystal Fiber PCF was also found to have a greater sensitivity to bending with its maximum sensitivity being $d\lambda/dR = -12.4 \pm 1.2$ nm.m compared to $d\lambda/dR = 3.7 \pm 0.1$ nm.m. The LPG in the Crystal Fiber PCF was also found to have directional bending properties.

8. References

1.S.W. James and R.P. Tatam. 'Optical fibre long-period grating sensors: characteristics and application'. *Meas. Sci. Technol.*, 2003 **14** (5) pp R49-61

2.A.M. Vengsarkar, P.J. Lemaire, J.B. Judkins, V. Bhatia, T. Erdogan and J.E. Sipe. 'Long-period fiber gratings as band rejection filters'. *J. Lightwave Technol.*, 1996, **14**, pp. 58-64

3.G. Rego O. Okhotnikov, E. Dianov and V. Sulimov. 'High-temperature stability of long-period gratings produced using an electric arc'. *J. Lightwave Technol.*, 2001, **19**, (10) pp. 1574-1579

4.D.D. Davies T.K. Gaylord, E.N. Glytsis, S.G. Kosinski, S.C. Mettler and A.M. Vengsarkar. 'Long-period fibre grating fabrication with focused CO_2 laser pulses'. *Electron. Lett.*, 1998 **34** (3) pp. 302-303

5. J.W. Berthold III. 'Historical review of microbend fiber-optic sensors'. *J. Lightwave Technol.*, 1995, **13**, (7) pp. 1193-1199

6. T. Allsop, D.J. Webb and I. Bennion. 'A comparison of the sensing characteristics of long period gratings written in three different types of fiber'. *Opt. Fiber Tech.* 2003 (9), pp.210-223

7. T. Allsop, A. Gillooly, V.K. Mezentsev, T. Earthgrowl-Gould, R. Neal, D.J. Webb and I. Bennion. 'The Spectral Characteristics of Long Period Gratings Written in D-Shaped Optical Fiber as Bending Sensors'. *Proceedings of the 16th International Conference on Optical Fibre Sensors (OFS '2003)*, IEICE, Japan, 2003. pp. 88-91

8. A. Malki, G. Humbert, Y. Ouerdane, A. Boukhenter and A. Boudrioua. 'Investigation of the writing mechanism of electric-arc-induced long-period fiber gratings'. *Appl. Opt.*, 2003, **42**, (19) pp. 3776-3779

9. T.A. Birks, J.C. Knight and P.St.J Russell. 'Endlessly single-mode photonic crystal fiber'. *Opt. Lett.*, 1997, **22**, (13) pp. 961-963

10. X. Shu, L. Zhang and I. Bennion. 'Sensitivity Characteristics of Long Period Fiber Gratings'. *J. Lightwave Technol.*, 2002, **20**, pp 255-266

11. K. Morishita and Y. Miyake. 'Fabrication and resonance wavelength of long-period gratings in a pure-silica photonic crystal fiber by the glass structure change'. *J. Lightwave Technol.*, 2004, **22**,(2) pp. 625-630

12. G. Humbert, A. Malki, S. Février, P. Roy and D. Pagnoux. 'Electric arc-induced long-period gratings in Ge-free air-silica microstructure fibres'. *Electron. Lett.*, 2003 **39** (4) pp. 349-350

13. G. Humbert and A. Malki. 'Electric-arc-induced gratings in non-hydrogenated fibres: fabrication and high-temperature characterisations'. *J. Opt. A, Pure Appl. Opt.*, 2002, **4**, pp. 194-198

14. W. Du, H. Tam, M Liu and X. Tao. 'Long-period fiber grating bending sensors in laminated composite structure'. SPIE Conf. Proc. Smart Structures and Materials, SPIE, San Diego, USA, 1998, Vol.3330, pp. 284-292

THERMAL AND ENVIRONMENTAL LIFE CYCLE ANALYSIS OF DOMESTIC SOLAR WATER HEATING SYSTEMS

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Abstract
In this paper an analysis of the pollution caused by the burning of fossil fuels is briefly presented followed by a study on the environmental protection offered by domestic solar water heating systems. The results presented in this paper show that by using solar energy for domestic water heating considerable amounts of greenhouse polluting gasses are avoided. The savings, compared to a conventional system, are about 80% with electricity or diesel backup. Additionally, both systems investigated give positive and very promising financial characteristics. With respect to life cycle assessment of the systems, the energy spent for the manufacture and installation of the solar systems is recouped in about 1.2 years, whereas the payback time with respect to emissions produced from the embodied energy required for the manufacture and installation of the systems varies from a few months to 3.7 years according to the fuel and the particular pollutant considered. Moreover the cost of damage avoided by some of the pollutants is investigated with respect to damages to crops, materials, mortality and morbidity. It was found that C£31 are avoided per year when the system is using electricity as auxiliary and C£13 when diesel is used for each solar water heating system. It can therefore be concluded that solar energy systems offer significant protection to the environment and cost savings and should be employed whenever possible in order to achieve a sustainable future.

1. Introduction
All nations of the world depend on fossil fuels for their energy needs. However the obligation to reduce CO_2 and other gaseous emissions, in order to be in conformity with the Kyoto agreement is the reason behind which countries turn to non-polluting renewable energy sources.

Energy is considered a prime agent in the generation of wealth and a significant factor in economic development. The importance of energy in economic development is recognised universally and historical data verify that there is a strong relationship between the availability of energy and economic activity. Although at the early seventies, after the oil crisis, the concern was on the cost of energy, during the past two decades the risk and reality of environmental degradation have become more apparent. The growing evidence of environmental problems is due to a combination of several factors since the environmental impact of human activities has grown dramatically. This is due to the increase of the world population, energy consumption and industrial activities. Achieving solutions to environmental problems that humanity faces today requires long-term potential actions for sustainable development. In this respect, renewable energy resources appear to be one of the most efficient and effective solutions.

The principal objective of this paper is to discuss briefly the environmental impact of energy use and to analyse the environmental benefits resulting from the use of solar water heating systems. Additionally, the amount of pollution saved because of the use of solar energy against the pollution caused for the manufacture of the systems is examined.

2. Environmental Impact of Conventional Energy Sources
One of the most widely accepted definitions of sustainable development is: "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". There are many factors that can help to achieve sustainable development. The main ones are the rational use of energy and the use of renewable energy resources.

A few years ago, most environmental analysis and legal control instruments concentrated on conventional pollutants such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), particulates, and carbon monoxide (CO). Recently however, environmental concern has extended to the control of hazardous air pollutants, which are usually toxic chemical substances which are harmful even in small doses, as well as to other globally significant pollutants such as carbon dioxide (CO_2). Additionally, developments in industrial processes and structures have led to new environmental problems. A detailed description of these gaseous and particulate pollutants and their impact on the environment and human life is presented by Dincer (1998).

Pollution depends on energy consumption. There are a large number of factors which are significant in the determination of the future level of the energy consumption and production. Such factors include population growth, economic performance, consumer tastes and technological developments. Furthermore, governmental policies concerning energy and developments in the world energy markets will certainly play a key role in the future level and pattern of energy production and consumption (Dincer, 1999).

Problems associated with energy supply and use are related not only to global warming, but also to other environmental impacts such as air pollution, acid precipitation, ozone depletion, forest destruction, and emission of radioactive substances. Today much evidence exists, which suggests that the future of our planet and of the generations to come will be negatively impacted if humans keep degrading the environment. The three major environmental problems that are internationally known are the acid rain, ozone layer depletion and global climate change.

Today the world daily oil consumption is 76 million barrels. Despite the well known consequences of fossil fuel combustion on the environment, this is expected to increase to 123 million barrels per day by the year 2025 (www.worldwatch.org). In developed countries, energy consumption in the building sector represents

a major part of the total energy budget. In the European Union this is approximately equal to 40% of the total energy consumption (Argiriou *et al.*, 1997). Most of this amount is spent for hot water production and space heating. One way to reduce this amount of energy is to employ solar energy.

3. Renewable Energy Technologies

Renewable energy technologies produce marketable energy by converting natural phenomena into useful forms of energy.

Several potential solutions to the current environmental problems associated with the harmful pollutant emissions from the burning of fossil fuels have evolved, including renewable energy and energy conservation technologies. Many countries consider today solar, wind and other renewable energy sources as the key to a clean energy future.

Renewable energy systems can have a beneficial impact on the environmental, economic, and political issues of the world. The benefits arising from the installation and operation of renewable energy systems can be distinguished into three categories; energy saving, generation of new working posts and the decrease of environmental pollution (Diakoulaki *et al.*, 2001).

The energy saving benefit derives from the reduction in consumption of the electricity and/or diesel which are used conventionally to provide energy. Additionally, of equal importance is the ability of renewable energy technologies to generate jobs as a means of economic development to a country. The penetration of a new technology leads to the development of new production activities contributing to the production, market distribution and operation of the pertinent equipment. Specifically in the case of solar energy collectors, job creation mainly relates to the construction and installation of the collectors. The latter is a decentralised process since it requires the installation of equipment in every building or every individual consumer.

In this paper emphasis is given to solar energy systems and in particular to solar water heating systems. These are very popular systems used extensively in many countries with good sunshine potential such as the Mediterranean countries. In particular for countries like Cyprus which is a world leader on installed solar water heating systems it is of interest to know the magnitude of environmental advantage of these systems.

4. Solar System Considered

A schematic diagram of the solar water heating (SWH) system considered in this study is shown in Fig. 1. Flat plate collectors are used which are by far the most used type of collectors. The instantaneous efficiency of the collector considered is given by the equation:

$$\eta = 0.792 - 6.65\left(\frac{\Delta T}{I}\right) - 0.06\left(\frac{\Delta T^2}{I}\right) \quad (1)$$

where ΔT is temperature difference between the collector inlet and ambient temperatures and I is the global solar radiation.

As can be seen from Fig. 1 an active solar system is considered, i.e., a pump is employed to transfer the solar thermal energy to storage, operated by means of a differential thermostat. The thermostat compares the temperature at the outlet of the solar collectors and the storage tank and whenever the collector temperature is higher than the storage temperature by more than 8°C the pump is switched on. It switches off whenever this difference is lower than 4°C. The storage tank is well insulated to reduce thermal loses to the environment and is equipped with heat exchangers for both the solar system and the auxiliary system. In SWH systems the auxiliary can be electricity or diesel. In the cases where diesel is considered this is used in a central heating boiler, which supplies the energy for the heating needs of a house and is not used only as the solar system backup. The specifications of the solar system are shown in Table 1.

Parameter	Specification
Type of system	Active
Collector area	3.8 m^2 (2-panels)
Collector slope	40°
Storage capacity	160 l
Auxiliary capacity	3 kW
Heat exchanger	Internal
Heat exchanger area	3.6 m^2
Hot water demand	120 l (4 persons)

Table 1. Specification of the solar system considered

Traditional hot water systems comprise a hot water cylinder powered either by electricity or by diesel oil through the central heating boiler. Therefore the extra equipment required for the solar system are the solar collectors, piping to connect the collectors with the storage tank, pump and differential thermostat.

5. Thermal and Economic Analysis

The system is simulated with Polysun program (version 3.3.5g) with the weather conditions of Nicosia, Cyprus (Polysun, 2000). The program provides dynamic annual simulations of solar thermal systems and helps to optimise them. It operates with dynamic time steps from one second to one hour, thus simulation can be more stable and exact. The program is user friendly and the graphic-user interface permits a comfortable and clear input of all system parameters. All aspects of the simulation are based on physical models that work without empirical correlation terms.

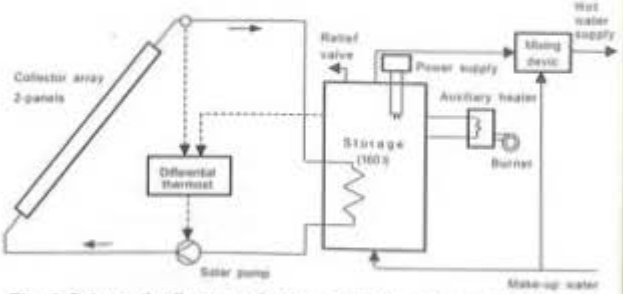

Fig. 1 Schematic diagram of the solar water heating (SWH) system

In addition the program performs economic viability analysis and ecological balance, which includes emissions from the eight most significant greenhouse gasses, thus the emissions of systems working only with conventional fuel and systems employing solar energy can be compared. Program Polysun was validated by Gantner (2000) and was found to be accurate to within 5-10%. The optimum slope of the solar collectors, shown in Table 1, was calculated with a special routine of the Polysun program.

Two types of solar water heating systems were considered one with electric heating backup and one with a boiler backup. In houses where a central heating exist the last option is preferred as the price of diesel is much lower than that of electricity and the owners prefer to use their central heating boiler to produce hot water, as a solar system backup, irrespective of the requirement for heating. The annual energy balance and the monthly solar contribution of the systems considered are shown in Tables 2 and 3 respectively.

As can be seen from Table 3, all variations of domestic hot water systems considered cover all the requirements during summertime and a large percentage during wintertime. The annual figure is also high. It should be noted that by adjusting slightly the consumption profile, contributions of 100% could be obtained in the months May to October, which is what actually happens in practice. The program however considers a standard consumption throughout all months that is why values slightly below 100% are given.

Table 2. Annual energy balance of the systems considered.

Parameter	Electricity backup	Diesel backup
Solar system yield (kWh)	2046.4	2063.1
Total auxiliary energy (kWh)	269.3	238.5
Hot water demand (kWh)	1780.0	1780.0
Solar fraction	88.4	89.6

Note: Solar fraction = solar yield / (solar yield + auxiliary)

Table 3. Monthly solar contribution

Month	Electricity backup	Diesel backup
Jan	61.1	61.7
Feb	75.8	76.5
Mar	86.5	88.7
Apr	90.8	91.2
May	96.0	98.2
Jun	96.5	97.3
Jul	97.0	98.5
Aug	98.8	99.4
Sep	98.5	99.9
Oct	94.9	94.9
Nov	87.3	89.0
Dec	72.0	74.5
Year	88.4	89.6

Note: All values are expressed in percentage

The results of the economic analysis are shown in Table 4. These were obtained by using the current fuel and electricity rates, a twenty years period and market discount rare of 4%. No subsidies were considered. As can be seen in all cases the solar systems give much lower specific energy costs than the conventional systems and the pay back times are reasonable. It should be noted that the cost of the boiler and other necessary auxiliary equipment is not taken into account in the economic analysis, i.e., only the cost of the extra equipment required for the solar installation is considered.

Table 4. Results of the economic analysis for the various types of fuels considered

Parameter	Electricity	Diesel
Total system cost (solar)	550	550
Annual fuel savings (CE)	95	74
Pay-back time (years)	4.2	5.4
Energy costs:		
Solar energy only (CE/kWh)	0.0253	0.0251
Solar+conventional (CE/kWh)	0.0332	0.0293
Conventional (CE/kWh)	0.105	0.0739

6. Environmental Benefits of Solar Energy Systems

To investigate the environmental benefits of utilising solar energy instead of conventional sources of energy, the different emissions resulting from the solar system operation are estimated and compared to those of a conventional fuel system. The emissions reported are those which are responsible for the most important environmental problems. The environmental pollution is expressed in physical units of the emitted substances per year. The quantities of the emissions depend on the solar collector size and the required auxiliary energy and are compared to a non-solar system which is using conventional fuel. The environmental analysis of the above systems which includes the different pollutants as calculated by the program Polysun is tabulated in Tables 5 and 6. In the tables the eight most important greenhouse gasses are compared.

Table 5. Environmental impact of the SWH system with electricity backup

Emissions	Units	Conventional	Solar system	Savings (%)
Carbon dioxide (CO_2)	Tons/year	1.982	0.40	79.8
Carbon monoxide (CO)	g/year	496	100	79.8
Nitrogen oxides (NO_x)	g/year	74	15	79.8
Nitrous oxide (N_2O)	g/year	7	2	79.8
Methane (CH_4)	g/year	12	3	79.8
Hydrocarbons	g/year	50	10	79.8
Sulfur dioxide (SO_2)	g/year	743	150	79.8
Dust	g/year	248	50	79.8
Savings in GHG	%	-	-	**79.8**

Table 6. Environmental impact of the SWH system with diesel backup

Emissions	Units	Conventional	Solar system	Savings (%)
Carbon dioxide (CO_2)	Tons/year	0.766	0.259	66.3
Carbon monoxide (CO)	g/year	1615	363	77.5
Nitrogen oxides (NO_x)	g/year	1615	324	80.0
Nitrous oxide (N_2O)	g/year	7	1	80.7
Methane (CH_4)	g/year	15	3	82.8
Hydrocarbons	g/year	62	11	82.8
Sulfur dioxide (SO_2)	g/year	775	145	81.3
Dust	g/year	136	52	61.7
Savings in GHG	%	-	-	**80.0**

As can be seen in both cases by using solar energy instead of conventional fuel a very large amount of pollutants are avoided. Additionally, the amount of emissions depends on the type of fuel used as auxiliary. The percentage saving obtained in the cases where electricity or diesel backup is used is about 80%. It should be noted however that the quantities of emissions in all these cases are completely different and the proximity of the percentage numbers obtained is due to the generation efficiency of each system. Electrical energy is produced at a maximum efficiency of about 35% whereas in the case of diesel backup a boiler efficiency of 85% is considered.

The usual type of SWH system encountered in Cyprus is of the thermosyphon type. This system uses the same collector area as the one considered here but it has no pump and differential thermostat. Its thermal behaviour is very similar to the studied system. Cyprus began manufacturing solar water heaters in the early sixties. Today more than 93% of all houses have solar water heating systems installed and operating. The total number of systems is equal to 190,000 units. In fact the number of units in operation today corresponds to one heater for every 3.7 people in the island, which is a world record (Kalogirou, 2001). Therefore for the Cyprus case, if the above numbers are considered, one can understand the magnitude of the environmental pollution reduction per year, just for water heating. It is believed that similar results can be obtained for other countries with good solar resource.

It can be concluded from the results presented in this section that considerable amounts of polluting gases are avoided by both types of systems considered, which implies that the solar water heating is environmentally friendly irrespective of the backup fuel used.

7. Pollution Created From Solar Systems

The negative environmental impact of solar energy systems includes land displacement, and possible air and water pollution resulting from manufacturing, normal maintenance operations and demolition of the systems. However, land use is not a problem when collectors are mounted on the roof of a building, maintenance requirement is minimal and pollution caused by demolition is minimal as most materials used in the construction of the collectors can be recycled. The pollution created for the manufacture of the solar collectors is estimated by calculating the embodied energy invested in the manufacture and assembly of the collectors and estimating the pollution produced by this energy.

Initially the embodied energy of one solar collector panel, 1.9m^2 in area is determined. This is the same collector considered in the performance analysis of the systems. The analysis is based on the primary and intermediate embodied energy of the components and materials as illustrated in Fig. 2. In the present analysis no allowance is made for the unit packing, transportation and maintenance as these have insignificant contribution compared to the total.

The total embodied energy required to produce a complete flat-plate collector is calculated using primary and intermediate production stages. The primary stage is established from an assessment of the various materials used and their corresponding mass. Using the embodied energy index (MJ/kg) defined by Alcorn (1995) the material embodied energy content within the unit is determined. Table 7 summarizes the unit materials used and lists their corresponding mass and embodied energy content. As can be seen from Table 7, the total embodied energy content for the production of one flat-plate collector panel is calculated at 3540 MJ. This comprise the primary embodied energy of materials and the intermediate embodied energy, i.e., the amount of energy used in the production and assembly of the component parts during the construction stage and was determined through a stage-by-stage appraisal of the power sources used. Inherent within this intermediate stage is the fabrication of purchased components like screws, glass and insulation.

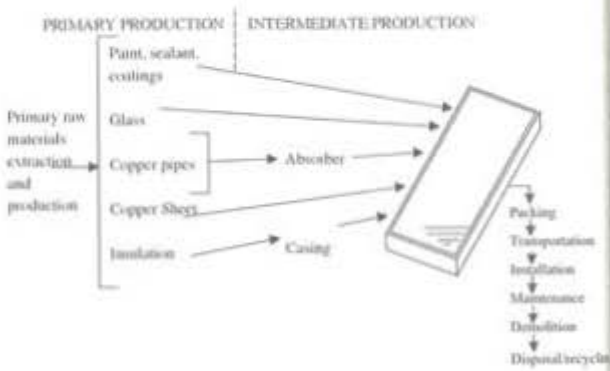

Fig. 2. Factors considered in the calculation of embodied energy of a flat-plate collector

Table 7. Embodied energy content of one flat-plate collector 1.9m^2 in area.

Description	Mass (kg)	Embodied energy index (MJ/kg)	Embodied energy content (MJ)
1.9x1x0.05m insulation	6	117	702
1.9x1x0.005m glass	13.4	15.9	213.3
2m, 22mm copper pipe	2.4	70.6	169.5
20m, 15mm copper pipe	12.4	70.6	875.5
2.3x1.3x0.005m galvanized steel sheet	11.7	34.8	408.4
6m rubber sealant	0.6	110	66
Black paint	0.3	44	13.2
Casing paint	0.9	44	39.6
20 No. screws	0.00125	34.8	Ignored
1.9x1x0.003m copper absorber	5	70.6	353
Total			2840.5
Add 10% for contingencies			284.1
Unit manufacture using a net to gross value of conversion rate of 27%			415.4
Grant Total			**3540**

An analysis of the embodied energy content of a complete solar hot water system is shown in Table 8. It should be noted that only the extra components of the solar system are considered in this analysis as the other components are standard and are also present in the conventional system. As can be seen the total embodied energy for the complete system is 8700 MJ.

Table 8 Embodied energy content for the construction and installation of the complete solar hot water system

Description	Mass (kg)	Embodied energy index (MJ/kg)	Embodied energy content (MJ)
2 No solar panels	-	-	7080
4m, 22mm copper pipe	3.8	70.6	268.3
4m, pipe insulation	1	120	120
Steel frame	30	34.8	1044
Total			8512.3
Installation			187.7
Grant Total			**8700**

The objective of this analysis is to compare the pollution created for the manufacture and installation of the solar systems against its benefits due to the lower emissions realized during the operation of the systems. Therefore, for the life cycle assessment of the systems considered the useful energy supplied by solar energy per year, shown in Table 2, is compared with the total embodied energy of the system shown in Table 8. As can be seen the total energy used in the manufacture and installation of the systems is recouped in about 1.2 years, which is considered as very satisfactory.

The emissions created from total embodied energy for the systems considered are presented in Table 9. Additionally, these emissions are compared with the emissions saved because solar energy is used instead of auxiliary energy, according to the type of fuel used in the various cases of solar systems investigated, in order to estimate the payback period for each pollutant. In all cases the emissions are estimated by considering that all embodied energy was produced from electricity. This is not quite correct but electricity is chosen, as is the most polluting fuel, therefore it gives the worst possible results. As can be seen from Table 9, the payback periods for the cases investigated vary from a few months to 3.7 years according to the fuel and the particular pollutant considered.

Table 9 Pollution created for the construction and installation of the solar hot water system and payback for the two types of backup fuels considered

Emission	Pollution created from solar system embodied energy	Savings and payback of solar system	
		Electricity	Diesel
Carbon dioxide (CO_2)	1.934 Tons	1.582 (1.2)	0.517 (3.7)
Carbon monoxide (CO)	483 g	396 (1.2)	1252 (0.4)
Nitrogen oxides (NO_x)	72.5 g	59 (1.2)	1291 (0.06)
Nitrous oxide (N_2O)	7.3 g	5 (1.5)	6 (1.2)
Methane (CH_4)	12.1 g	9 (1.3)	12 (1.0)
Hydrocarbons	48.3 g	40 (1.2)	51 (0.9)
Sulfur dioxide (SO_2)	725 g	593 (1.2)	630 (1.2)

Notes: 1. Number in parenthesis represent payback in years
2. The units of savings are in g/year except carbon dioxide which is tons/year

Moreover the cost of damage avoided by some of the pollutants is investigated with respect to damages to crops, materials, mortality and morbidity. The results of this analysis are shown in Tables 10 and 11.

Table 10 Typical damage costs per kg of pollution emitted by power plants in Europe (Rabl and Spardaro, 2001)

Pollutant	Impact	Cost
SO_2	Crops, materials, mortality and morbidity	6.33
NO_2	Crops, mortality and morbidity	9.6
VOC (via O3)	Crops, mortality and morbidity	0.54
CO (primary)	Morbidity	0.0012
CO_2	Global warming	0.0174

Notes:
1. Cost in C£/kg
2. Mortality refers to premature deaths
3. Morbidity refers to illness

Table 11 Damage cost avoided per year from some of the pollutants for domestic SWH systems

Pollutant	Amount saved (kg)		Damage cost avoided (C£)	
	Electricity	Diesel	Electricity	Diesel
CO_2	1582	517	27.5	9.0
CO	0.396	1.252	~0	~0
SO_2	0.593	0.630	3.75	3.99
		Totals:	**31.25**	**12.99**

As can be seen about C£31 are avoided per year when the system is using electricity as auxiliary and C£13 when diesel is used for each solar water heating system. Therefore for a more correct analysis of SWH systems the damage cost avoided, shown in Table 11, should be added to the annual fuel savings shown in Table 4. By performing this analysis the pay-back time is reduced to 3.2 and 4.6 years, from 4.2 and 5.4 years (shown in Table 4) for the two types of systems considered, thus there is a further increase in the economic viability of the systems. It is believed by the author that such type of analysis must always be considered in feasibility studies of solar systems.

8. Conclusions

In the present study, the environmental impact of energy utilization has been investigated and the potential benefits that solar systems offer are discussed in detail. From the analysis presented in this paper it can be concluded that the environmental impact of any energy system is an important factor and solar systems have the potential to reduce environmental pollution.

Crucial to discussions on prevention of global climate change are thorough evaluations of the costs of reducing emissions. Many countries through several national and international institutes and agencies have started taking actions to reduce (or eliminate) the pollutant emissions and to attain a sustainable supply of energy. One way to achieve this is by using as much as possible solar energy. This is in compliance with the agreement reached in the December 1997 International Kyoto Conference on climate change,

where a list of fifteen concrete proposals came out for the reduction of global greenhouse gas emissions. The list includes, among others, the use of solar energy.

Additionally, in this study the environmental protection offered by the most widely used renewable energy system, i.e., solar water heating is presented. The results show that by using solar energy considerable amounts of greenhouse polluting gasses are avoided. For the case of domestic water heating system with electricity or diesel backup the saving, compared to a conventional system, is about 80%. Additionally, both systems investigated give positive and very promising financial characteristics. With respect to life cycle assessment of the systems, the energy spent for the manufacture and installation of the solar systems is recouped in about 1.2 years, whereas the payback time with respect to emissions produced from the embodied energy required for the manufacture and installation of the systems varies from a few months to 3.7 years according to the fuel and the particular pollutant considered. Moreover, the cost of damage avoided by some of the pollutants is investigated with respect to damages to crops, materials, mortality and morbidity. It was found that about C£31 are avoided per year when the system is using electricity as auxiliary and C£13 when diesel is used, for each solar water heating system. When these are added to the annual fuel savings very satisfactory pay-back times of 3.2 and 4.6 years, for the two types of systems considered, are obtained.

It can therefore be concluded that solar energy systems are friendlier to the environment and offer significant protection of the environment. The reduction of greenhouse gasses pollution is the main advantage of utilising solar energy. Therefore solar energy systems should be employed whenever possible in order to achieve a sustainable future, thus applying the slogan "THINK GLOBALLY-ACT LOCALLY".

REFERENCES

Alcorn J., 1995. Embodied energy coefficients of building materials. Centre for Building Performance Research. Victoria University of Wellington, New Zealand.

Argiriou A., Klitsikas C., Balaras C. and Asimakopoulos D., 1997. Active solar space heating of residential buildings in northern Hellas-a case study, *Energy and Buildings*, 26(2), pp. 215-221.

Diakoulaki D. Zervos A., Sarafidis J. and Mirasgedis S., 2001.Cost Benefit Analysis for Solar Water Heating Systems, *Energy Conversion and Management*, Vol. 42, No. 14, pp. 1727-1739.

Dincer I., 1998. Energy and environmental impacts: present and future perspectives. *Energy Sources*, 20(4/5), pp. 427-453.

Dincer I., 1999. Environmental impacts of energy, *Energy Policy*, 27(14), pp. 845-854.

Gantner M., 2000. Dynamische Simulation thermischer Solaranlagen, Diploma thesis, Hochschule für Technik Rapperswil (HSR), Switzerland.

Kalogirou S., 2001. Solar Water Heating in Cyprus: Facts and Prospects, *Proceedings of Sharjah Solar Energy Conference Incorporating the Regional World Renewable Energy Congress and the 7th Arab Conference on Solar Energy on CD-ROM*, UAE.

Polysun, 2000.*User's manual for Polysun 3.3*, SPF, Switzerland.

Rabl A. and Spardaro J.V., 2001.The cost of pollution and the benefit of solar energy. In: Gordon J.M. (Ed.) Solar Energy: The state of the Art, ISES, James and James (Science Publishers) Ltd, London, UK, pp. 437-475, Chapter 8.

www.worldwatch.org, 2003.

RECLAMATION OF DISTURBED TERRAIN BY USING WASTEWATER SLUDGE: CYPRUS ASBESTOS MINES

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Abstract:
Disturbed sites like Amiandos(asbestos) mine in Cyprus when appropriately developed and reshaped can be used for a variety of uses. If a revegetation project is to be applied, the lack of fertility of the disturbed terrain is a serious drawback. Various combinations of wastewater sludge and local soil remaining after mining works are to used in order to determine optimized conditions. Sludge which is a valuable soil enrichment resource in combination with the spoil material produced after mining activities, is believed to be effective in the reforestation and revegetation processes. As asbestos control is a complicated and lengthy process, this paper will concentrate on the enriching effect of sludge on the sterile soils of the area.

Key words: Revegetation, reclamation, disturbed terrain, sludge.

Introduction:
The Cyprus asbestos mines are situated in the Troodos Mountains at a height of about 1400m asl. Asbestos occurs in the ultrabasic rocks of the Troodos massif . The ultrabasic rocks have been separately mapped as dunite, enstatite-olivinite, harsburgite-wehrlit and a peridotite-pyroxenite group. The principle minerals occurring in these rocks are olivine,enstatite and diopsidic augite.

The restoration of the Amiandos mining area started in the winter of 1995.The main target of the restoration was the stabilization of the sterile spoils and the modular reforestation of the area.The main aim of the reforestation was the restoration of the local nature to its pre-mine condition which will be harmonic with the general environment of the area. It is therefore necessary to cover the area with productive soil so as trees and bushes can grow which will stabilize the soil on the slopes and reduce exposed asbestos fibers.

Sludge as enrichment material:
The shortage of humus for fertility of a disturbed terrain is a challenge for research in terms of organic enrichment. A short field investigation has been carried out, on which various combinations of wastewater sludge from Vathia Gonia treatment unit in Cyprus together with spoil which resulted after mining works have been mixed in various proportions .Lettuce was selected in this experiment, a sensitive plant which could give quick and useful results.
The characteristics of the sludge used are shown in table1 below. Spoil characteristics are shown in table 2.

N(%)	P(%)	K(%)	O.M (%)	Na (%)	B (p.p.m)	Zn (p.p.m)	Cu (p.p.m)	Cd (p.p.m)	Ni (p.p.m)	Pb (p.p.m)	Cr (p.p.m)	FE (p.p.m)	MN (p.p.m)
3.47	2.0	0.26	67.0	0.35	67	1196	218	3.8	35	67	161	13213	187

Table 1.characteristics of experimental sludge

It was decided to use various combinations of sludge and spoil from the site in order to create a productive cover material. All variants used together with their proportions in percentages by weight are shown in table 3.

The field experiment was carried out in experimental pots holding a 2kg total soil and sludge together, in a four-fold repetition. Initially a close observation of the spoil material-clay (table 2) is necessary and the comments are listed below.

- Ph of clay is 8.3 which means that alkalinity condition prevail and this decreases the concentration of toxic ions in the soil solution and helps the release of more essential nutrients to become available.

- A phosphorous deficiency is evident in the clay material (0.7 parts per million), as well as low levels of Nitrogen and nutrients necessary for plant growth.

- Care should be taken when using only clay, as clay mineralogy influences the degree of compaction that may result after the use of heavy compaction equipment which may be used in the stage of mining and reshaping. There is evidence that compaction may limit plant growth by reducing water infiltration and nutrient release.

Smaller particles expose a larger surface area per unit volume to forces of weathering than coarse fragments. This results in a more rapid release of chemicals during the weathering process.

Table 2 spoil composition - **Spoil characteristics**

N	Parameters	Clay
1	Abs.dry matter %	63,03
2	Ashes %	77,19
3	Ammonium N %	0,003
4	Total N %	0,007
5	Total P2O5 %	0,007
6	Total K2O %	0,05
7	Na %	0,18
8	Mg %	0
9	Ca %	0,051
10	Al %	46
11	Fe %	1
12	Zn mg/kg dry matter	48
13	Cu -"-	10
14	Pb -"-	22
15	Ni -"-	8
16	Co -"-	3
17	Cr -"-	30
18	Mn -"-	503
19	Cd -"-	traces
20	pH	8,3

Sample No.	1	2	3	4	5	6	7	8	9	10
Spoil Content (%)	100	0	100% Spoil irrigate with fertilizer	95	90	85	80	75	50	25
Sludge Content (%)	0	100		5	10	15	20	25	50	75

table 3 proportions of mixing for spoil and sludge

Results and Discussion

Interesting results were obtained as shown in figure 1 below. For each sample the growth pattern is demonstrated. The total growth is found if the initial growth is subtracted from the final growth. The highest growth pattern appears in sample no.7 where a 20 percent sludge was used. Satisfactory growth is shown in all samples where sludge was used. Good results are shown in almost all sludge proportions, with the poor results evident at the no sludge sample no. 1.

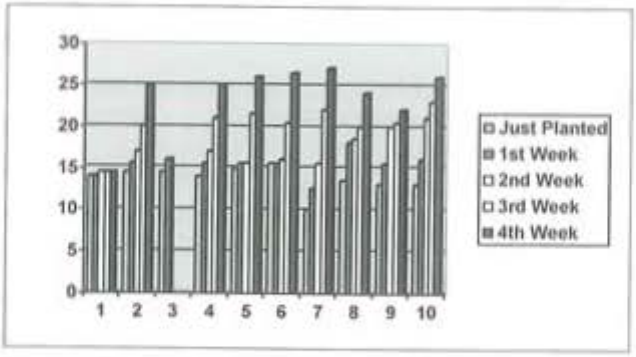

Figure 1.Speciment number against growth in cm

Conclusions

Application of sludge for the enrichment of disturbed sites is considered a feasible sludge disposal method. The experiment performed indicates that the received soil substrates are good medium for the development of plants and can be recommended. Optimal results are demonstrated around the 20 percent sludge quantity.

As our purpose is soil enrichment , an economic analysis will determine the optimal sludge proportions for the selected plants. Groundwater pollution as well as other ecological risk factors as applied and in accordance to EU directives should be considered.

References

[1]. USEPA(1983) Land Application of Municipal Sludge, Municipal Environmental Research Lab Cincinnati

[2]. Crites R W ,Land use of wastewater and sludge, Environ.Sci.Technol. Vol. 18,No 5 1984

[3]. Petrov K. and Kathijotes N., *"Non-conventional water for Irrigation during Drought in Bulgaria"*, Geo Journal Vol.40 No.4 pp 413-419 Dec.1996, Dordrecht/Boston/London

[4]. Petrov K. and Kathijotes, N. ECOLOGIA 96.International Symposium. Burgas Bulgaria Sept.96

[5]. Metcalf and Eddy, INC (1979), Wastewater Engineering: Treatment Disposal Reuse

[6]. Koren Herman, (1980) Handbook of Environmental Health and Safety, Pergamon Press, New York

[7]. LHermut,P., "Treatment and use of sewage sludgeand liquid aricultural waste' 1991 London UK

[8]. Horan, N., "Nutrient removal from wastewaters" 1994 Basel, Switzerland

[9]. Marinova, S., "Annual Scientific Report" Poushkarov Institute,1994, Sofia Bulgaria

DEVELOPMENT OF A MECHANICAL GARBAGE COLLECTOR FROM HIGH-WAY EMBANKMENTS

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Abstract

The sight of garbage filled high-way embankments in Cyprus is appalling and the cost of keeping them clean comparatively high. A proposal was presented to the Research Promotion Foundation for the development of a mechanical garbage collector which will shred/collect the garbage and palletise them. The collector head, arm and hydraulic system, the suction pump system and the storage/palletising trolley were designed, manufactured and tested, and the project was brought to its successful conclusion on time.

Introduction

If one takes a quick look at the embankments, whilst driving on one of the high-ways in Cyprus, will see nothing but a rich variety of garbage, ranging from plastic bags and bottles to soft-drink canisters and cartons, torn tires and occasionally the old TV set or washing machine. The scope of this project was to design and manufacture a prototype garbage collector that will be mounted on, and powered by an agricultural tractor. The project was divided into three stages design, manufacture and testing/modifications. The design stage was undertaken by the Higher Technical Institute (HTI), the manufacturing stage by Lanitis Farm Ltd and the testing/modification stage by both the HTI and Lanitis Farm Ltd.

Design and Manufacture of Collector Modules

The garbage collector modules were defined as shredder/collector head, extendable arm, hydraulic system, suction system and garbage storage system.

Shredder/Collector Head

The collector head was designed to shred any grass growth or plants, paper or plastic bags and at the same time, force/throw them into the suction hose to be dragged into the storage trolley. The main parts of the head assembly included a housing and a steel shaft upon which a series of loose wire-rope spikes were attached along and around the periphery of the shaft. Compression rings were attached, a few centimeters away from the end of the wire-rope spikes, such that on first impact the wire-rope end, below the compression ring, will open up in the form of a steel brush. In so doing each brush covers bigger area for more effective cleaning. Figure 1 shows the collector head assembly.

Figure 1

Extendable Arm

The extendable arm was designed in two sections with three hydraulic pistons, allowing linear and rotational movement of the arm. By considering the diagram in Figure 2 and stress analysis at points of high stress concentration, it was decided to use 70mmx70mm, 3mm thick square section for the construction of the arm. The arm would extend as far as 5m down to the embankment. The arm was placed on the left hand side of the tractor and mounted on a heavy metal plate attached to the lower part of the tractor as shown in Figure 3. This contributed to lowering the centre of gravity of the tractor even further, thus making the whole structure more stable.

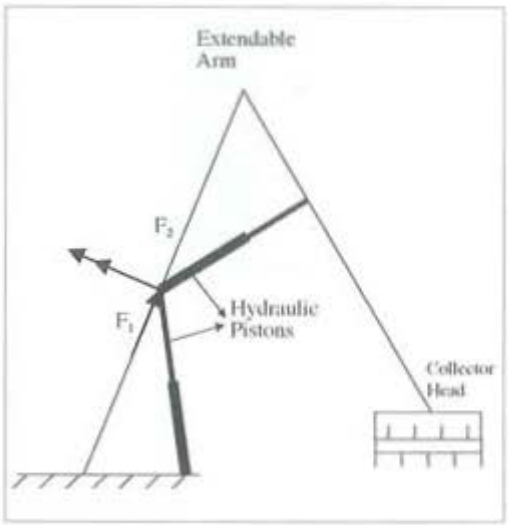

Figure 2

Figure 3

Hydraulic System

The collector head and extendable arm were operated through the tractor's own hydraulic system. A control panel with the required control levers was selected and connected to the hydraulic pump and pistons accordingly. Details of the hydraulic control panel are shown in Figure 4.

Figure 4

Suction System

A suction pump, shown in Figure 5, was selected and a new impeller was designed and manufactured to increase the suction efficiency and at the same time accommodate the impact from metallic objects, stones or jamming by plastic bags, clothing materials, wires and the like. The impeller was balanced in order to avoid vibrations and overloading of the shaft bearings.

A series of pulleys and belts were employed to transmit power from the tractor's rear power take off (P.T.O) axle to the suction pump and increase the speed from 540 r.p.m to 2500 r.p.m. The suction pump was connected to the collector head via a 20 cm diameter, heavy duty, plastic hose which run along the extendable arm as shown in Figure 6.

Figure 5

Figure6

The suction system was assembled to the rear of the tractor and mounted on the storage trolley, as shown in Figures 7 and 8.

Figure 7

Figure 8

Storage System

A storage system was designed to accommodate all the garbage picked up by the collector head and dragged into the storage trolley by the suction pump. A pressure plate connected to a hydraulic piston, compacts the garbage into a pallet, inside the storage compartment. The garbage may be tipped over into a skip and transported to a rubbish-damp. Details of the storage system are shown in Figures 9 and 10.

Figure 9

Figure 10

Testing the Prototype Garbage Collector

The prototype garbage collector was completed, with all the final touches and safety features, ready for testing on the highways. It was taken on site and tested under real-life conditions with very satisfactory results.

Some improvements to the efficiency of the prototype were realised during testing which include the following:

(a) Increase the speed of the suction pump

(b) Reduce the surface area of the inlet on the collector head to the hose

(c) Minimise the cloud of dust generated in the vicinity of the trolley during the summer months.

The first two problems were addressed and some of the design parameters were altered favourably, the third problem requires further work and experimentation and is in the process of being solved.

The Final Prototype

The final prototype was completed and tested on time, meeting the set design specifications. Interest was expressed from private companies, already involved in the cleaning of highways, to purchase the prototype garbage collector. Details of the final prototype are shown in Figures 11 and 12.

Figure 11

Figure 12

THE SWITCHING FUNCTION TECHNIQUE AND THE SEARCH FOR A SWITCHING FUNCTION ALGEBRA

Christos Marouchos

Introduction

This is a brief presentation of the switching function technique as it is applied to analyse Power Electronic circuits. The application of the basic circuit analysis theorems is modified. The presented rules and properties of the switching function might suggest the existence of a Switching Function Algebra.

Power Electronic systems include the UPS, Frequency changers and rectifiers. Rectifiers are the essential part of a power supply found in any electronic equipment such as the computer. The switching function is a new tool employed to analyse Power Electronic systems. It was first suggested in 1981 and it was used about the same time quite independently to analyse a new circuit configuration[2]. It is now presented in a new book to be published by the IEE Publishing[3] in 2005 where it is extensively used to analyse all types of power electronic circuits.

The standard approach applied so far to derive the mathematical model of a power electronic converter is usually done in terms of its modes or states. Because of its switching nature the circuit changes configurations. These are the modes of the circuit and a set of differential equations describing the circuit in each mode is derived. The linking parameter between modes is usually a variable such as a voltage or a current or both. These equations are solved for each state and then linked together: the final value of a variable within a mode is the initial value in the next mode. The solution is repeated until the initial and final value is the same within a mode. This is the steady state of the circuit and it might take many cycles until steady state is reached. One might speed up things by setting appropriate non-zero initial values for certain key variables.

The switching function technique is applied in a different way. It attempts to derive analytical expressions that represent the voltages and currents at all times and for the circuit as a whole, not only for a single mode. At the moment the effort is concentrated for the steady state but the transient response cannot be excluded in the future. In analysing many well- known circuits[3] with this new technique a procedure has evolved and a number of rules seem to apply.

The switching function

For the application of the switching function technique, a Switching Function is defined. It is a signal which takes the value of "zero" or "one" thus representing the on and off state of a semiconductor switch. A semiconductor switch such as a diode or a power transistor operating in a regular manner, is acting as an amplitude modulator. Its switching action is defined by a mathematical expression F(t) that is a series of pulses representing the periods that the switch is on and off. This is the unipolar switching function and it can be used to derive other switching functions for more complex switching patterns such as the one operating on the bridge configuration, poly-phase systems and the PWM signals.

The switching function is a statement of the time instances that both the input and output of a switch or a switch configuration are the same; the input is reflected to the output. The switching function relates the input to the output in a similar way that the transfer function relates input to output in control systems. Hence:

$$OUTPUT(t) = INPUT(t)\, F(t)$$

Definition of the unipolar switching function

Consider the simple circuit below, Fig.1 where a voltage source, V(t) is connected on the LHS of the semiconductor switch. The voltage on the right of the switch will take the value of the input voltage, V(t), when the switch is closed. When the switch is open, the output voltage is zero. If the state of the closed switch is attributed the logic value of 1 and the state of the open switch the logic value of zero then a function of time, F(t), can be defined as:

F(t) = 1 switch open $t_1 < t < t_2$ $V_{AB}(t) = V(t)$

F(t) = 0 switch open $t_2 < t < t_3$ $V_{AB}(t) = 0$

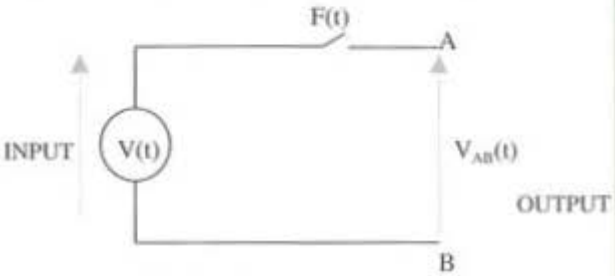

Fig.1 Definitionof the switching function

The period of the switching function is t_3-t_1 and the switching frequency, f_s, is $\frac{1}{t_3-t_1}$.

F(t) is a pulse-function as shown in Fig.2 and it can be expressed by a sum of sinusoids according to the Fourier series as

$$F(t) = K_o + 2\sum_{n=1} K_n \cos(n\omega t - \theta n) \qquad (1)$$

n is an integer number

K_o = duty cycle of the switch

$K_n = \frac{\sin(n\delta)}{n\pi}$

$\delta = (t_2 - t_1) / 2$ half the on period of the switch

ω = switching frequency, $2\pi f_s$

θ = the phase angle of the switching function relative a reference

This switching function is termed *unipolar* because it takes only positive values. It is a series of pulses of unit magnitude and pulse width 2δ, at a switching frequency **w** phase displaced by θ relative to a reference, Fig.2. This switching function describes the basic repetitive action of the semiconductor switch.

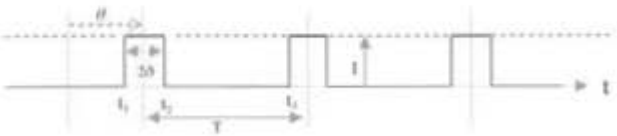

Fig.2.The basic switching function

The voltage on the RHS of the switch, $V_{AB}(t)$, is given by

$$V_{AB}(t) = F(t)\, V(t) \qquad (2)$$

Expression (2) above implies amplitude modulation.

Superposition Theorem in Switched circuits

The Superposition Theorem allows the calculation of voltage across two points in a circuit with multiple voltage sources. Here we will see how it is applied in a switched circuit. Consider the circuit in Fig.3 where N number of voltages sources are supplying a single load connected across AB. At the moment lets consider zero source impedance and no overlap of the switching functions; no two switches are closed at the same time, hence

$$\sum_{n=1}^{N} F_{N(t)} \leq 1$$

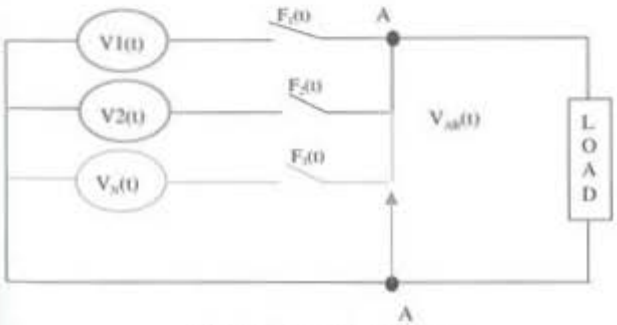

Fig. 3. Superposition Theorem

Every voltage source contributes to the output voltage, $V_{AB}(t)$ during the period that the series switch is closed. Expression 2 above gives the voltage across AB during the on period of a single switching function

$$V_{ABn}(t) = F_n(t)\, V_n(t) \qquad \text{Where n indicates the } n^{th} \text{ switch.}$$

Hence the contributions of all the voltage sources make up the output voltage $V_{AB}(t)$. This is also demonstrated graphically in Fig.4

$$V_{AB}(t) = F_1(t)\, V_1(t) + F_2(t)\, V_2(t) + \ldots\ldots\ldots F_N(t)\, V_N(t)$$

$$V_{AB}(t) = \sum_{n=1}^{N} F_n(t)\, V_n(t) \qquad (3)$$

In applying the above formula care must be taken that the on–periods of all the switching functions sum up to give the *period* of the circuit. The *period* of the circuit is the time taken for the *mode sequence* of the circuit to be completed[3].

The condition $\sum_{n=1}^{N} F_n(t) \leq 1$ implies no overlap otherwise the Kirchoff's laws are violated in the absence of source impedance. In the presence of source impedance more than one switch can be closed. In that event, the mode of the circuit under overlap is derived and the appropriate switching is defined.

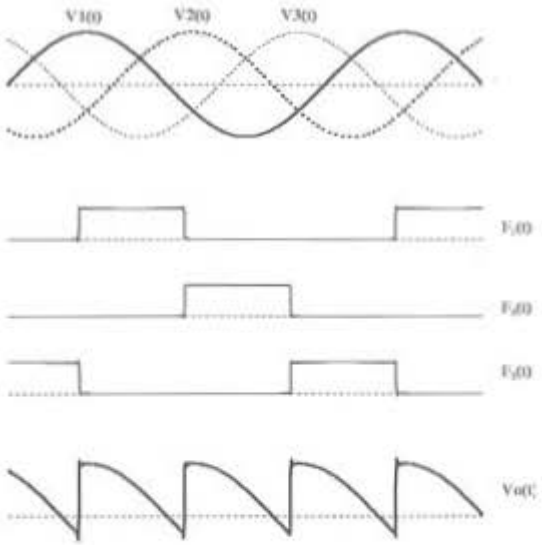

Fig.4. Superposition Theorem in switched circuits

Kirchoff's Current Law

The textbook definition of the Kirchoff's law of current or the junction theorem, states *that the sum of the currents into a specific junction in the circuit equals the sum of the currents out of the same junction. Electric charge is conserved: it does not suddenly appear or disappear; it does not pile up at one point and thin out at another.*

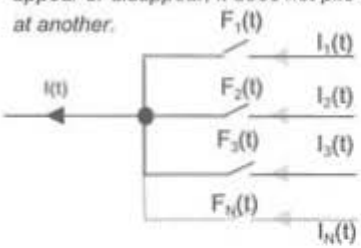

Fig. 5.
Kirchoff's Current Law: Circuit diagram.

For a switched circuit the junction theorem is applied in a slightly different way. Consider the circuit in Fig.5 where N switched branches contribute current to a junction. At the moment lets consider no overlap of the switching functions, thus implying that no two switches are closed at the same time, hence

$$\sum_{n=1}^{N} F_n(t) \leq 1$$

Each switched branch contributes to the junction; during the on period of a specific Switching Function, Fig.6, the current is given by $I(t) = Fn(t)In(t)$

Hence the current I(t) at all times is given by

$$I(t) = \sum_{n=1}^{N} I_n(t)\, F_n(t) \qquad (4)$$

In applying the above formula care must be taken that the on–periods of the switching functions sum up to give the period of the circuit. The period of the circuit is the time taken for the mode sequence of the circuit to be completed[3].

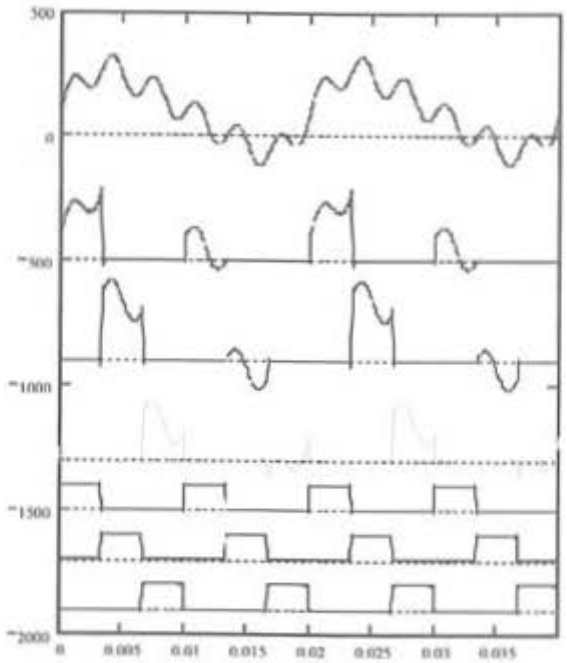

Fig.6 Kirchoff's Current Law: Time waveforms

Kirchoff's Law of Voltage

The second rule, the loop equation, states that around each loop in an electric circuit the sum of the emf 's (electromotive forces, or voltages, of energy sources such as batteries and generators) is equal to the sum of the potential drops, or voltages across each of the impedances, in the same loop.

Application of the Kirchoff's Law of Voltage to Fig.7 gives the loop equation

$$V_{in}(t) = I(t)\, Z_{(wn)} + V_{SW}(t)$$

The challenge is to express the voltage across the switched circuit, $V_{SW}(t)$ in a single expression which is valid at all times. This voltage is shaped by the action of the switches and Superposition Theorem as explained above can be applied to derive it; a procedure is outlined in reference[3].

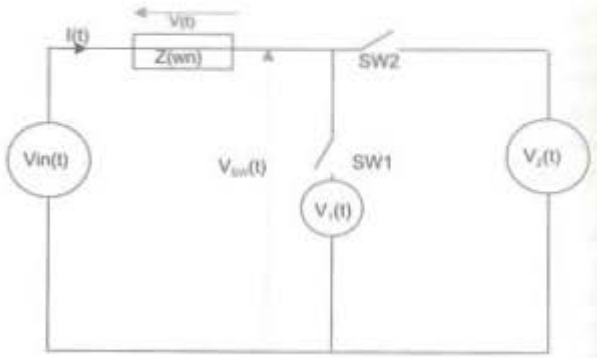

Fig.7 Kirchoff's law of voltage

In Fig.7, the two switching functions are working in anti-parallel. This is necessary in order to avoid short-circuiting the two voltage sources.

$$F_{SW1}(t) = 1 - F_{SW2}(t)$$

According to superposition established above

$$V_{SW}(t) = V1(t)\, F_{SW1}(t) + V2(t)\, F_{SW2}(t)$$

$$V_{in}(t) = I(t)\, Z_{(wn)} + V1(t)\, F_{SW1}(t) + V2(t)\, F_{SW2}(t) \qquad (5)$$

The application of the switching function for the Kirchoff's laws and the superposition theorem works fine for the steady state analysis. The application for the transient response remains to be investigated. Any ideas?

The square of the unipolar switching function

The square of the unipolar switching function is encountered a few times in applying the technique. The square of the switching function is given by raising every point of the waveform of Fig.1 to the square. It is obvious from the same figure that if every point of F(t) is raised to the square, it will give exactly the same shape, hence:

$$F(t)^2 = F(t) \qquad (6)$$

By replacing with Expression 1

$$\left[Ko + 2\sum_{n=1}^{\infty} K_n \cos(n\omega t - \theta{\cdot}n)\right]^2 = Ko + 2\sum_{n=1}^{\infty} K_n \cos(n\omega t - \theta{\cdot}n)$$

The proof of the above expression demands expanding the LHS of Expression 1 and equating LHS and RHS. A tedious task!! Is there a more elegant way to prove it?

The inverse of the unipolar switching function, $\overline{F(t)}$

By definition the inverse of the unipolar switching function, $\overline{F(t)}$ is a new function that represents the off periods of the switching function. In other words, the function $\overline{F(t)}$ takes the magnitude one when F(t) is zero. With reference to Fig.8 this function is 1-F(t)

$$\overline{F(t)} = 1 - F(t) \qquad (7)$$

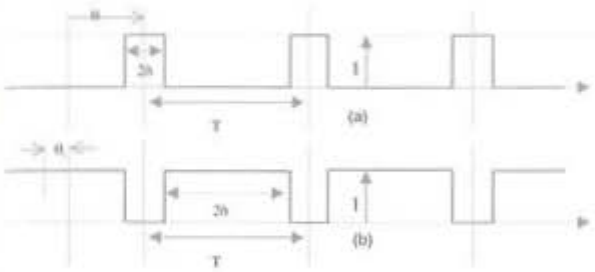

Fig.8 The unipolar switching function (a) and its inverse (b)

Replacing Expression 1 in $\overline{F(t)} = 1-F(t)$ we have

$$Ko + 2\sum_{n=1}^{\infty}\frac{\sin(n\delta)}{n\pi}\cos(n\omega t - \theta^*n) = 1 - Ko - 2\sum_{n=1}^{\infty}\cos(n\omega t - \theta^*n)$$

Recognizing that the inverse function has a pulse-width T- Δ, and a phase θi, we have

$$1 - Ko - 2\sum_{n=1}^{\infty}\frac{\sin(n\delta)}{n\pi}\cos(n\omega t - \theta^*n) = 1 - Ko - 2\sum_{n=1}^{\infty}\frac{\sin[n(T-\delta)]}{n\pi}\cos(n\omega t - \theta^*n)$$

$\theta_i = \theta + T/2$

Expanding both sides and collecting terms should verify the equality. A tedious task!! Is there a more elegant way to prove it?

The voltage reflection equation

In many power electronic circuits a capacitor is present, Fig.9 The stored energy on the capacitor gives rise to a voltage, ac or dc depending on the circuit. This voltage appears modulated on the other side of the switch or switching arrangement. It is modulated by the switching function of the switch or the switching function arrangement. In all cases the switched capacitor and the switching arrangement is fed from the voltage source by an impedance, usually an inductor. The series inductor limits the current flowing and to a large extent sets the magnitude of the flowing current. This has let to the introduction of the "constant current source" concept to replace the voltage source and the series inductor. This approach is not adopted by the switching function. First we consider a single branch, Fig.9a. The current through the n^{th} capacitor is given by

$$I_{Cn}(t) = F_n(t)\ I(t)$$

The voltage across the n^{th} capacitor

$$V_{Cn}(t) = \frac{1}{C}\int F_n(t)\ I(t)\ dt$$

The reflection of the n^{th} capacitor voltage across AB

$$V_{ABn}(t) = F_n(t) * V_{Cn}(t)$$

$$V_{ABn}(t) = F_n(t)\ \frac{1}{C}\int F_n(t)\ I(t)\ dt$$

Now we consider the N branches, Fig.9b. The switching functions have no overlap and no dead periods.

$$\sum_{n=1}^{n} F_n(t) = 1$$

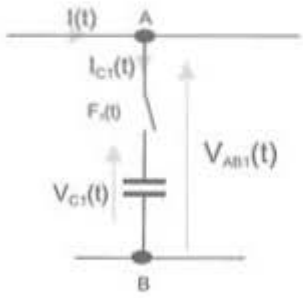

Fig.9a

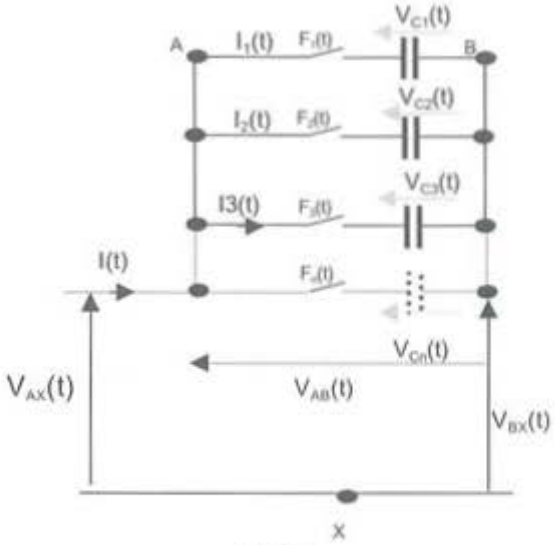

Fig.9 b

Contribution of the N capacitors to the voltage across AB, VAB(t)

$$V_{AB}(t) = \sum_{n=1}^{n} F_n(t)\ \frac{1}{C}\int F_n(t)\ I(t)\ dt \qquad (8)$$

Fig.10 presents a number of power electronic circuits where voltage reflection takes place. In the case of the dc to dc converter the input loop expression is

$$V = L\frac{dI(T)}{dt} + [1 - F_n(t)]\ \frac{1}{C}\int [1 - F_n(t)]\ I(t)\ dt \qquad (9a)$$

In the switched capacitor filter case the input loop expression is

$$Vp\ \sin\omega t = L\frac{dI(T)}{dt} + \sum_{n=1}^{n} F_n(t)\ \frac{1}{C}\int F_n(t)\ I(t)\ dt \qquad (10a)$$

In both cases the only unknown is the current I(t) which is of the form

$$I(t) = I_{dc} + \sum_{k=1}^{n} I_k \cos(k\omega t + \theta_k)$$

$I_{dc} = 0$ for the ac circuit

Solution of Expressions (9a) and (10a) is not simple. It is simplified though by approximating the capacitor voltage $\frac{1}{C} \int F_n(t)\, I(t)\, dt$ to the dominant component. The rest of the components, the ripple voltage, is ignored at the moment. In the dc to dc converter the dominant component is the dc component, hence Expression (9a) is re-written as

$$V = L\, d[I(t)] / dt + [1 - F_n(t)]\, V_{dco} \qquad (9b)$$

The dc component Vdco is derived directly by equating dc the components on both sides. The current is derived by equating the ac components on both sides.

In the switched capacitor filter circuit the dominant component is the source frequency hence Expression (10a) is written as

$$V_p \sin wt = L\, d\, I(t)/ dt + \sum F_n(t)\, V_{c1} \sin(wt - A_n) \qquad (10b)$$

Grammer's rule is employed to calculate the current I(t).

The ripple component of the capacitor voltage is derived by considering the current through it, $F_n(t)\ I(t)$ or $[1-F_n(t)]\ I(t)$ and integrating. This is an approximate method that works fine for most practical cases. A more accurate solution of expression 9a and 10a would be welcomed. Any suggestions?

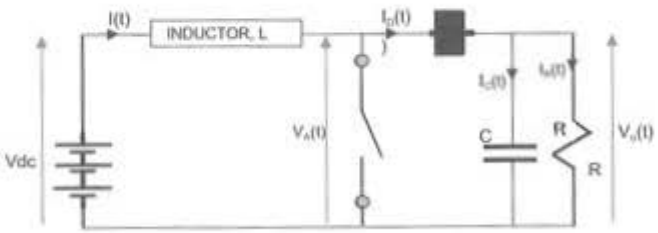

Fig.10a Voltage reflection: The dc to dc step up converter

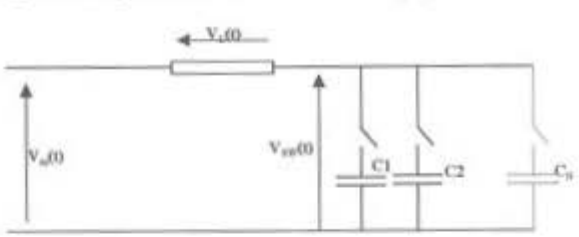

Fig.10b. Voltage reflection: The switched capacitor filter

Fig.10c Voltage reflection: The dc to ac converter / inverter

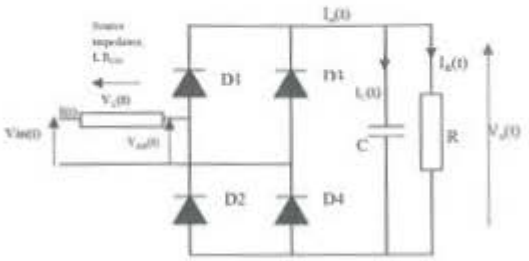

Fig.10d Voltage reflection: The dc to ac converter

The PWM expression

The switching function is employed in reference 3 to derive compact expression for a pulse width modulated (PWM) signa The fundamental frequency is w and it is the desired outp frequency for an inverter circuit. The carrier or switching frequen is mw. A display of the frequency spectrum is shown in Fig.1 and as shown the desired output component, w, is accompani by undesired band of frequencies centred at mw and its multiple

$$mw \pm 2w,\ 2mw \pm w,\ 3mw \pm s2w.$$

The PWM signal is given by

$$F_{pwm}B(t) = \sum \sum Kn \cos[nwt - n\,(\theta - \frac{T}{2})] \qquad (1$$

$$Kn = \frac{\sin(n\delta)}{n\pi}$$

$$\delta = \{\cos[(k-1)T] - \cos(kT)\}D + \frac{T}{4}$$

$$\theta = Tk - \frac{T}{4}$$

The magnitude of each harmonic component, Expression (12), i given by expanding Expression (11). P gives the order of th desired frequency component. Fig.11 is the frequency spectru of the PWM signal derived from Expression (12). The fact tha the desired frequency w is separated from the undesired frequenc components by almost *mw* makes the use of the PWM signal attractive in Power Electronic signals. Nevertheless there is n mathematical prove to show that this is happening. Such a proc will satisfy the academic curiosity: starting from Expression 11 t prove that the other frequency components are actually of zer magnitude.

$$FpwmBAS(P) := 4 \cdot \sum_{n=1}^{n} \sum_{m=1}^{r} \left[\frac{\sin\left[n \cdot \left[\frac{1}{2} \cdot \left[\cos\left[(k-1) \cdot T \right] - \cos(k \cdot T) \right] \cdot D + \frac{T}{4} \right] \right]}{n \cdot \pi} \cdot \sin(n \cdot T \cdot k - T) \right]$$

$$FpwmBAS(P) := 4 \cdot \sum_{n=1}^{n} \sum_{m=1}^{r} \left[\frac{\sin\left[n \cdot \left[\frac{1}{2} \cdot \left[\cos\left[(k-1) \cdot T \right] - \cos(k \cdot T) \right] \cdot D + \frac{T}{4} \right] \right]}{n \cdot \pi} \cdot \cos(n \cdot T \cdot k - T) \right]$$

$$Magn(P) := \sqrt{FpwmBAS(P)^2 + FpwmBAC(P)^2}$$

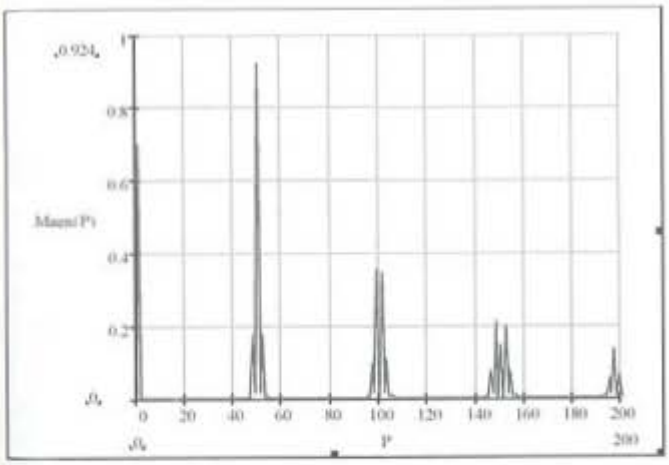

Fig.11. The frequency spectrum of a PWM signal coding a 50Hz sinwave.

Extraction of single components

The switching function itself is a sum of a series of cosine terms.

$$F(t) = Ko + 2\sum_{n=1}^{\infty} Kn \cos(n\omega t - n\theta)$$

Voltage and current quantities within the power electronic circuit are expressed in the same way.

$$I(t) = \sum_{k=1}^{\infty} Ik \cos(k\omega t - \theta k)$$

In applying the switching function technique complex expressions of voltage or current are derived containing multiple sums of sinusoids.

$$[\sum_{k=1}^{\infty} Ik \cos(k\omega t - \theta k)] \; [Ko + 2\sum_{n=1}^{\infty} Kn \cos(n\omega t - n\theta)]$$

This is a typical product and it is advisable for the user of the technique to equip himself with the necessary trigonometrical identities. The resulting expressions for voltage and current are more cumbersome. For example

$$I(t) := \sum_{n=1}^{n} \sum_{m=1}^{r} 4 \cdot \frac{Vp \cdot \frac{\sin(n \cdot \delta)}{n \cdot \pi} \cdot \frac{\sin(m \cdot \delta)}{m \cdot \pi}}{\sqrt{R^2 + [w \cdot (n+1) \cdot L]^2}} \cdot \sin\left[(n+m+1) \cdot w \cdot t - (n+m) \cdot \gamma - \operatorname{atan}\left[w \cdot \frac{(n+1) \cdot L}{R} \right] \right]$$

It is necessary to identify the single frequency components from the above expression. This is done by introducing a new variable P to replace the coefficient of w, n+m+1. One of the counter variables n or m is expressed as a function of P and m or n. Deeper investigation into that point might suggest a more elegant way to do it.

Discussion

The Switching Function technique for the analysis of power electronic circuits is discussed in this report. The switching function technique enables the application of the Kirchoff's laws and the Superposition theorems in power electronic circuits in order to derive expressions of voltage and current. These expressions are valid at all times and they contain the sum of series of terms and the product of such series.

In applying the technique, certain properties of the switching function are easily identified. These refer to the square and the inverse of the switching function. These properties are easily verified from the graphical presentation of the original function and derived function. A rigorous proof though of these properties remains to be found.

The voltage reflection equation is presented and the approximate solution explained. Still a more exact solution is required.

References

1.Switching Power Converters, Peter Wood, Van Nostrand Reinhold Co, 1981

2. Switched Capacitor circuits, PhD thesis Brunel University 1982, CC Marouchos

3. The Switching Function: Analysis of Power Electronic Circuits, Dr CC Marouchos, IEE Publishing Co, 2005.

EVOLUTION OF STANDARDS FOR LENGTH MEASUREMENTS

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From our beginnings as creatures, we have struggled to harness our natural resources and know how much we had. We almost instinctively created systems of measurement, using body parts for length standards, for example, to answer this vital question. As we created cities and governments, we needed better refined standards for manufacturing and bartering with other cultures. After all, not everyone's forearm, for example, is the same length. The ruler of a certain city or state would usually eliminate conflict by choosing his own body parts as the standards. In the process, he or she vested the responsibility for determining measurement standards in the state. Even today, differences in measurement standards can create conflict among nations: for example, during the World Wars, some parts manufactured for military systems designed jointly by the United States and England would not fit because of the different measurement standards used.

Figure 1. The Egyptian cubit shows recognition of metrology fundamentals that still apply today. The unit of length was the Pharaoh's forearm. The standard was the royal cubit and to this standard, the working cubits were added.

The earliest recorded standard is the Egyptian cubit, Figure 1. The Egyptians were very serious about ensuring that everyone was using the same measurement standard. Failure to calibrate the working cubit to the royal cubit at each full moon was punishable by death. But wonders of Egyptian architecture like the pyramids could not have been built without their strictly enforced system of measurement.

As use of the cubit spread throughout the ancient world, each culture modified the standard. The historical use of the cubit and its parallel measurements are not directly related, however. Whenever man has developed civilization, we have created a measuring system, and these systems have always been very similar. For example, the ancient Roman ounce and modern English ounce are nearly identical.

So we can see the similarity between the cubit of Ramese_s II (1324-1258 B.C) and the English yard of King Henry I (1068-1135). In about 1130 A.D., Henry established the distance from his nose to the tip of his thumb when his arm was extended as a standard unit of length, the iron ulna. Of course, other cultures had used this body length as a measurement, but making the English yard a standard was a major advance in the Dark Ages. Around the same time, the inch, defined as one thumb-breadth, and the foot, were commonly in use. It sounds funny today, but in the sixteenth century, the English rod was defined as the combined lengths of the left feet of the first sixteen men to leave church on a particular Sund

Each culture creates its own standards for measurement, t these measurements do not necessarily convert easily – ev among measurement systems of the same culture. The discrepancies allowed "sharp operators" to take unf advantage of customers and allowed rulers to use overgenero measures when collecting taxes.

Our inch-pound system is based on traditional Engli standards, but this system has had its problems, too. Duri the late eighteenth century, the English commonly used least three different "miles" and two units for subdivision Eventually, the English adopted the Imperial Standard Ya as the basis for all linear measurement. Unfortunately, th original standard was destroyed by the House of Parliamen fire in 1834. When the new one was constructed, it was slight different from the original.

The example of the Imperial Standard Yard demonstrates th two axioms of metrology. First, in order to measure there mus be a standard; second, that standard must be reproducible

ORIGIN OF THE METRIC SYSTEM

Abuses of measurement were among the causes of the Frenc Revolution, so the French Republicans addressed the problem of standardizing measurement early in setting up the new government. In 1790, they established the meter: the distance between the North Pole and the Equator passing through Paris, divided into ten million parts. But the Earth is difficul to use as a standard of length, so a metal standard, the Mete of the Archives, was made and adopted as the official standard in 1799. The Republicans also set up new units for mass and time.

It was hard for the people to get used to 110-day weeks and days divided into 10 hours of 100 minutes each. They were even more reluctant to buy produce in 10s and 20s instead of dozens. Despite the beheading of Antoine L. Lavoisier (1743-1794), the principal member of the Metric Committee, the new metric system was enforced. By 1799, the metric system was so unpopular that Napoleon Bonaparte I (1769-1821) won popular support by relaxing metric regulations and finally permitting old standards to be used again in 1812. The metric system, however, remained the legal standard of France.

In 1870, the first of a series of international conferences to establish the metric system worldwide was held, with 48 delegates representing 25 countries, including France. In 1889, a general conference in Paris approved the work of the committee. Thirty prototype meters and 40 prototype kilograms were constructed of a platinum-iridium alloy and calibrated

with each other. The one new standard most nearly equal to the Meter of the Archives was selected as the International Prototype Meter, and it is now located at the International Bureau of Weights and Measures near Paris.

The remaining 29 prototypes were distributed and became the national standards of the participating countries. Periodically, they are returned to the International Bureau for checking. This plan might have created an accepted international standard, but each country had its own interpretation of the metric system. In 1960, the metric system was revised world-wide, and the system was renamed to distinguish it from the other metric systems. Its new name: Le Systeme International d' Unites, abbreviated SI. As with all measurement systems, the people using it are still adapting it, identifying problem areas, and revising the standards. The terms, symbols, and abbreviations used in SI, summarized in Figure 2, were established by an international committee and adopted by the National Bureau of Standards. Because "s" is the SI symbol for "second", plural terms are not used.

As with all forms of language, the terminology of SI has its own quirks. For example, many of the units are derived from the names of famous scientists, but these units are not capitalized. As we become familiar with and use these terms, their conventions will come easily to us.

SI PREFIXES					
Factor	Prefix	Symbol	Factor	Prefix	Symbol
1024	yotta	Y	10-1	deci	d
1021	zetta	Z	10-2	centi	c
1018	exa	E	10-3	milli	m
1015	peta	P	10-6	micro	μ
1012	tera	T	10-9	mano	n
109	giga	G	10-12	pico	p
106	mega	M	10-15	femto	f
103	kilo	k	10-18	atto	a
102	hecto	h	10-21	zepto	z
101	deka	da	10-24	yocto	y

Figure 2. These are the prefixes used in SI to show magnitude. A centimeter, for example, is one-hundredth of a meter.

LEGALITY OF THE METRIC SYSTEM IN THE UNITED STATES

The early measurement standard established for the United States by Congress was an 82-inch brass bar that was prepared in London. This standard was brought to the United States in 1813, and it defined the "yard" as the distance between its 28th- and 64th inch graduations. In 1866, an act of Congress legalized the use of the metric system but did not make its use mandatory. This act also established the ratios between corresponding units of the measurement systems in the United States and the metric system; for example, the "yard" was defined as 3600/3937 meter. When the metric standards were created, the United States received two, Numbers 27 and 21, which were received in 1890. Three years later, Congress passed the Mendenhall Act, which established the metric International Prototype Meter as the legal standard and standardized its relationship to the yard. However, the Mendenhall Act did not specifically legalize the inch-pound system that was popularly in use. So the United States has a legal system of measurement not widely used and a popular system that never has been legalized.

THE INTERNATIONAL INCH

Popular measurement systems are also revised as governments change. The Mendenhall Act defined the United States inch as 25.4000508 mm, but the British Imperial Standard Inch was 25.399978mm. In 1922, the British revised their standard to 25.399956 mm, increasing the discrepancy between measurements made in United States and Great Britain. In 1951, Canada also revised their inch to exactly 25.4 mm. So, at one time, there were three "inches" commonly in use.

The three "inches" were reconciled to each other in 1959, when all three governments agreed that one "international" inch would equal 25.4mm. It was accepted by general agreement but without specific Congressional legislation.

Soon afterwards, light waves, a consistent, natural phenomenon, replaced metal bars, which were man-made, in the measurement of international standards. Scientists have started working on using light for standards back in 1892, but light waves were not accepted as the basis for standards until 1960. Light waves allow greater precision in measurement and work well for any measurement system.

FUNDAMENTAL CRITERIA

In order to evaluate possible measurement systems, we must understand as much as possible about each system and be as unbiased as possible.

- NATURALNESS OF THE SYSTEMS

By now, you should be able to recognize that any measurement system is an arbitrary invention of man: Nature has no need for quantitative measurement. Even if a system is based on a natural phenomenon, such as the length of a forearm or the distance from pole to equator, practical application will compromise the pure, theoretical accuracy of the measurement system.

In addition, the subdivision of measurement standards is arbitrary. We may have ten digits on both hands, but dividing a measurement into ten sections is not necessarily a "natural" thing. By now, most of us think that it is natural to have a day of 24 hours, an hour of 60 minutes, a minute of 60 seconds, and so forth. But remember the French Republicans and their ten-hour day. The dozen and gross are used extensively in trade, but they are measurement standards that can be subdivided easily into a variety of smaller packages to meet the needs of a world of customers.

- ECONOMIC CONSIDERATIONS

In the past, manufacturers have argued that it was too expensive to completely overhaul their facilities for a new measurement standard. Machines, tools, and manuals were replaced only when the old equipment was obsolete.

Today, however, manufacturers are competing in a global economy. For example, parts manufactured in the Far East must be also to fit precisely with parts made in Europe, and these parts must be able to be replaced by parts made in the United States Manufacturers must recognize international demands and adapt manufacturing processes to the accepted standards of the global economy.

- EITHER/OR REASONING

Throughout this text, you will notice that we notate measurements in both SI and inch terminology. Some people would demand that we use just one system of measurement in the text, in manufacturing, and throughout the world-either English or SI.

In addition, some people demand that we completely convert our entire notation of fractions to decimal. But people are accustomed to speaking in fractions – a Frenchman will order a half-liter of wine, not 500cc-and the use of fractions does not hinder our understanding of the measurement. In computing, decimals provide the highest precision; In communication, inch-based fractions create the clearest picture of the measurement for most people.

It is the conversion of measurements between systems that can cause confusion: Thomas A. Edison (1847-1931) created a 1-3/8 in. (34.925mm) standard for film - a standard that was misnamed 35mm. As long as metrologists have a thorough understanding of conversion methods and their implications to precision and quality assurance, there is no reason why we cannot accommodate the use of both systems of measurement.

THE BEST SYSTEM

At this point, we can safely say that the "best" system of measurement depends on what is being measured, what use the measurement has, whether scientific, commercial, or cultural, and the audience that must understand the results of the measurement process. We must use the measurement system that helps other people understand the goals that we are trying to accomplish-the goals that created the need to measure in the first place.

PRACTICAL CRITERIA

Every step in the measurement process is potentially a source of error. To achieve the most precise and reliable measurement possible, you must choose the measurement system that requires the fewest steps, from instrument selection to the final computations made with your results. To determine the best system of measurement, we use three factors:

1. Metrological factor – which act of measurement will yiel useable results.

2. Computational factor – which system yields figures that w can use mathematically.

3. Communicative factor – which system makes it easiest fo us to share the measurement with other people.

In turn, each of these factors must be evaluated by four subcriteria, whether the systems provide:

1. Maximum measurement potential
2. Minimum time required
3. Minimum error potential
4. Minimum cost incurred

Metrologically, both the metric and inch systems can handle extremely large measurements and very fine measurements. We use similar instruments in both systems; they require about the same time to operate; and they are subject to the same errors. However, as a cost consideration, the inch system requires two sets of scaled instruments: one for fractional measurements and one for decimal-inch measurements.

In computational, the metric system's increments are uniform, whereas the inch system must be converted among different terms (inch, foot, yard, rod, mile) that are not systematically related. Clearly, converting among distances in the same measurement system is easier in metric terminology.

In terms of communication, the inch system is easier for most Americans to immediately comprehend than the metric system. Years of experience with inches, feet, yards, and so forth, give us the mental references we need to easily understand a measurement. We can learn the same mental references for metric, but only through the consistent, practical application of this measurement system in daily life.

Again, your choice of measurement system comes down to what you are measuring, what you are going to do with the measurements, and who you are measuring for. It is easier for scientists to express the vast distances between stars or the minute space between atoms in metric terms. But scientists also still use the term "horsepower", which is based on the English inch system. Similarly, most screws threads are still stated in inch or "soft metric" terms, even if they are sold as "metric" screws; and, in 1961, Japanese officials had to pass a law forbidding the calibration of speedometers in miles per hour, even though the metric system had been enforced for thirty years.

THE DECIMAL-INCH SYSTEM

In order to try to eliminate some of the computational problems with the inch system, the decimal inch system was created. It is not such a new idea because the decimal foot was used

in surveying in the United States before 1856. In fact, until the Civil War, 1/64 in. was the smallest standard measurement used in practical work; thousandths of an inch were nothing more than theories.

The decimal-inch system made its first major breakthrough into popular use when, in 1930, the Ford Motor Company adopted it, followed quickly by the aircraft industry. The Society of Automotive Engineers (SAE) published a complete decimal-inch dimensioning manual in 1946. Thirteen years later, the American Standards Association (ASA) and the Society of Manufacturing Engineers (SME) chose to jointly urge greater use of the decimal inch, proposing an American Standard for the definition and use of the decimal inch.

METROLOGICAL CONSIDERATIONS

As we said earlier in this chapter, your eye can see light through a crack as small as 2.54 _m (0.0001 in.) However, when light goes through a crack, it creates a contrast between the dark sides and the light coming through. Your eye would be less accurate if you were trying to read the same division – a small black mark – on a metal ruler.

In Figure 3, you can see the relationship among inch, metric, and decimal- inch rulers. You can also see how difficult it might be to accurately read a measurement, especially if the distance fell somewhere between marks. So, if you are trying to measure with a ruler, the traditional inch ruler is hard to read because of the variety of fractional marks; the metric ruler's divisions are either too large to be useful or too small to be read easily by the unaided eye. Users have a tendency to round to a mark too often with the decimal-inch ruler. Obviously, to make precise, find measurements, you need a different kind of instrument.

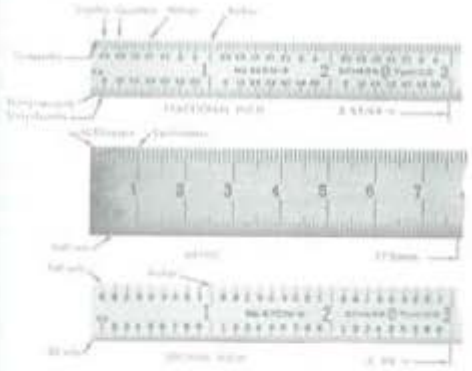

Figure 3. The decimal-inch readings provide nearly the precision of the fractional-inch scale and the simplicity of the metric scale. Steel rules with both scales are available.

COMMUNICATIONS CONSIDERATIONS

The usefulness of any measurement depends in part on your ability to communicate your results to other people. You must be familiar with the terminology of all the measurement systems commonly used today so that you can understand what others are telling you and so that others can understand what you are telling them.

Like all language, some of the terms used in measurement make sense, and others have no logical explanation. "Foot" is derived from the body part used originally to measure it, but "inch" does not have a similar correlation.

The prefixes used with the arbitrary term "meter" are derived from the languages of ancient Greece and Rome, as are the terms used in the decimal-inch system, Figure 2. For example, one-tenth of one thousandths of an inch is point one mil or one-hundred micro inch from the Greek and symbolized by _ (mu).

COMPUTATIONAL CONSIDERATIONS

One advantage of the metric and decimal-inch system is obvious: there are no fractions to combine when you are making calculations. The measurements in this system add, subtract, multiply, and divide easily. During computation, you can add decimal places as needed to report the measurement to its last significant figure.

But any skilled metrologist will also be familiar with the use of fractions. You might spend up to five times as long calculating measurements in fractions because many times you first have to compute a common denominator, then reduce the result back down.

Of course, using decimals can create problems, too. If a measurement is originally made using the inch system, you will have to convert all fractions to decimal first. Conversion can lead to problems with rounding off. When the number "1" is divided into 64ths, you end up with six decimal places, the extra figures may or may not be significant but they can add up to create errors of 1/64 very quickly. Also, at times, you will need to convert the decimal result back to a fraction after all your calculations.

When we round off, we eliminate unnecessary figures in any computation. However, you must know both the correct method of rounding off and the number of significant figures needed in order to round off properly.

- WHAT IS THE REAL ISSUE

With the pocket calculator, however, we now can convert any system of measurement with ease; the computer has destroyed any remaining separation among systems of measurement. Why then are systems of measurement still an issue? The simplest, strongest reason is world trade. For example, the governments of France and Japan require that imports be in metric dimensions. In contrast, the United States government places no such restrictions on other countries' products. Most manufacturers in the United States have used soft metrication to circumvent this problem; for example, a 22 caliber M16 rifle

is referred to as a 5.56 mm in a metric-based country.

International standards and trade specifications sometimes result in problems for exporters. For example, if skids are standardized only in metric, they are mismatched for goodsmanufactured in inch pounds. Soft metrication does not help; and exporters must pay the penalty.

The metric versus inch-pound controversy is finally winding down throughout the world. The advantages of operating in the global economy-an economy based almost solely in SI-have encouraged the majority of manufacturers to adopt the system and adapt to it. In some manufacturing, the fractional-inch and decimal-inch systems of measurement are still used. The purpose in this extract was to familiarize you with the measurement systems in use, their advantages and disadvantages; and their histories and futures.

SUMMARY

Because it is necessary to understand each other, some terms must have specific meanings. Linear measurement expresses distance between points. It permits distances to be reproduced. A measurement consists of a unit of length and multiplier. Each measurement begins at a reference point and terminates at a measured point. It lies along a line of measurement, which must have a known relationship to the feature being measured.

A feature is a measurable characteristic. It is bounded by edges, usually but not always, formed by the intersection of planes. Features are spoken of as being male, female, or some combination. The dimension of the feature is the designer's concept of perfection. Features of actual parts are not perfect.

Measurement shows the deviation from perfection. The measured conformity to the dimension is the accuracy. The refinement with which this can be known is the precision. Th effect of accuracy and precision on attaining the desired resul is reliability. Precision is essential for reliability but alon cannot produce it. Increased reliability requires increase accuracy and that requires increased precision. Therefor the general term used to denote progress in measurement precision.

There is no insurmountable difficulty involved in a total chang from the inch-pound system to the metric system, nor is ther any convincing proof that such a change is needed or desirabl The metric system is unquestionably superior in ease c computation. Popular use of the metric system in scienc clearly advocates its continued use. The units of the metri system were selected theoretically. It is not surprising tha they bear little natural relation to most things in the real world including the resolving power of the human eye

The inch-pound system is handicapped by an apparentl disorderly assortment of units. This slows computation an sometimes clogs communication. However, its basic units ar of such convenience that it finds wide use even in places i which the metric system is the legal system.

Each system has merit and has roles in which it is fully accepted It is even possible to borrow good points from one system t enhance the other; an example of this is the decimal inch Furthermore, in this computer age the system of annotatio is relatively unimportant and should not be an issue. Ou efforts are needed far more for the application of soun principles and the perfection of our reference standards.

Extract from "Fundamentals of Dimensional Metrology", 3rd edition, By Ted Busch, Roger Harlow, Richard I. Thompso and Published by Delmar Publishers.

THE HTI E-LEARNING PLATFORM - A REMOTELY ACCESSIBLE SOLAR ENERGY LABORATORY

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Abstract

This paper presents the solar energy e-learning laboratory developed at the Higher Technical Institute (HTI) within the framework of the Leonardo da Vinci project MARVEL. MARVEL focuses on experiential based learning-arrangements allowing remote and distributed training with laboratories, workshops and real working-places in the field of Mechatronics. As a prototype working example the HTI solar energy laboratory comprises a remotely accessible pilot solar energy conversion plant.

1. Introduction

Remote engineering is becoming an import element in engineering education and vocational training. Accordingly there is growing need for new educational concepts, learning media and tools. As a prototype working example we present in this paper the solar energy e-learning laboratory developed at the Higher Technical Institute (HTI) within the framework of the Leonardo da Vinci project MARVEL. MARVEL (Virtual Laboratory in Mechatronics: Access to Remote and Virtual e-Learning) focuses on experiential based learning arrangements allowing remote and distributed working with laboratories, workshops and real working-places in the field of Mechatronics to train students in remote engineering [1].

The HTI solar energy e-learning laboratory comprises a pilot solar energy conversion plant which is equipped with all necessary instrumentation and control devices needed for remote access, control, data collection and processing. A major goal of the HTI solar energy e-learning laboratory as well as of the MARVEL project in general is the usage of real worlds in virtual learning environments in order to support work-process-oriented and distributed cooperative learning with real-life systems. Telematics, remote and mixed reality techniques are used cooperatively within a network that includes colleges, industry partners, and national bodies dealing with certification and standardisation issues.

This paper presents one of the learning scenarios, which is developed within the MARVEL project while some of the forthcoming trends in the training of remote engineering are described. The HTI solar energy e-learning laboratory is also presented, followed by a description of a number of remotely accessible laboratory experiments in the field of solar energy.

2. Training Needs in Remote Engineering

Currently, engineering work is undergoing significant structural changes worldwide. Various studies give evidence for the increasing for telematic-based work environment important in the context of geographically distributed commissioning, installation, maintenance and repair of plant and machinery. Remote engineering, remote maintenance, teleservice or e-maintenance are all catchwords for these novel engineering and management concepts whereby construction and maintenance of plants and machinery are monitored and managed over the Internet [2, 3]. The emergence of these techniques has its roots in the dissemination of Mechatronics components - which are nowadays available in almost all modern systems – and the Internet of course. Remote service techniques have benefits for the engineering and plant construction industries as well as for their customers: problems can be diagnosed off site and local engineers can be supported by a central team of remote experts. At the same time, communication between the manufacturer and the user of Mechatronics systems is being improved. This helps to reduce service costs while increasing the availability of systems.

As remote engineering becomes increasingly important, there is also a growing need for qualified employees in maintenance departments, in production, in customer service and in other fields [4]. Such demands imply further training for skilled workers, technicians and engineers, which have to acquire qualifications and skills in the following areas:

- installation and using of remote diagnosis and service tools,
- creating and operating communication access points,
- acquiring data for e-maintenance purposes,
- providing remote-services in different network and communication structures.

In contrast to "traditional" engineering, experts in remote engineering are deployed in a relatively broad range of activities that span different sectors of industry. They typically work in locally distributed teams and coordinate their work amongst themselves. This requires not only competent handling of tools and methods for diagnosis, maintenance, monitoring and repair, but above all the ability to communicate effectively with others (e.g. customers, users, installers) with the help of computer-aided means of communication. Skilled service technicians must solve the "mutual knowledge problem", for example by integrating the know-how of others in order to accomplish their goals using appropriate tools (e.g. electronic conferencing or groupware applications).

Special focus must be placed on accessing distributed information from suppliers, customers and manufacturers over the Internet. Because e-maintenance is primarily immaterial, the quality assessment made by customers is highly dependent on those employees who perform such services. For this reason, technicians and engineers must also be trained in customer orientation with an emphasis on communication training and customer-centred action.

With the aforementioned requirements in mind, the general goal in MARVEL is to produce evaluated working examples of remotely accessible practical environments (remote laboratories,

workbenches and e-shops) to train engineering students in remote engineering, e-maintenance, remote process control and supervision.

3. The HTI Solar Energy e-learning Lab

The HTI solar energy e-learning laboratory comprises a pilot solar energy conversion plant which consists of two flat plate solar collectors having a surface area of 3 m^2 located on the flat roof of the central HTI building, an insulated thermal storage tank located in the solar energy laboratory and other auxiliary equipment and accessories. It is also equipped with all necessary instrumentation, control and communication devices which are needed for remote access, control, and data collection and processing. The schematic diagram of the system is illustrated in figure 2.

The installed hard- and software includes features for controlling external devices, responding to events, processing data, creating report files, and exchanging information with other applications. All relevant weather data as well as operational and output data of the system are registered during an experimental session and can be stored on the users' PC for various calculations and/or documentation.

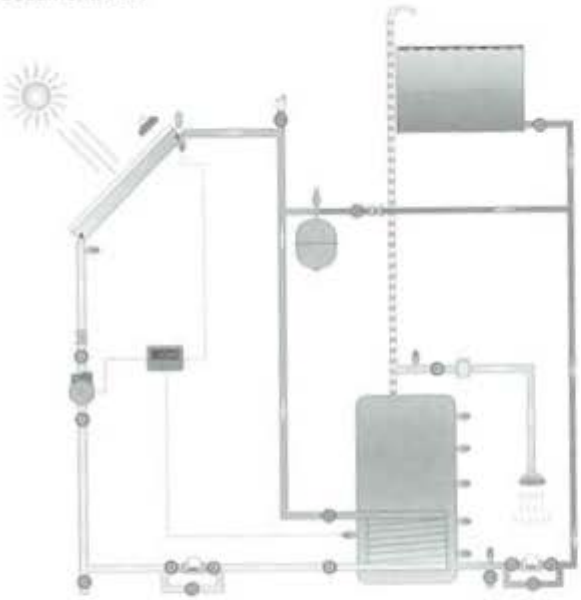

Figure 1: Schematic diagram of MARVEL Solar Pilot System, HTI

The aim is to use the Internet as a tool to make the laboratory facilities accessible to engineering students and technicians located outside the HTI premises, including overseas. In this way, the solar energy e-learning lab and its equipment and experimental facility will be available and be shared by many people, thus reducing costs.

Furthermore, the field of solar energy chosen for this purpos willoffer a unique opportunity to students from countries of poo sunshine to have access to real conditions experiments wit abundant of solar radiation. The system enables real-time, remot control, data acquisition and evaluation. It allows remotely locate students to conduct experimental work in an interactive an independent way.

Students from collaborating partner institutions have remote acces to the system. A booking tool is available to control the acces time for the equipment by the instructors. A number of laboratory experiments and learning tasks were already developed including familiarisation exercises as well as system performance investigations and e-maintenance tasks. All exercises and learning tasks are supported by web-based learning materials in the form of 'virtual books'.

4. Learning Platform

To achieve the whole process of experimentation via the web, one needs to have a learning platform in order to deliver the various notes and learning material, provide some means of guidance, examinations etc. This platform is not only the provider of material but also the learning and teaching tool of the future. After a search for the most suitable platform to use, we came across a number of platforms, most of which were commercial highly priced platforms used by a number of Universities. We finally decided to use Moodle [5], which is a widely used software package for producing internet-based courses and web sites and is provided freely as Open Source software (under the GNU Public License).

Moodle is copyrighted, but users have some freedoms of its use. One is allowed to copy, use and modify Moodle under certain conditions. The software will run on any computer that can run PHP, and can support many types of databases (particularly MySQL) [6].

The word Moodle was originally an acronym for Modular Object-Oriented Dynamic Learning Environment, which is mostly useful to programmers and education theorists. A number of early prototypes of Moodle were produced and discarded before the released version 1.0 on August 20, 2002. This version was targeted towards small classes at University level. Since then there has been steady series of new releases adding new features, better scalability and improved performance, while in 2003, the company moodle.com was created to provide additional commercial support for people who need it, as well as managed hosting, consulting and other services.

Moodle is now used not only in Universities, but in high schools, primary schools, non-profit organisations, private companies, by independent teachers and even home schooling parents.

5. System Architecture

The system architecture used in the HTI solar energy e-learning lab is illustrated in figure 2. The user will be able to have access to the e-learning lab through a PC which will act as web server. This server will host the e-learning platform with all necessary extensions for PHP support as well as the database necessary for this platform. It will also communicate with the machine hosting the TestPoint [7] web server. Whenever a user wishes to get into the system, the communication will be done through this server. That is, the user sends his/her request to the system, the web server communicates with the TestPoint web server and it collects the data and transfers them to the user.

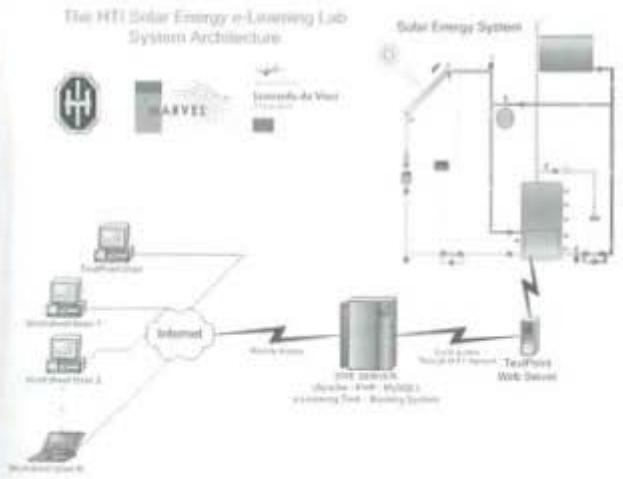

Figure 2: The System Architecture

The actual running of the set-up is done via the TestPoint, which is an interface tool capable of acquiring data through various sensors, storing the data in a form that the user likes, and processing and handling the data in a meaningful manner. This particular software consists of two parts, the programming and the runtime parts.

The programming is needed only to the system designer, while the runtime is necessary to run the particular experiment and is available to the interested user. Any collected data can be stored in popular programme formats (Excel) allowing the user to print his own report formats and hand in a report of his choice. This tool is located on a dedicated server allowing faster data handling. TestPoint is a software tool which brings capability to VISA, IEEE-488, RS232, and Ethernet instrument control. Data transfer, serial and parallel polling, triggering, and all IEEE-488 commands are accessed with specially designed buttons. One can also package instrument commands of his choice so that often used commands are immediately available as a drop-down list. Building a VISA interface provides hardware independence when switching from one type of interface to another.

6. Learning Scenarios - Experimental Work

The learning scenario comprises a series of exercises of different degree of difficulty and complexity. For each exercise, the student undergoes an online assessment and is allowed to proceed to a real experiment only if he/she is successful to the pre-lab and familiarisation exercises. It also comprises an indexed glossary which includes a good number of terms and definitions related to the solar energy laboratory. Following is a brief description of the four categories of learning exercises.

6.1 Familiarisation with the HTI Pilot Solar Energy Plant

Two introductory exercises were prepared for the prospective user. Their objective is to familiarize the student with the HTI solar energy e-learning lab and make him/her conversant with the components of the pilot solar energy conversion plant (figure 3). Upon completion of these exercises the student should be able to name each component in the plant and identify the various components needed to construct a solar plant.

Figure 3: A screenshot within Moodle – Familiarisation with the HTI solar energy plant

6.2 Component functions

Two more advanced exercises for the interested student were also prepared. The objective of these exercises is to familiarize the student with the system layout, make him conversant with the function of each component and the system operation. At the end of these exercises the student should understand the function and operation of each piece of equipment in the system and appreciate its role in the system as well as introduce him into the hydraulics and flow circuits of the plant.

6.3 Data collection and Storage tank stratification

This part of the work comprises two more advanced functions of this work. The student will get acquaint with the remote control of the system (getting into the system through the internet, switching ON and OFF the system) and exercise in taking the readings of the various measuring devices, such as temperatures, flow rates and solar radiation. The student will take sets of readings for

various conditions and different scenarios. One of the scenarios will be to elaborate on the stratification of temperatures in the vertical type storage tank and get a first-hand experience of the variation of temperatures across the tank at different operational conditions, explain the stratification effect and comment on the results.

6.4 Real Experiment and Investigation of collector instantaneous efficiency

This will take the student into the real world of experimentation with a number of capabilities i.e. to investigate the instantaneous efficiency of the collector or determine the rate of thermal energy removed from the storage tank to the consumption. For this purpose, the student will record a number of readings (incident solar radiation, water flow rates, temperatures, etc.) and using certain thermodynamic equations [8] he/she will determine the performance characteristics of the collector and compare them with those given by the manufacturer.

The student will have the possibility of investigating the above either by the above methodology or directly through the software tool.

The test will be conducted at various conditions and with different scenarios such as for example: with or without consumption of service hot water, at different temperature differentials, etc. Sh the student have more time available, he could also plot a g for the collector efficiency.

7. Conclusion

The HTI e-learning lab goes beyond traditional remote labs: providing distributed work places for complex remote learn work tasks.

An important innovation within our approach is that concepts examples for real working and learning are developed and acces virtually through remote processes. Accordingly we go bey 'traditional' remote laboratories, because we are trying to pro distributed work places for remote engineering in technical vocational training.

8. Acknowledgements

This paper was prepared within the MARVEL project, wh receives support from the European Leonardo da Vinci Programn We would like to thank our colleagues in HTI and our proj partners in the MARVEL consortium for their contribution a interesting and fruitful discussions. For further information plea visit the HTI e-lab web site at http://e-lab.hti.ac.cy and the MARVI web site at http://www.marvel.uni-bremen.de.

REFERENCES

[1] Müller, D., Ferreira, J. M, "MARVEL: A mixed-reality learning environment for vocational training in mechatronics," Proceedings of the Technology Enhanced Learning International Conference, (TEL'03), Milan, Italy, November 2003.

[2] Lee, J., Qiu, H., Ni, J., Djurdjanovi, D: Infotronics Technologies and Predictive Tools for Next-Generation Maintenance Systems. 11th IFAC Symposium on Information Control Problems in Manufacturing. Salvador, Brazil April 5-7th, 2004

[3] Graupner, Tom-David; Westkämper, Engelbert: E-maintenance web-based services for production systems. In: Qu, Liangsheng (Ed.) et al.: Proceedings of International Conference on Intelligent Maintenance Systems. October 30 - November 1, 2003, Xi'an, China. Changsha, China: National University of Defence Technology Press, 2003, pp. 637-645.

[4] Erbe, H.-H., Bruns, F. W.: Didactical Aspects of Mechatronic Education. 5th IFAC International Symposium on Intelligen Components and Instruments for Control Applications (SISACA) Aveiro - Portugal 2003.

[5] Moodle – A free, Open Source Course Management Syste for Online Learning, http//moodle.org/.

[6] Matt Riordan, Moodle – An electronic classroom, Teache Manual, http//moodle.org/.

[7] TestPoint - Keithley Solutions for Data acquisition http://www.test-point.com/gen_tp.html.

[8] Duffie J. A. and Beckman W. A.: Solar Engineering of Therma Processes. John Wiley, New York, 1991, pp. 301-307

AN ATTEMPT TO APPLY FUZZY COGNITIVE MAPS TO THE POLITICAL-ECONOMIC PROBLEM OF CYPRUS

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Introduction

The dynamics involved for the security and stability of Cyprus, as well as the economic development, is related to the interests of both the Greek-Cypriot and the Turkish-Cypriot communities. Due to the historical roots of the two communities and the strategic position of Cyprus, there are antagonistic and cooperative interests among other countries involved in the problem. These are primarily Greece, Turkey and the United Kingdom. The entry of Cyprus into the European Union, as well as the recent terrorist events (USA on September 11 2001 and in Spain on March 11 2004), has made the involvement of Europe, USA, Russia and Israel important influential-dynamical factors.

An attempt to model the dynamics of the problem, using a fuzzy cognitive map-like approach has been made. The main parameters involved in the interrelated dynamics are: Nationalism, religiousness, knowledge of history, level of educational development, tourism, oil, other natural resources, settlers, and the general interests of the above countries and the two communities.

A cognitive map consists of a set of cause-effect relationships that are presumed to exist among specific concepts (factors, parameters, activations, attributes, ...). Using a suitable and systematic process, it is possible to establish the effect of a change in the state of any concept (or set of concepts) on any other concept or on the entire system. Different fuzzy cognitive map (FCM) paradigms have been proposed [Craiger et al 1996, Hagiwara 1992, Kosko 1986, Kosko 1992, Schneider et al. 1998] as well as different application areas [Dickerson and Kosko 1994, Pelaez and Bowles 1996, Stylios et al. 1997]. Each concept may be related to other concepts through appropriate degrees of effectiveness (causality, sensitivity).

Dynamic simulation

A growing dynamical system may be modeled as a quasi-statically and interactively evolving set of components, so that changes in the various parameters (concepts in the established FCM terminology) affect either directly or indirectly all other parameters of the system. The basic algorithm that may be followed is depicted in Figure 1.

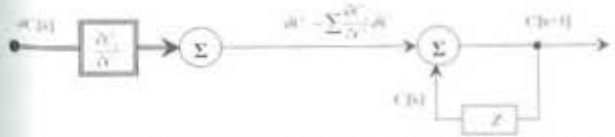

Fig. 1. The basic unit adopted for the evolution of the system

Where *C's* are the concepts, Z^{-1} the unit delay, and K the discrete integration counter. The partial derivatives $\frac{\partial C_i}{\partial C_j}$ are considered to be the sensitivities (or influencing factors, or weights) *Sij* characterizes the degree by which a change in concept *i* may affect (either increasing or decreasing) concept *j*. The FCM we adopt is forced to evolve as per the equations shown in Figure 1.

The FCM concepts

For this study, 30 influencing parameters have been explored. These are presented in Table 1.

Table 1. The various influencing parameters that have been studied

INFLUENCING PARAMETERS (Concepts)	
C1	Welfare of the Federal State of Cyprus
C2	Welfare of the Greek Cypriot State
C3	Welfare of the Turkish Cypriot State
C4	Greek Cypriot nationalism
C5	Christian religiousness
C6	Knowledge of Turkish language by the Greek Cypriots
C7	Knowledge of Turkish history by the Greek Cypriots
C8	Educational level of the Greek Cypriots
C9	Turkish Cypriot nationalism
C10	Islamic religiousness
C11	Knowledge of Greek language by the Turkish Cypriots
C12	Knowledge of Greek history by the Turkish Cypriots
C13	Educational level of the Turkish Cypriots
C14	Political interests of Europe
C15	Political interests of USA
C16	Political interests of Russia
C17	Political interests of UK
C18	Political interests of Israel
C19	Political interests of Greece
C20	Political interests of Turkey
C21	Military interests of Israel
C22	Military interests of Greece
C23	Military interests of Turkey
C24	Military interests of UK
C25	Military interests of USA
C26	Interests of Anatolian settlers
C27	Level of tourism in the federated state
C28	Oil fields
C29	Quality of environment
C30	Other natural resources

It should be emphasized that these factors are difficult to quantify and definitely not agreed by every person involved in the analysis and decision. Some form of fuzzy approximation may be employed by combining the knowledgeable opinions of various experts and the extensive experience as well as the cumulative wisdom of politicians. The decision on which parameters to use, what initial values and what sensitivities to employ, has been based on feedback from such persons.

Furthermore, each parameter embodies a general state (and associated trend), as it is commonly employed and understood. For instance by the term "Welfare of the Federal State of Cyprus" we mean a state that has characteristics of prosperity, political stability, social development, high quality of life, etc.

Some parameters are included, even though they are non-existent presently – e.g. presence of oil fields and other natural resources – because of the prospects of finding such, and as an input for a possible systematic scenario. Of course such developments, as well as a much awaited political solution of the problem, necessitate a drastic re-evaluation of the parameters, their interactivities, sensitivities and initial values.

The initial values of these parameters as well as the sensitivities themselves are fuzzy in the sense that they can not be known with certainty, and they represent a general state as being defined by some expert.

The parameter sensitivities

The sensitivities *Sij* have been used to update the various concepts by implementing the general equation 1.

$$\delta C_i = \sum_{i=1}^{m} \frac{\partial C_i}{\partial C_i} \delta C_i = \sum_{i=1}^{m} S_{ij} \delta C_i \qquad (1)$$

An extract of the sensitivities that have been used, for the first 10 parameters is shown in Table 2. They were suggested by few knowledgeable persons that have been inquired to give their wisdom. Obviously, different experts, or more opinions would result in possibly different values. They express the accumulated wisdom of knowledgeable persons and thus are fuzzy.

Table 2 The sensitivities that have been used in the FCM. Concept *i* (row) influences concept *j* (column)

0	0.7	0.8	-0.1	0	0.2	0.1	-0.6	0.6	-0.7
0.6	0	0.3	-0.3	-0.1	0.3	0.1	0.1	0.3	0.1
0.2	0.1	0	0.1	0.1	0.2	0.1	-0.1	0	-0.3
-0.2	-0.1	-0.9	0	0.2	-0.2	-0.1	0.8	-0.1	0.8
-0.3	0	-0.5	0.6	0	-0.1	-0.1	0.6	-0.1	0.8
0.3	0.1	0.4	-0.1	-0.1	0	0.4	-0.2	0.2	-0.2
0.1	0	0.3	0	0	0.2	0	-0.1	0.2	-0.1
0.5	0.5	0.2	-0.2	-0.1	0.2	0.1	0	0	0
-0.4	-0.5	-0.1	0.4	0.3	-0.1	-0.1	0	0	0.3
-0.3	-0.3	-0.1	0.2	0.3	-0.1	-0.1	0.8	0	0

Results of simulations

Due to the constraint of having to be confined to a reasonably short article, only three cases will be presented. These are:

The effect on all other parameters of a significant **increase in the Islamic religiousness**

The effect on all other parameters of a significant **increase in the political interests of Europe**

The effect on all other parameters of a significant **increase in the political interests of USA**

In order to study these effects, the system was forced to gr from a set of starting values for each of the influencing paramete setting the parameter under study to zero value. The system, af few iterations (no more than 20 were needed), gradually setti to new parameter values. The same was done when setting t parameter under study to its maximum possible value (100%

With this model, it is noted that a significant increase in the Islan religiousness results in significant increase in the Greek Cypr nationalism (+36%) and a bigger increase in Christian religiousne (+283%). Also, this will result in an increase in the military interes of Turkey, Greece and Israel. Of significance is the observati that the welfare of the Federal State of Cyprus will reduce by 7 and the welfare of the Turkish Cypriot community by 4%. Son reduction in the level of tourism and the quality of the environme is also observed.

As for the significant increase in the European political interes in Cyprus, it may be observed that the model predicts a significa increase of the Greek language and history by the Turkish Cyprio and vice versa for the Greek Cypriots, being more pronounce within the latter. It is however very interesting that the mod suggests a significant reduction in Christian religiousness (-28% and somewhat less (-5%) in the Islamic religiousness. Mos interesting though, is the suggestion that the interests of th Anatolian settlers will reduce by 20%.

For the case of significant increase in the political interests of USA in Cyprus, the model predicts a 12% increase in the politica interests of Israel and a 12% increase in the welfare of the Turkis Cypriots. What is most interesting though, and somewhat unusua is the reduction of the Christian religiousness by 16%, of th Turkish Cypriot nationalism by 18%, of the Islamic religiousnes by 8%, of the political interests of Greece and Turkey by 11% an 16% respectively, and of the military interests of UK by 18%

Concluding remarks

The FCM system that has been developed has shown reasonabl trends and effects in relation to the studied scenarios, but als suggested some unexpected trends. It is an interesting tool t study the trends and the dynamics involved, rather than th absolute parameter values, which they are highly fuzzy in the firs place. The system is easily expandable to include more influencin factors, focusing in more specific effects such as the overa economy or sectors of it. Further explorations are needed to veri its credibility and to fine-tune the various parameters and processes

References

Craiger J., Goodman D., Weiss R. and Butler A. (1996) Modeling Organizational Behavior with Fuzzy Cognitive Maps. International Journal of Computational Intelligence and Organisations. vol. 1. pp. 120-123.

Dickerson J. and Kosko B. (1994) Virtual Worlds as Fuzzy Cognitive Maps. Presence. vol. 3. pp. 173-189.

Hagiwara M. (1992) Extended Fuzzy Cognitive Maps. Proceedings of IEEE International Conference on Fuzzy Systems. pp. 795-801.

Kosko B. (1986) Fuzzy Cognitive Maps. International Journal of Man-Machine Studies, vol. 24, pp. 65 - 75, 1986.

Kosko B. (1992) Neural Networks and Fuzzy Systems. Prentice Hall International, NJ.

Pelaez C. and Bowles J. (1996) Using Fuzzy Cognitive Maps as a System Model for FMEA. Information Sciences. vol. 88. pp. 177-199.

Schneider M., Shnaider E., Kandel A. and Chew G. (1998) Automatic Construction of FCMs. Fuzzy Sets and Systems. vol. 93. pp. 161-172.

Stylios C., Georgopoulos V. and Groumpos P. (1997) Introducing the Theory of Fuzzy Cognitive Maps in Distributed Systems. Proceedings of 12th IEEE International Symposium on Intelligent Control. Istanbul, Turkey. pp. 55-60.

WRITING IN HIGHER EDUCATION IN RELATION TO THE SCIENCE WORLD

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Introduction

Writing has been a major topic for discussion and debate in applied linguistics for at least fifty years now, due to its manifold and compound nature. These debates are mainly directed to firstly how writing operates and secondly how it should be taught. Its significance in our life is overarching due to the diversity of the writing's roles in various contexts, ranging from social, professional to academic environments. Our ability or inability to handle writing correctly and appropriately determines our life opportunities and so writing projects itself as an evaluating tool.

Writing is used in a variety of contexts and for various purposes and it is an area closely associated with our personal experience and our social identities. The emphasis of this essay will be on writing in Higher Education Science Context, an area which has witnessed major changes in its academic structure, design and execution. These changes have been inevitable, following the rapid expansion of the new technologies of the last thirty years, throughout the academic and working environments, and have established "new contexts" as far as the student writing in higher education is concerned.

I will closely refer to these "new contexts", at a later part of this article, especially within the science higher education environment. Furthermore, I will attempt to outline the requirements and difficulties young scientists of today face. Additionally I will consider the Academic / Workplace environments they find themselves in, writing as a social interaction process and the place of the "personal" in these writing practices.

1. "New Contexts" and Higher Education Purposes

Let us begin with the idea of "new contexts", a term referred to extensively by Mary R. Lea and Barry Stierer (2000), having in mind the writing practices being created in contexts other than the traditional ones. For instance, the phenomenon of professional training and English for academic purposes (EAP) and the non-traditional writing practices emerging within traditional academic disciplines, for example, writing journals in various subjects. Additionally we now have "teaching quality audits" (formal accreditation), determining the standard of education offered. Also, a wide range of educational, cultural and linguistic backgrounds as well as an increasing awareness of lifelong learning which includes study skills, new style courses, in-service training, professional development programmes, distance-learning courses and others.

> *"...writing in higher education is assumed to be a competence which, once acquired, enables students to communicate their knowledge and understanding in virtually any context". (Lea and Stierer 2000 : 2)*

Another area which needs to be considered is the new emerge purposes of HE. The National Committee of Inquiry Report (199 (quoted in Allen Miller 1998:9), chaired by Sir Ron Dearin identifies four main purposes of HE. The first is to inspire a develop the capabilities of individuals to the highest potent levels throughout life, so as to grow intellectually and becon well-equipped for work, therefore contributing effectively to socie as well as achieving personal fulfilment. Secondly to enhanc their own personal knowledge and understanding to levels th could be beneficial to the economy and society. Thirdly to be ab to serve the needs of an adaptable, sustainable knowledge-base economy at local, regional and national levels and finally to becom a contributing factor in the creation of a democratic, civilize inclusive society.

We could rearrange these purposes further and try to group the in major areas following Bligh's (1981) suggestions concernin HE (quoted in Miller 1981:11). These are: 1) The cultural whic tries to pass on the future, the past, the heritage or sustainabl knowledge from one generation to the next. 2) The functiona which aims at producing qualified manpower to assist the futur industry and contribute to the national development. 3) The socia which aims at advancing individuals to higher personal levels an consequently enabling them to become fundamental contributin factors to society, satisfying the governments' needs, an requirements of professional bodies. Finally 4) Perpetuating aiming at continuing the national system of beliefs and values with certain evolutionary elements, often in an effort to challeng government policy.

Whatever the wording and subdivisions of higher educatio purposes are, the truth remains that contemporary higher educatio does not exist because individuals want it, but in its wholenes it exists because countries, governments need it, demand it

> *"Governments have come to see higher education more than ever as an aid to the achievements of social an economic goals and increasingly expect it to be responsive to their agendas". (Kogan 1994, quoted in Miller 1998 11).*

I would like at this point to expand further on the area of the social since this is an area of great concern at the Higher Technica Institute where I am employed as a lecturer of English. HTI was established in 1968 between UNDP (United Nations Development Project), UNESCO (United Nations Scientific and Cultural Organisation), and ILO (International Labour Office)and the Government of Cyprus. Initially it was intended to be a five-year project, but, eventually, due to its success, it has established itself permanently. Its main purpose is to train high level Technician

Engineers in order to satisfy the needs of industry. Presently all the courses of the Institute are expected to be incorporated into the new "Technological University of Cyprus", due to commence its operation in the near future. HTI has for more than 30 years been solely responsible for the training of Technician Engineers capable of fulfilling the local industry's needs.

> *"A key strength is the emphasis we place on industrial training, close co-operation with employers and industry, summer industrial training, summer training through IAESTE* – (International Association for the Exchange of Students for Technical Experience.) *and ensuring that the skills and knowledge acquired by our students are geared up to meeting the demanding requirements of today's workplace".* (N. Loizou Ag. Director of HTI, 2002).

It is indeed these '*workplace requirements*" that most Higher Educational Institutions are aiming to cater for. Since though there is no homogeneity among employers and professional bodies, the striving for advancement among HE Institutions, is perpetual. However, there are certain themes that run through, such as the awareness among employers that graduates, even with some perhaps shortcomings are an asset to any business. In fact Knapper and Cropley (1985), quoted in Miller(1998: 14), have come to the conclusion that

> *"...the task is to develop forms of higher education that are adapted to current economic, social and political needs of contemporary society ".* Additionally they list 7 *"skills of competencies for lifelong learning"*, the kind that employers are looking for. These are: 1) Capacity to realistically set goals. 2) Effectiveness in the practical application of already possessed knowledge. 3) Ability for self-instruction. 4) Skill at locating information. 5) Effectiveness in the application of different learning strategies, and in different settings. 6) Skill in using learning aids such as, libraries, technological tools. Finally, 7) Ability to use and interpret materials from a variety of sources.

It is common knowledge that universities have long been involved in the preparation of people for entry into various vocations and professions. However, more and more employers are voicing the opinion that college graduates are more suitable for direct entry into the workforce than university graduates, simply because these college graduates have directly been involved in the industry as part of their college training. This is certainly the case with HTI, where students undertake a six-week training during the summer in their first year, a six-week summer training between the second and the third year of studies in applied industries and sixty days during the third year of studies. Therefore upon graduation they seem to be very much in demand among employers. In the UK, now that polytechnics, colleges and institutes are being designated as universities, there is genuine concern that the practical training of students will perhaps diminish. This is why there is need for constant assessment of higher education bodies, initially to direct and enhance student learning and in continuation to maintain standards through the accreditation system.

It is evident by now, that HE purposes do not exist in a vacuum but are directly influenced by social demands and government policies. It is after all society that sets the pace and government that funds and materializes the goals. The expectations of HE have common recipients, whether these are governments, employers, parents, school teachers and students. The providers of HE need to be convincing in their arguments that their provisions for education are genuine and widely-directed and not simply self-serving.

While contemporary Higher Education has a lot to aim for in the future, it is perhaps useful to return to the past at times for guidance and enlightenment. I find for example Confusius' saying (551-479 BC), quoted in Allen Miller (1998: 22), apt for the occasion. When Confucius was asked by a student the true meaning of knowledge, Confucius replied: *"When you know a thing, say that you know it, when you do not know a thing, admit that you do not know it. That is true knowledge"*. Indeed admission of ignorance and weakness will inevitably lead to exploration, questioning and continuous striving for answers.

The next part of my article will outline further the importance of writing in Higher Education and the difficulties that students are faced with.

2. Writing in Higher Education

In order to understand the difficulties a novice writer comes up against, we initially need to examine the various disciplinary contexts within which he/she has to write, or more accurately the disciplines they are writing themselves into. For instance, engineers must write differently to sociologists. Nurses need to obtain various different texts in order to write an essay: journals, articles, clinical reports. Clearly we are faced with *"living disciplinary"* and *"contextual heterogeneity"*.

> *"...rather than being neat homogeneous discourse communities, academic disciplines are radically heterogenous and constituted in difference". (Baynham* in Lea & Stierer (Eds.,) 2000:18).

As a result of this heterogeneity and difference, the student academic writers are writing themselves into *"disciplinary politics"*, having to face and make choices as to what counts as knowledge, and what should be taught where and when in the curriculum. Mary Lea, Brian Street and Mike Baynham, all referred extensively to this disciplinary diversity. I find at this point Mike Baynham's divisions concerning academic writing useful, where he identifies three perspectives on the theorization of academic writing.

The first perspective is the "*skills-based approach*", which assumes that there is a generic set of skills and strategies that once taught can be applied in particular disciplinary contexts. Within this traditional perspective, students are taught how to write essays or make references, and once these skills are absorbed they can be applied in any disciplinary context.

A criticism of this perspective is that it does not take into consideration the specificity of writing requirements.

The second perspective is the "*text-based approach*" which is grounded on the resources of linguistic analysis in particular register (Halliday & Martin 1993) and genre analysis; to understand the discipline-specific nature of writing. Within the register analysis we can distinguish whether a text is a science, or a history piece of writing, whereas genre analysis concentrates on what text types are required for each area; for example a history essay or a laboratory report. A criticism of this text-based approach, though is that it usually assumes a homogeneity in disciplines, ignoring variations within disciplines.

Finally a third perspective is the "*practice-based approach*" which emphasizes the social and discursive practices through which a discipline constitutes itself. Namely the preparation of laboratory reports or the completion of log reports, as in the case of HTI students. Language is a dynamic means in projecting this disciplinary knowledge which tends to be regenerating itself constantly.

> *"Language is, after all, a major means,(if not necessarily the only means) by which disciplinary knowledge is constituted, reproduced, contested and added to, and learned"*. (Baynham in Lea & Stierer (Eds.,) 2000:19).

A similar contextualization theory was also devised by Bernstein (1990) (quoted by Foley (1995) in Mary R.Lea & Barry Stierer (Eds.,) 2000:21) who argued that:

> *"Within adult education as a field of study, there are different schools of thought, with different versions of what counts as knowledge, even the boundaries of the field"*.

Since we have established the general theorization on academic writing, I would next direct my attention, more specifically to the science academic writing and the challenges and difficulties young scientists are faced with.

2.i Science Language

We have so far set the scene for the higher education environment with regards purposes, heterogeneity and significance. I would like now to proceed by taking a closer look at the actual language used, and more specifically the language within science education, an area which I am directly involved in the Institute where I work.

Research of the past thirty years has established that a major difficulty in learning science is learning the language of science. Sadly, this is not a realization that has particularly disturbed science teachers who view this, as marginally relevant. At this point let us consider three basic findings: 1) Learning the language of science is a major part of science education. 2) The language is a major obstacle in learning science. 3) There are practical strategies and ways that can help. These realizations soon become blatantly evident in any science environment, especi among students or even lecturers who, like myself, are science lecturers but language lecturers placed in a scie environment. My first encounter with the science world wa 1999, when I was appointed as a Lecturer of English in a Hig Technical Institute. My duties included teaching the structure the English language as well as technical English for C Mechanical, Marine, Electrical, Computer Engineers. Althou up to that point in my career I had had extensive teach experience, never before had there been a need to explain operation of Disc Brakes, the Lawn Mower, Engineering Forc Maglev Train and so on. The greatest obstacle was the richn of terminology and the various functions. After all, that was the English encountered in an ordinary English classroo playground or club. Since it took a great deal of effort and stu on my part, an experienced teacher, to familiarize myself with t new context, it would be easy to visualize the exertion on the p of the students.

2.ii Policy Background

The debate about language in science education is not a n issue but for brevity let us start in the 1970s. Postman (1971), fashionable author of the time wrote:

> *"Almost all of what we customarily call "knowledge" language, which means that the key to understanding subject is to understand its language…What is histo other than words? Or astronomy? Or physics?"*. (Postma & Weingartner 1971 quoted in Wellington & Osbor 2001:3).

The Bullock Report, published four years later, advocated al that all teachers should view themselves as language teache

At a later stage, in 1995 the "*Science in the National Curriculu* document included a "*Use of Language*" section in its comm requirement for all key stages, and this view was further reinforc most recently in the 2000 National Curriculum QCA (Quali Council Accreditation) documents, where there was a : "*Use language across the curriculum*" section in all subjects, emphasizi skills in speaking, listening, reading, writing. More specifically writing, the emphasis should be on correct spelling and punctuatio following grammatical conventions, coherent and logic organization of ideas. Additionally students should be able handle specialist vocabulary and learn the language of scienc so as to read critically and actively and develop interest in readi about science, as well as being able to scrutinize claims a arguments.

Part of the complexity of the science vocabulary is the use familiar words in unfamiliar settings. For instance the word "field "energy", "cell".

> *"Learning science is, in many ways, like learning a ne language…Science thus involves dealing with famili words, like energy, and giving them new meanings new contexts"*. (Wellington & Osborne 2001:5

Consequently we could conclude that one cannot learn science effectively without learning to use the language of science. As Vygotsky (1962) pointed out, when a child uses words, only then he/she is able to develop concepts. Language development and conceptual development are inextricably linked.

> *"Thought requires language, language requires thought. Viewed from a negative angle, difficulty with language causes difficulty with reasoning".* (Byrne 1994, quoted in Wellington & Osborne 2001:6).

Luckily though communicating science is more than just words and there are other semiotic modes that come to rescue and assist the teacher and learner. In science, more than any other subject we place enormous faith and rely heavily on a combination of interaction modes (visual – verbal – graphical – symbolic – tactile), corresponding to diagrams, images, pictures, speech, graphs, symbols, equations, tables, charts and experimenting by hand. They all contribute to the conception of meaning by either assisting or completing one another. The onus of a successful teacher is to employ and combine these modes appropriately and correctly whenever and wherever needed, in order to present a clear view of the science subject presented.

2.iii Writing Difficulties

When academic staff embark in setting assignment tasks and project work to students, they most certainly provide implicit theoretical frames within which students are expected to move. Mary R. Lea and Brian V. Street (in Candlin & Hyland (Eds.) 1999:62) refer to a set of guidelines for students within the different fields. These guidelines fall broadly into three major groups. **1) Institutional** (what the various institutions require). **2) Disciplinary** (discipline, subject, course, tutor and **3) Individual** (personal stance and identity). The theoretical frames vary from general advice to staff on assessing literacy to rules for writers. Certainly different fields require different criteria, and these criteria again are subdivided into two further categories. Firstly the **general** criteria which include advice on referencing, plagiarism, word limit, coherent organization etc and secondly the **literacy** criteria, such as spelling, grammatical structure, style, cohesion, formal language capacities, being able to produce critical argument. The guidelines for HTI students are set similarly in three major areas 1) **Presentation** (appearance, layout, subdivisions, graphs etc). 2)**Technical Information** (relevant background theory, data and calculations) and 3) **Critical Analysis and conclusions** (approach to the problem, how the technical information is utilized etc). The underlying problem though here is, that although students may mechanically follow guidelines, they do not always have the developing skill necessary to produce a coherent text. In fact, in many cases they do not even possess sufficient formal skills in order to present a clear, adequate argument. Additionally, tutor requirements vary from course to course and from institution to institution. This was clearly indicated by a major research Mary R. Lea and Brian V. Street carried out (1995-1996) – as well as Candlin and Plum - indicating the variability and asymmetry of tutor comments:

> *"I need argument, persuasion", "I need evidence, reasons provided", "You need to treat texts with a certain caution and probe for meaning", "The essay should properly identify the subject"*, (Lea, Street, Candlin & Plum in Candlin & Hyland (Eds.) 1999:74-79). Also comments such as *"Very good ..however – one or two details need attention"*.

Although the comments seem perfectly reasonable to an experienced tutor, to a novice writer they might even be more confusing than the original assignment title.

> *"Evidence from our research suggests that across the university, students are attempting to unpack the ground rules underlying assignment questions set by tutors within different departments. It is this very gap between student and staff expectations of what is involved in answering the question which seems to* result *in the problems that faculty and students alike perceive around writing for assignments".* (Lea and Street in Candlin & Hyland (Eds.) 1999:78).

Certainly the gap and the variance among tutors and students is even greater in cases where students are attempting to produce a piece of writing not in their native language - as in the case of HTI students - English. The production of a text is a great endeavour and constant effort needs to be made on the part of the students, directed at various angles. From making sense of the question, to following the guidelines, understanding the tutor's feedback as well as constantly being aware of grammatical structures, language elements and choosing the appropriate vocabulary.

Students who have managed to become good writers will inevitably become effective engineers and scientists. The requirements in scientific and technical writing are primarily the same: accuracy, simplicity, completeness. Writing is part of science yet many scientists are not taught how to write. Writing helps them to observe, remember, think, plan, organize, communicate. Students are always judged by their written work (essays, records, log books, reports, projects) and eventually by written examinations. Writing enables us to give an account of ourselves from either through an application or a business letter to a thesis/project or dissertation. Students who reach higher education are normally intelligent and capable individuals, yet often they fail because of their inadequacy to write.

> *"In the universities students are bright and clever but deprived because their teachers have neglected to instruct them in the element of literacy expression".* (Rivet 1976, quoted in Barass 1996:2).

Professor Rivet carried out a survey among arts and science students and was able to identify specific problems with nearly everybody. A major issue was **spelling mistakes and malapropisms**. Considering the situation in HTI, we often find "common" spelling mistakes running through, such as *"propaply"*,

"lences", "harmfull", "presise", "desing", and so on. Also, errors between **homonyms** and **homophones** are frequent. E.g. were/where, plain/plane, whether/weather, two/too, it's/its. Additional mistakes with **syntax**, **punctuation**, and particularly **word order**. Since a majority of students tend to translate from their native language, e.g. Greek, one of the commonest errors occurring in assignments is the wrong word order and wrong use of conjunctions. E.g. *"...Instead of the usual energy source, most commonly known as diesel engine, there are **and** some other ways to produce power..."*, or *"...There is also a garage, which is used **and** as a store"*.

A further commonly occurring mistake is the plural **form** in adjectives, again a direct translation from Greek. E.g. *"...experts on photovalvic system sizing consider this method as one of the **bests**"*.

Another error worth referring to is the inclusion of **verbosity** in many papers. Students in their effort to clarify a point, produce long, confusing and ambiguous sentences.

> *" ...a great amount of congested and unclear writing the social sciences tolerate"*. (Bernard Crick 1975, quoted in Barass 1996:68).

Yet the irony of the situation is that educated people, in this case, most scientists, are content with their writing. Perhaps scientists writing in a language other than their own are more weary and concerned with the possibility of making mistakes, and this makes them more cautious. The bottom line though is, how can we as educators help and assist students in achieving the ability to recognize the variety of literary practices to a point where they become self-evident and second nature to the writer, or as Fairclough (1989) puts it, to obtain *"common sense"*, with regards to reading and writing. Practically and realistically, there are assisting methods and strategies that can perform this duty, from note taking to progress reports, log books, laboratory diaries, summaries, indexes, data sheets, index cards, field notes, essays, to memoranda and so many others that could provide material for a whole publication. Ideally, this is an ongoing effort, a multifarious task, for people who are willing to persist and vie for improvement and clarity. Words are tools which present themselves for meaning, expression and communication.

> *"Words are the only currency in which we can exchange thought even with ourselves"*. (Sir Arthur Quiller Couch 1916, quoted in Barrass 1996:12).

The next and final part of my article will consider writing as a social process and the place of the personal and stance within this content.

3. Writer Stance in Academic Writing

Academic writing, and more specifically science academic writing, is often considered as impersonal, informative and factual production of texts where the writer is present only in the form of a narrator of facts and experiments, rather than the creator original messages. This is true up to a point, and obviously the is less literary flexibility in science writing than in other forms literary texts. However, even scientific texts cannot be persuasi and reflective if they do not carry certain social and linguis conventions addressed to the reader.

> *"Texts are the result of actions of socially situated write and are persuasive only when they employ social a linguistic conventions that colleagues find convincing* (Hyland in Candlin & Hyland (Eds.,) 1999: 99

Ken Hyland has extensively researched the way writers represe themselves and their readers, through writer stance, which projec itself as an evaluative and interactional mechanism able to mak judgment, assess situations, express opinion and deplo commitment. Although, in general, scientific writing is n extensively promoted to the general public, it cannot remotel be accepted if it does not carry sufficient conviction among reader who have similar scientific knowledge. A successful science writ needs to strike a balance between presenting objective data an setting subjective evaluation. Personal feelings and writ dispositions, or more appropriately *"speaker attitude"*, cannot b set aside and these are the ones that add the stigma of individuali and uniqueness. Although there are many combinations withi academic writing, at the end of the day it is a matter of selectio and choice in order to adopt the most reflective alternatives t one's personality. Roz Ivanic and John Simpson have also extensively researched this area of selection and individuality arguing that:

> *"...there is no ready-made alternative variety of writte English for someone wanting to "write with my own voice" Rather, it is a question of making choices from a rang of alternatives within academic writing, trying to find one which are most in harmony with our sense of ourselve : the present mix is unique to the writer so creating you own identity as a writer means taking responsibility fo choosing the bits that make up your unique mix"*. (Ivani & Simpson in Fairclough (Ed.,) 1996:142)

The choices a writer makes, have to do with lexical and grammatica elements and these are the ones that will create the convincing "I", or the detached "we". Ivanic and Simpson advocate strongly for the powerful "I", because they believe that it carries boldness responsibility, truthfulness, and above all confidence in your writing On the contrary, impersonal style leads to long windiness regurgitated and contorted sentences.

However, in an actual classroom environment, and when you are dealing with struggling, novice writers, the truth of the matter is somewhat different. I have closely examined a number of final year diploma projects written by HTI students and have noted certain linguistic choices made, that seem to run through the majority of them. For instance, the use of passives is a safe, neutral way of presenting an argument: *"The annual consumption*

of energy can be expressed...", "...new resources have to be discovered...", "...big amounts of money and time are spent worldwide for relative programmes", "...some programmes can be applied for our small island Cyprus", etc. Although scientific writing is expected to incorporate passives to some extent, it is nevertheless undeniable that they also provide a safe, impersonal barrier between reality and assumption. If information is presented passively, the writer does not assume any responsibility for inaccuracy and imprecision, therefore perhaps possible objections or disagreements are shifted elsewhere.

Picking up again on Ken Hyland's research (1996) (quoted in Candlin, C. 1999 : 103), I would like to refer to his taxonomy of stance features, corresponding to five main functions. **1) Hedges, 2) Emphatics, 3) Attitude Markers, 4) Relational markers** and **5) Person Markers**.

Looking through HTI project reports I was able to distinguish an abundance of **hedges**, such as *"may...", "possibly...", "perhaps..."*, believe even the interesting phrase, *"...to be on the safe side, we set..."*, and many other similar choices. These hedges allow the writer to abstain from complete commitment.

Emphatics on the other hand, such as *"certainly", "definitely", "undoubtedly"*, carry a lot of conviction and students tend to use them only when they are absolutely certain of a statement. I must confess, though, that I had a great difficulty in locating many, if any, of these emphatics in the projects I have looked through.

The third feature discussed by Hyland was the **attitude markers**, which convey surprise, obligation, agreement, disappointment, rather than commitment. The corresponding lexical items to this feature is attitude verbs, such as: *"I agree...", "I think"..., "we believe..."*, also necessity modals i.e. *"must... should..."*, as well as adjectives like *"understandable", "preferable", "logical"*, etc.

A further feature is the **relational markers**, which aim at involving the reader into the argument. These include question forms such as: *"What can be done with the waste?", "What about solar hot water services for hotels?"*, or the use of imperatives: *"Let us consider...", "Reflect for a moment...", "Contemplate on..."*, as well as digressions, which directly address the reader .e.g. *"We are all familiar with the use of solar collectors in our houses...", "We all know that...a small usage of this kind of energy is possible to be attained..."*etc.

Finally the **person markers** – which, as we have already seen, have been extensively discussed by Ivanic and Simpson- refer to the use of 1st person pronouns: *"I"* and *"we"*. (1983 quoted in Fairclough, 1996 : 144). Pronouns are very important in conveying stance because they range from the subjective *"we..my..I.."*, to the objective *"It is evident that..."*, *"The calculations indicate..."*,etc. Engineering and science papers, tend to include personal markers with verbs related to experimental activities: *"calculate", "measure" "analyse"*, and so on.

Overall, Hyland's research - and I strongly agree with this, following my own study of student projects - indicates that the most common stance feature is the hedges, because perhaps this is the feature that expresses students more accurately. Hedges have certain element of doubt, possibility for error and an aura of weariness and caution.

Stance markers seem to be used more frequently in soft disciplines (philosophy, marketing, applied linguistics), rather than hard disciplines (engineering, sciences). Furthermore, there is no "purity" of stance markers because there is clearly some overlapping between them, and often the same marker might be chosen to perform a different task. There is a kind of interweaving between them, a sort of a unifying thread.

This account of literacy choices clearly indicates that there are certain conventions of stance which need to be followed in order to express a community and its conception about what corresponds knowledge and knowing.

Effective academic writing, as argued above, is all about making choices and selecting the relative linguistic resources available in an attempt to present one's views and ideologies as lucidly and convincingly as possible. Clearly writers do not function outside society, therefore, the way they express themselves must normally be incorporated within the various community practices. Additionally various rhetorical contexts deploy different stance attitudes. Writing as a sociologist is a whole different technique to writing as a scientist. As Hyland puts it:

> "Rather than thinking of academic discourse as impersonal, then, we need to think of it as reflecting the different social practices of disciplinary communities in constructing knowledge. Simply, some fields permit greater authorial presence than others". (Hyland in Candlin & Hyland (Eds.,) 1999: 121).

Having this realization in mind we could urge our students to exert interpersonal intrusion in their writing, try to create an authorial persona and assume responsibility for their writing. Clearly the more experience they obtain the more confident they become in the production of texts and gradually they begin to lose their initial intimidation with regards the expression of their ideologies and views.

Conclusion

I have tried in this article to argue that writing enfolds itself in many contexts; from the mundane, professional environment to the academic, scientific setting, and dexterity or inability in orchestrating writing effectively will either downgrade or upgrade our life opportunities. My contention was that the language in science matters and more often than not students have difficulties with science, because they are linguistically handicapped.

Undeniably, in the contemporary context, there is a dominance of science and technology, and now more than ever societies are placing great demands and stipulations on individuals to become adept in their chosen fields. Writing plays a major part in this challenge and learners should genuinely vie for improvement, if they are to manage to overcome the difficulties.

Although science is an empirical subject, more than any other, and practical work is prioritized above everything else, we must not lose sight of the fact that scientific observations, measurements and experiments will only be convincing if they are interpreted and argued for successfully through a deliberately invented mechanism of visual and linguistic code and conventions. Correct interpretation of scientific ideas requires symbols, diagrams, charts, but most importantly words. Words, which when harmoniously and coherently arranged will provide clarification of purpose, which in turn will lead to successful comprehension and communication.

Educators, examiners, instructors, teachers and lecturers have been chosen to provide the overarching framework of criteria with regards explicit specifications and requirements when setting and assessing written assignments; more often than not this goal is successfully achieved. At the same time though, these same people have been summoned to provide guidance and assistance as to how to go about achieving this objective. Apart from the practical prerequisites needed, their role also entails constant encouragement, feedback and support.

The road to success and achievement is long and arduous. However, despite students' initial shortcomings and inhibitions, when it comes to expressing themselves, especially through the written text, their own experiences, along with their accomplishments and failures will gradually and ineluctably provide the desired linguistic fluency. Experience in one's own field will lead to confidence, will build a stance of authority and create a "persona" of prestige, leading the way to the paths of knowledge.

> "Experience is turned into something close to knowledge when the multitude of particular facts are, as it were, compressed into a single general fact...Knowledge in sum, is bred by generalization out of perception". (Aristotle 300 BC, in Barnes 1987:59).

BIBLIOGRAPHY

Barnes, J. (1987) Aristotle : Past Masters, OUP

Barrass, R. (1996) Scientists Must Write, Chapman & Ha

Baynham, M. (2000) Chapter 1 : Academic Writing in New a Emergent Discipline Areas, in Lea, M.R. & Stierer, B., (Eds.) The Society for Research into Higher Education and Ope University Press.

Candlin, C.N. & Hyland, K. (1999) Writing : Texts, Processes a Practices, Longman, London & New York.

Fairclough, N. (1996) Cultural Language Awareness, Longma London & New York.

Fairclough, N. (1989) Laqnguage and Power, Longman, Londo & New York.

Haybin, J. (1994) Language and Literacy in Social Practice, OU

Higher Technical Institute : Prospectus (2002-2003), Press a Information Office – Republic of Cyprus.

Higher Technical Institute : Review (2002-2003), Press a Information Office – Republic of Cyprus.

Hyland, K. (2000) Disciplinary Discourses : Social Interaction Academic Writing, Kogan Page, London.

Hyland, K. (2002) Teaching and Researching Writing, Longma London & New York.

Ivanic, R. (1997) Writing and Identity, John Benjamins Publishin Company.

Knapper & Cropley (1985), Chapter 1 : Purposes of Highe Education, in Miller, A., Bradford, W.I. & Cox, K (Eds..) (1998) Kogan Page, London.

Lea, M.R. & Stierer, B. (2000) Student Writing in Higher Educatio : New Contexts, The Society for Research into Higher Educatio & Open University Press.

Lea, M.R. & Street, B. (1999) : Chapter 3 - Writing : Texts Processes and Practices in Candlin, C.N. and Hyland, K., (Eds.) Longman.

Miller, A.H., Bradford, W.I. & Cox, K. (1998) Student Assessmen in Higher Education, Kogan Page.

Wellington, J. & Osborne, J. (2001) Language and Literacy Science Education, OUP.

LOW ENERGY BUILDING DESIGN IN THE MEDITERRANEAN AREA

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Abstract

This introduction projects the potential application of Bioclimatic Design interwoven with the objective of energy conservation and utilization of renewable energy resources for indoor comfort.

This is of particular interest for the Mediterranean Countries, since Architecture is currently influenced beyond the usual functional, cultural and technological constraints by the incidence of rapid urban development and huge tourist inflows. This often results to standardized "International Architecture" with high technology services. Sadly these international designs rely mostly on mechanical means, ignoring the local tradition of climatic design which, through various types of vernacular architecture, reflects the thread of continuity coherence and local flavour.

This adoption of foreign architectural solutions has catastrophic ecological and cultural consequences and often accentuates the liabilities of the climate by defeating its aim to provide shelter. By behaving "worse than the climate itself" such designs demand more consumption of auxiliary energy through mechanical equipment, simply to control the indoor environment.

Further to these interrelated factors which increase the complexity of the architecture in Mediterranean area, is the question of the climate itself. The temperate Mediterranean weather pattern, usually lacking in extremes, would appear to present no special problem for bioclimatic design. Yet buildings must be designed and constructed to cope with the possibility both of uncomfortably hot summers and surprisingly cold winters. This design challenge is highlighted and all the more complex when the designer uses the architectural design itself to utilize natural renewable energy sources rather than the use of auxiliary energy, for the provision of indoor comfort.

It is precisely the approach to this challenge of bioclimatic passive and low energy architecture, posed to every designer as the co-ordinator of multiple considerations that is to be presented and discussed during this introduction.

The prospects of the adoption of bioclimatic design will be outlined through appropriate examples, survey and monitoring of buildings as well as results of thermal analysis carried out with the aid of microcomputer programmes for heating and cooling in Mediterranean buildings.

1. Introduction

Bioclimatic Architecture considers the building totally from the stage of its inception as a place of energy exchange between the indoor and the external environment, natural and climatic. It considers the building as a living organism; a dynamic structure which utilizes the beneficial climatic parameters (solar radiation for winter, sea breezes for summer) whilst avoiding the adverse climatic effects (cold winds for winter, solar radiation for summer).

In order to assess the energy demands for heating and cooling in buildings and evaluate the free energy systems available to contribute to these requirements, the comfort criteria and the local climatic conditions must be carefully considered and analysed.

Through bioclimatic chart analysis, it is then possible, to outline the appropriate architectural strategies that could result to indoors thermal comfort for that location for winter and summer.

Such bioclimatic analysis is important for preliminary architectural designs. The selection of the appropriate design strategies, derived from a bioclimatic analysis, compatible with each other and other architectural aspects, could considerably reduce the cost of a building by minimizing, the mechanical means for cooling and heating.

The lengthy procedure involved do not permit the bioclimatic analysis to be made in this introduction. Nevertheless the main heating and cooling strategies for the Mediterranean area will be outlined and their adoption in the design process will be approached in four stages from site planning, orientation and shape, layout and envelope of the building. These aspects will be illustrated with appropriate examples from international and evolving styles, to indicate how bioclimatic techniques address the problems of thermal and optical control. The "Protoype Solar House for Cyprus" and "Bioclimatic Designs for the Student Housing of the New University Campus of Cyprus" for which I was the bioclimatic consultant, are also going to be presented.

The presentation will be complimented with measurements of thermal performance of buildings and thermal calculations carried out with the aid of microcomputer programmes for thermal analysis and which conclude to the comparative assessment of results and design recommendations for buildings in the Mediterranean region.

2.Siting the Building for Bioclimatic Design

Fig. 1. Courtyard defined by circular wall with wetted rubble stone columns for summer evaporative cooling and enhancement of western breezes. In winter the courtyard becomes a pleasant sunny place, warmed by sun and mass

The best opportunities for achieving energy efficiency of the building appear in the early stages of the design process, when the significant decisions are taken relevant to the siting of the building. This affects the orientation, the layout, the landscaping and the integration of passive solar strategies. If the designer doesn't utilize the potential which is offered by the site and its surroundings, the opportunity to achieve energy savings, with relatively simple building tuning will be lost. In later stages much more complicated and costly techniques will be necessary.

It is natural that different sites present totally different constraints and opportunities. Therefore, prior to the siting of the building a study of the site must be carried out, both under existing built conditions and taking into account extensions and development which may be governed by regulations to determine the optimum solar gain in winter. The microclimate, the predominant wind patterns, particularly their direction and intensity and the solar radiation are affected by the topography of a location, the presence of water, the vegetation and the man-made features. Appropriate landscape may offer buffering to the cold winter winds shading and generally cooling effect on the building by channeling the cool summer breezes and causing reduction of air and ground temperature.

3. Shape, Volume and Orientation

For the optimal seasonal performance *of the building its shape volume and orientation are determined by the strategies whic must be adopted for the Mediterranean climate. The main ai of these strategies for winter is to maximize solar gains an minimize heat losses. Reversely, in the summer the aim is t minimize solar gains and maximize heat losses.*

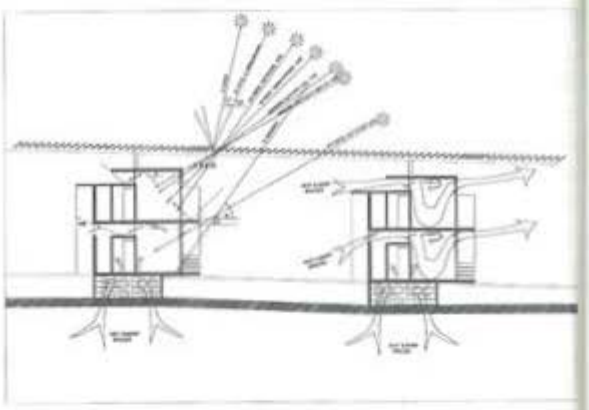

Fig. 2. Section views showing, in winter, the sun penetration in th center of the day through the properly angled canopy slats. In summe direct sun penetration is prevented by the slat angle and spacin The narrow shape and placement of openings promote natur ventilation. Evaporative cooling from the underfloor wetted rubbl stones provides additional summer comfort.

The strategies to achieve this in winter regarding shape volum and orientation could be outlined as follows:

- To minimize the outside wall and roof areas [ratio of exterio surface to enclosed volume]. For a given volume the more compac the shape the less wasteful it is in losing heat.
- Elongating the building with long East-West axis to maximiz exposure to winter sun. This maximizes exposure to winter su and minimizes heat in Summer.
- Streamlining the geometric form of the building to minimiz winter wind turbulence. This could deflect air flow over the hous avoiding air dam effect that its height would otherwise have
- To recess structure below grade or raise existing grade for earl sheltering effect. This eliminates infiltration and reduces conductio convection losses.
- To provide outdoor semi-protected areas for year-round climat moderation.

For the summer exposure to the sun could be minimized an utilization of the summer breezes maximized with the followin strategies:

- The proportions of the plan should be selected to equalize th sum of gains at north and south elevations with those receive at the East and West facades. This minimize exposure to summer su

- Using split levels, high building facades and orientation of the longer ones perpendicular to prevailing winds enhances ventilation.
- Providing outdoor semi-protected areas.
- Recessing structure below grade to avoid direct exposure to the sun and provide a source of cooling.

Building simulation studies for Mediterranean houses regarding the building shape explicitly indicate that a change of one parameter can frequently be compensated for by changes in the others, thus emphasizing the vital importance of an integrated design approach.

In the studies the varied shape design of the buildings was considered in combination with other variables such as:

- Orientation of fenestration
- Addition of mass internally and externally
- Introduction of insulation

Pertaining to the tests on shape it was found that simple compact shapes are more energy efficient than complex ones. However, it is noted that variations or introduction of other parameters on complex shapes may also render them equally or more energy efficient than simple ones. Insulation on the envelope can act as a regulator of complex buildings. The east-west orientation of the long axis of the building with more surface exposed to the south improves the performance for energy efficiency. Regarding mass, addition of it externally increases heating and cooling load on all shape variations, whereas addition of internal mass decreases both. Addition of internal mass facing south, in combination with large areas of south glazing, reduce energy load. It is obvious from the shape study that the development of the building variables in various shapes, into a dynamic and effective pattern of design choices and constraints, necessitates thermal studies for each single building with its own geometry configuration and particularities.

4. Building Indoor Planning

The indoor planning is fundamental for the adaptation of the building to the bioclimatic conditions and the utilization of the beneficial environmental aspects of a location.

The orientation, organization and location of the indoor spaces is complex. Besides their thermal requirements, a large number of various interrelated factors must be considered for the appropriate choice of the location of the spaces and their openings, such as the view, ensuring privacy and security and the expected functions, amenities and services.

In approaching the indoor planning of the building five major strategies are identified:

- Zoning the indoor building volume
- Orienting indoor spaces for energy efficiency
- Locating and organizing climatic buffers
- Planning for heat recovery,distribution and storage
- Planning for airflow and cooling

Partitioning the interior of the house into different heating and cooling zones is significant in adjusting the indoor spaces to meet their daily living and thermal needs. Also subdivision of the interior to create separate zones into seasonal areas and lesser used areas of the house than others, will contribute enormously to expend less energy and at the same time maintain comfort levels in these areas.

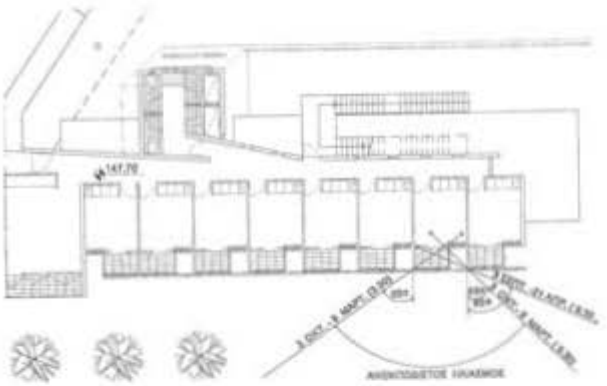

Fig. 3. The elongated shape of the structures, with an east-west long axis, allows favorable solar orientation to all student living units and common spaces, in all buildings. Shown is the unobstructed solar access, sunrise to sunset, from the beginning of October to mid-March.

For the Mediterranean house a linear layout with the long axis stretching East-West in one room depth will offer an optimum south orientation for most of the rooms which presents interesting solar and architectural possibilities. In addition, the building will enjoy daylight from two sides and cross ventilation.

Nevertheless, when orienting the rooms for favourable heating in winter and cooling in summer, in addition to the sun-Path the following must be considered:

- The heating and cooling requirements
- The levels of the internal gains
- The size exposure and function of the room.

The height and the number of floors are determining factors for the optimal, vertical thermal distribution. Two storey spaces and tall interior spaces create pressure differentials and cause vertical air movement. Hot air rises to the ceiling through an open stairwell; this causes upper levels and floors to become overheated while lower levels may have relatively low temperatures.

Stratification and separation with partitioning walls and opening devices may equalize temperature distribution at the desired comfort levels within each room and promote air flow and cooling.

The planning, the design, and the appropriate choice of materials, especially the mass distribution and the location, for these walls, the floors and the other indoor building elements contribute enormously in this. The geometry of the rooms, the building materials and the finishing of the internal surfaces aspecting south, have a bearing on the distribution of the incoming radiation among the room surfaces and affect the attainment, storage and redistribution of solar radiation in the form of heat.

From the building simulation studies it is derived that more complex configurations result to additional factors which intervene in the thermal behaviour of the building. Such additional factors are:

- The more composite internal layout encompassing more spaces and surfaces facing south.
- Larger internal thermal mass whose position, size and distribution reduces temperature fluctuations by retaining heat within it.
- When insulated, enhanced thermal protection on external envelope as a result of the morphology of the two more complex shapes,
- More useful exchanges through openings and surrounding walls.

It is also found that the addition of internal mass combined with the maximization of south glazing, increases energy conservation in heating. A rectangular layout presents the highest amounts of savings. This difference is attributed to the possibility of greater extent of south glazing increase on this shape, the positive effect of which it is not apparent prior to the mass addition; it seems that the position, the size and distribution of the mass acts positively on energy conservation in heating load when combined with the south glazing increase. The addition of thermal mass also decreases the cooling load in all configurations. The energy reduction is due to the potential of the mass to retain the coolness of the night.

5. The Building Envelope

The main considerations for the design of the building envelope could be outlined as:

- **The heat transfer** through the building envelope aiming to restrict heat losses in winter and to enhance solar gains, while limiting them in the summer and promoting cooling with various techniques.
- **The thermal Capacity** of which is an important property of the building envelope for energy conservation, since excess heat is stored in it and dissipated at a later stage when needed. In this way, the indoor temperature fluctuations are regulated and overheating is avoided.
- **Control of moisture migration and vapour formation**

Although both, the opaque (floors, walls, roofs) and transparent (windows, doors etc) elements behave very differently, in relation to the above aspects, nevertheless their role in the thermal performance of the building is equally important.

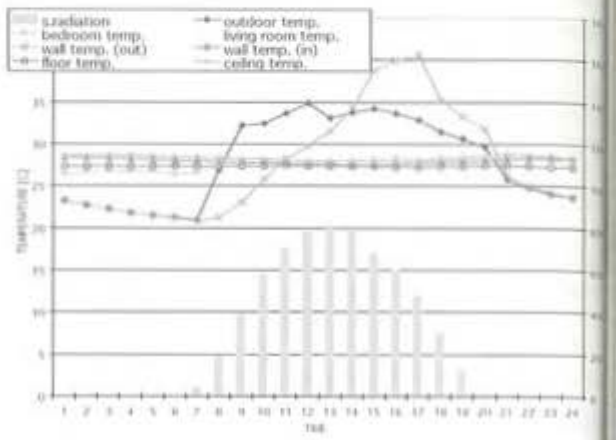

Figure 4. Well-insulated house: Average temperature measuremen results for August 1997.

Regarding the building envelope, simulation studies and buildin recordings were carried out on:

- **Insulation**
- **Mass**
- **Fenestration**

The insulation studies showed that the addition of insulatio could act as a regulator for energy conservation on a geometricall complex shape building. However, the economic assessment o insulation should be viewed in conjunction with each buildin configuration. Furthermore, the studies indicated that extensiv sensitivity studies are needed to define a pattern of the effectiveness of the insulation thickness although the tests on thickness impl diminishing returns as the insulation thickness increases. Comparison of insulation on reference and improved desig suggests that combination of other design measures of th improved design increases the effectiveness of insulation. Extern insulation is the most effective for the Mediterranean climate. Ye the insulation positioning depends also on the type of building an air conditioning used. The application of insulation on the roof i the most cost effective energy saving design measure. Extendin insulation on the walls and floor reduces energy load, but at a additional cost.

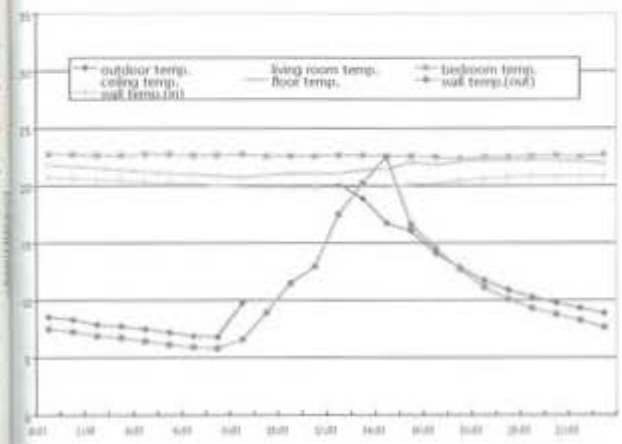

Figure 5. Well-insulated house: Average temperature measurement results for January 1998.

The aspects relating **to mass** are of particular significance for the Mediterranean region due to the large diurnal fluctuations and the potential possessed by mass for the large solar contribution in winter and cooling in Summer. This implies that heat admitted during the day in winter could be stored for use during the evening hours and in the summer could be dissipated into the cool night. In the study the addition of mass has been examined in relation to the building shape and it was found that addition of internal mass incurs energy conservation of varied extent according to the thermal behavior of each building. On the contrary, addition of external mass leads to higher energy consumption. Moreover from the studies it was found that in order to determine the full extent of the effect of mass on the thermal behavior of the building interdependent analysis is necessary concerning parameters such as:

- **Collective and storage characteristics of the materials of the surface finishing**
- **Location, quantity, distribution and surface of mass**
- **Orientation of internal surfaces**
- **Diurnal and spatial temperature swings**
- **Combination of window sizing and extent of thermal mass**

The thermal analysis reinforced the significance of the examination of fenestration in conjunction with the entire building as glazing is thermally a very sensitive, complex, many sided component. In the series of studies on Orientation, Shading, Ventilation, Infiltration and Glazing Type the following were observed:

- **The fenestration orientation** is a significant determining factor, for thermal gains in winter, as well as summer overheating in Mediterranean buildings. It was found that for the optimal orientation of fenestration, detailed studies are needed for each and every building since this variable is closely interrelated with many other building parameters such as the size and location of openings on the building façade. These in relation with the internal layout, the depth of space and the opaque building elements affect not only the direct insolation but also its conversion to thermal energy andits redistribution inside the building.

- **Permanent shading** such as overhangs and side walls must be designed in terms of orientation and dimensions for solar gains in winter and at the same time reductions of overheating in the summer. Movable shading devices offer flexibility and intrinsically have the potential for controlled operation. However they are subject to user intervention, as indeed is ventilation which constitutes an effective measure in minimizing air conditioning energy load.

- **The type of glazing** although an effective means of controlling heat losses in winter and overheating in the summer, financially depends on many other parameters of fenestration.

6. The occupants of the building

It is possible to achieve comfort conditions, for the Mediterranean climate, by many different combinations of optimized and effective variables in the building design, such as compact shape and the optimization of insulation, mass and fenestration designs. However, peoples' responses are a very important consideration in the creation of indoor comfort conditions, but the occupants' designed comfort level is not a manipulable input factor. Moreover, a house is not merely a container in which people act like robots and are placed to receive its thermal effects. There is a dynamic dialogue between building controls and building use. Furthermore, for the Mediterranean climate, it is necessary that some of the employed passive systems must be activated by the users in order to be effective. For this the relative thermal effects of the user interactive parameters in various combinations in computer simulations were considered. From the analysis at the results, it was found that the human element is instrumental in changing some of the assumed building characteristics by such simple acts as opening or closing doors, windows and shutters. It was also found that the effects of the behavior of the building and the users must be considered interdependently as it is the combined effect that is important.

7. Remarks

It is concluded that optimization of the regulatory building systems, in order to achieve its fine tuning and become a successful climatic moderator, evaluation of the building performance, and ultimately analysis of cost effectiveness, necessitates detailed and at the same time robust, dynamic and interactive design approach. This is now-a-days possible with the use of computer analogues, a well established practice, but at the same time on continuous development. No doubt the potential of bioclimatic design is dependent on a multi-disciplinary design approach. However, the thought that buildings could be permanent energy savers, demands building designers to consider carefully the practical options available to them in an integrated mode.

8. References

Balcomb J. D., Jones R. (ed.), Kosiewicz C. E., Lazarus G., McFarland R.D., and Wray W.O., (1983) Los Alamos National Laboratory, Los Alamos, New Mexico. American Solar Energy Society Inc.

Claux., P., Franca, J.P.,Gilles, R., Pesso, A., Pouget, A., and Raoust, M., "Method 5000" (December 1982), edition F.

Commission of the European Communitties (1986) "European Passive Solar Handbook" Directorate-General XII for Science Research and Development.

Commission of the European Communities (1990) "Workshop on Passive Cooling" Joint Research Centre Institute for Systems Engineering and Informatics Ispra.

Courtney G. Roger Ed. (1976) "Energy Conservation in the Built Environment" Proceedings of the 1976 Symposium of the International Council for BRE. The Construction Press.

Den Ouden C. Ed. (1980) "Thermal Storage of Solar Energy" Martinus Nijhoff for the Netherlands Organization for Applied Scientific Research.

Derricot and Chissick Eds. "Energy Conservation and Thermal Insulation" John Wiley & Sons Chistester - New York - Brisbane - Toronto.

Haves, P., (1983) "SERIRES": A Thermal Simulation Model for Passive Solar and Low Energy Buildings. Conference Proceedings C34, U.K-ISES London.

Haves, P., and Littler, J., (1987) "Refinements to SERI-RES" Etsu Report S-1130, Energy Technology Support Unit for the Department of Energy, ASRE Harwell.

Loukaides M. Philippou "Performance of an Insulated House i Cyprus" JISES Congress Japan 1998

Mazria E., (1979) "The Passive Solar Energy Book", Rodale Pres Emmaus Pa.

O'Sullivan P. O., (1988) "Passive Solar Energy in Builsings" Th Watt Committee on Energy Elsevier Applied Science Report 17

Paul J.K (1979) "Passive Solar Enregy Design and Materials Noyes Data Corporation New Jersey.

Public Works Department Ministry of Communications and Publ Works (1988) "Shedule of Rates" New Central Materials Laborato Nicosia.

Serghides, D., (1988) "Prototype Solar House for Cyprus Co Effective Detailing" Graduate School, Energy Studies AA

Serghides D., 1999 "Bioclimatic Designs for the New Uniiversi of Cyprus Campus "nd Competition: Phase A, Student Housin Proc ISES Congress 1999 Israel

Seymour J., (1980) "The Architect's Guide to Energy Conservatio McGraw-Hill

Statistics and Research Department, Ministry of Finance, Republi of Cyprus, (May 1988) "Monthly Economic Indicators"

Yannas S., (1988) "House Design Guide Project: Passive Solar Energy Efficient House Design: Principles, Objectives, Guidelines AA School of Architecture, for Energy Technology Support Unit Dpt. of Energy UK.

Watson D. & Kenneth Labs. "Cimatic Building Design" New York McGraw Hill, 1983 revised 1995

DIGITAL RADIOGRAPHY AND PHOTOGRAPHY IN THE DENTAL CLINIC: THE FUTURE IS NOW.

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Abstract

Radiography is a significant diagnostic tool in modern dental practices. The technology of radiographic imaging is continually evolving and if the modern dentist wants to provide state of the art diagnostic capability for effective treatment planning and successful therapy, should update his equipment. One of the most significant changes in dental radiography is digital imaging which is driven for improved image quality at reduced radiation doses. All dental radiation generators can be used with the appropriate digital sensor to produce high quality diagnostic digital images.

Associated with the above, but totally different, is digital photography which aims at enhancing the dentist's visual assessment and diagnosis.

This paper discusses the advantages and disadvantages of converting a dental clinic into a filmless, digital imaging clinic and investigates the technological options available. Reference will be made to the availability of equipment in Cyprus and the difficulties associated with implementing the change over.

Introduction

The question is not whether a dentist should switch to a filmless, digital imaging practice, but when to implement it.

A familiar scenario in a dental clinic is as follows: The patient enters the dental clinic, the dentist's assistant searches through the bulky filing system and retrieves last year's x-rays together with the treatment record. With the patient now, sitting patiently on the chair, the dentist looks, briefly, at x-ray images and states that it is time for more x-rays. He says "Open your mouth wider,..wider...now bite down." The dental x-ray tube is positioned and points towards the jaw. The dentist moves behind the protective screens and activates the x-ray unit. The film is removed from the patients' mouth and handed over to the assistant who walks down the corridor to the, usually, small room where the developing facility is located and disappears for while. A few minutes later he appears and places the tiny x-ray film on to the viewer for the diagnosis.

Digital radiography will change the above steps. Patients will still have to "open wide" and "bite down," but in place of the small flexible dental film they will be closing their mouths around, a somewhat bulkier, electronic x-ray sensor. The assistant will not disappear as there is no developing facility. The x-ray image will be available for viewing on a computer monitor within seconds after the exposure button is pressed. The image size will fill the monitor and the resolution will increase. The large digital image on the computer monitor can be made available for viewing by the patients enabling them to understand diagnosis and treatment. A definite improvement compared to holding up the little films.

Storage requirements are no longer bulky systems. In fact, the image storage is the computer's memory and disk which does not require any physical space. The digital image can be retrieved, combined, and manipulated in order to extract more information. Digital x-ray images are more portable and can move with the patient, because the dentist can copy all the available images on a CD and hand it over to him. Other advantages include the elimination of chemical waste during film processing and a considerable reduction of x-ray dosage.

The digital age has brought more changes into the dental clinic. Visual examination of the mouth and the teeth will not require a magnifying mirror, because, a small handy camera will be sending their images on the same computer monitor.

There are no available statistics, but according to Dr. Linda Niessen of Baylor College of Dentistry, by January 2004, in USA about 15 percent of general dentists use digital x-ray technology.

The historical background of the x-ray image.

Since the early days, going back almost 100 years, conventional radiography has been using film to capture the x-ray image. The exposed film is then chemically processed to create a visible image for diagnosis. Later on intensifying screens have been introduced so that the x-ray dosage is reduced and the efficiency is increased. These screens, however, have a disadvantage in that they scatter radiation, resulting in decreased spatial resolution and accuracy. Although automatic film processors are used extensively, image quality is determined by the developing procedure and the machine calibration. It is widely accepted that in the future, only incremental improvements in image quality can be expected from screen-film systems.

The x-ray film fulfils all the dentist's requirements: **capture**, **display**, **storage**, and **communication** of the image.

During the last few years the rapid development of electronic devices has technically enabled and made economically viable to use electronic technologies to replace film for the three of the above four functions: image display, storage and communication. The images are scrutinized on bright, high resolution display monitors, combined with high performance personal computers. Electronic image archives can more effectively store and retrieve the massive amounts of image data generated by an imaging facility. High speed electronic networks can transmit image files wherever and whenever needed. The missing piece has been an effective method for capturing high resolution x-ray image in a digital format.

X-ray imaging companies have been investigating alternative methods suitable for digital image capture. This search has resulted in a number of alternative ways which are either direct conversion from x-rays to electrical signals or indirect methods whereby x-rays are converted into some other form of energy, usually light, before they are converted into an appropriate electrical signal.

Advantages and disadvantages of digital X-ray imaging.
As stated above digital imaging is replacing analogue imaging in an accelerating way. It would therefore be useful to look at the advantages and disadvantages of the switch over.

The advantages include:
- Eliminates the need to purchase processing chemicals and X-ray film.
- Eliminates the need to dispose of the used processing chemicals as hazardous wastes.
- Cleaner and faster workflow
- Clearer diagnosis
- Original image is protected, easily reproduced and does not age
- Lower radiation doses
- Reduced space requirements
- Effortless communication

The disadvantages are:
- High initial cost.
- Lower quality image in some applications

It is, therefore, fairly obvious from the above that it is not a quess of whether digital X-ray pays off, but a question of how quick When comparing "digital versus analog" it is necessary to sum the total cost of the process. The initial capital outlay for a digi X-ray system is higher than for a conventional film-based equivale However, once this initial investment has been written off, subsequent X-ray exposures are practically free of charg

Digital Sensors.
Electronic x-ray sensors are manufactured using various techniqu and materials. The technology is rapidly changing following close the developments of the flat panel detectors developed for larg x-ray installations. However as the size of the dental sensor small the use of scintillator materials and Charged Coupled Devic (CCD) detectors is largely employed. What is very important the dentist is to have the normal size of sensor with the lea thickness as this will help him to place it correctly inside the patient mouth.

Figure 1. Dental sensors and their application in the patient's mouth

Make/Model	(1)	(1)	(1)	(1)	(1)
Technology	CCD	CCD/CMOS	CCD	CCD+optical fiber	CCD
Thickness - mm	4	3.2	5.8		
# 0 Physical/Active surface	33x19x4 / 27x15	32.5x26.4 / 26.8x21.6			
#1 Physical/Active surface	41x23x4 / 35x20	37.8x24.7 / 32.7x20.6	36.5x25x5.8 / 30x20	41X25 / 30x20	/ 30x20
#2 Physical/Active surface area	43x30x4 / 37x26	43.0x31.8 / 36.8x26.6	42x32x5.1 / 36.8x27.5	45X32 / 36x27	
#0-Mpixels in sensor	1.12	0.2705			
#1-Mpixels in sensor	1.88	1.26	1.2	1.57	0.96
#2-Mpixels in sensor	2.65	1.8	2.1	2.52	
Pixel size - _m	38 / 19 selectable		22x22	19.5	25x25
Resolution - lp/mm	13 / 26 selectable	22 +	15	20	20
AD conversion - bit	14			12	12
Gray tones	16384		4096	4096	4096
Connection	USB, PCI, Ethernet	USB	Parallel - EPP	USB	USB
Control box/Amplifier	Amplifier	YES	YES		YES
Cable length - m	20	3	5		3
X-ray source		70kV			50 - 70 kV @>.1

(1) Make and model information was withheld as local agents could not supply full details

Table 1. Sensor specifications

he details and specifications and features of the various sensors ere supplied by the corresponding authorized dealers in Cyprus.

lternative systems utilise reusable phosphor storage plates (PSP) place of x-ray film or flat plate detector to produce diagnostic uality intraoral radiographs. These use the existing x-ray equipment nd replace film with a phosphor storage plate. The images are en read and digitized using a dedicated laser scanner. The dvantage of the system is that if uses thin flexible plates, similar ordinary films. There are disadvantages however associated ainly with resolution and the laser scanner which tends to be ulky.

nother development recently introduced uses a wireless dental -ray detector, which transmits the x-ray image to a receiver onnected to the computer. The wireless sensor combines all the dvantages of digital radiography with the ease of placement of ditional film.

igital Intraoral Camera

he digital intraoral camera is a fully digital solution that provides e highest quality intraoral and extraoral pictures and video on computer screen. The camera allows the dentist to present ctorially to the patient the problem and the treatment plan, moothing the case acceptance process. Digital cameras connect th the host computer utilising a PCI video card or plug directly o the computer's USB from where it can also be powered, thus quiring no extra power source.

Intraoral cameras supply their own illumination either from a halogen lamp or from a extra bright LEDs.

Operating the camera is invariably very simple because they normally have a power on /off button and a click capture button set into the hand piece. They are autofocusing although it is not unusual to find a camera cable of switching between intra-oral, extra-oral and macro.

Intraoral camera aid the dentist with microdental procedures, by showing on a computer screen what cannot be seen with the naked eye. They, also, contribute greatly towards educating patients concerning dental problems and their solutions.

Benefits of introducing the digital camera into the dental practice include: Better and faster workflow, Better disease detection, Improved patient education and consequently improved treatment plan acceptance, Improved archival quality of image and easy reproduction of images, Better integration with the practice's management system and an excellent marketing tool for the practice.

Table 2 gives the relevant features of commercially available cameras. The table appears incomplete because a number of local representatives were not in a position to supply the requested information. In many instances the manufacturers' website was consulted. This is one the problems encountered in places such as Cyprus where the market is limited and the bigger companies do not show the expected interest.

Figure 2. Dental intraoral cameras

ake/Model	(1)	(1)	(1)	(1)	(1)
age sensor	1/3" HAD CCD	CCD	1/4" Colour CCD	1/4" CCD Sony	HAD CCD Sony
ewing modes	Auto		Intra/extra oral,macro	Intra-oral, mouth, macro	Intraoral, mouth, face
Mput	S-Vid, Comp (PAL & NTSC)		S-video and Comp	PAL NTSC Y/C and comp.	S-Video, Comp Video
onnection	PC Card	USB	Wireless, 2.4 Ghz	PCI board	PCI
esolution	470 lines		PAL-320k NTSC-270k	752x582	PAL-470k, NTSC-410k
ewing angle	53			72	67.5
agnification	x40x		x100	x60	
ght source	4-output halogen		6 LED	Halogen lamp	White LED
wer supply	12 V, 2 W	None	NiMH battery	Docking station	Docking station
eight - g	240		130	120	55

Make and model information was withheld as local agents could not supply full details

Table 2 Intra oral camera specifications

The x-ray unit

The change over to digital x-ray imaging does not necessarily mean that the dentist will have to purchase a new x-ray unit providing that the output of the existing unit would be suitable for the new digital detectors.

However, in many cases older units are rated at 50kV, 10 mA which will not be compatible with digital radiography.

A brief investigation into the Cyprus market produced the results shown in Table 2.

Make/Model	(1)	(1)	(1)	(1)	(1)
kVp	50, 53, 55, 57, 60, 63, 66, 70	60, 65, 70	70	60, 70	70
mA	2, 3, 4, 5, 6, 7, 8	5	8	7, 4(RVG)	7
Exposure time - s	0.01 - 3.2, 23 steps	0.2 - 2.5	0.04 - 1.32		0.06 - 3.2
Focal spot - mm	0.7	0.8	0.8	0.7	0.8
Focal length - mm	200	200	200	200	200
Generator - _P Control	YES	YES	NO	YES	NO
Operating Freq - kHz	66	High	MAINS	300	MAINS
Exposure control	66 progs	Tooth select	Pre-prog	Tooth select	Tooth selec
Handswitch cord	YES	3 m coiled			3m coiled
Wall mounted	YES	YES	YES	YES	YES
Extension arm - cm	148 - 198	140 - 185	1650-1980	1700 - 2050	185

(1) Make and model information was withheld as local agents could not supply full details

Table 3. X-ray generator specifications

The so-called dc generators, effectively high frequency, are very popular. The are more expensive, but the programmable operation offered makes them more flexible during use.

Selection of Equipment.

The tables shown above provide the background information required to make the appropriate selection. Decision-making should include: utilization type and rate, space requirements, image quality, ease of use, software compatibility, digital capability, total cost, parts availability, and serviceability. Emphasis must be placed on current and projected needs. But above all, consider the technical support through the local dealer.

Looking into the Future

The quest to see the minutest detail inside the human body drives the equipment manufactures to exploit new materials and drive technology to limit is order to satisfy the need. It is, therefore, imperative to keep future technological advances in mind during the decision making process. The occurrence of rapid advances in dental imaging techniques and procedures can result in making obsolete the new and expensive equipment purchased. In order to maintain or improve the clinic's standards care should be taken to strike the right balance between state-of-art technology and cost. The most important question is: can this piece of equipment be easily upgraded to accommodate future needs? Thorough evaluation of the product through a carefully prepared discussion with the sales representative and the study the relevant literature will reveal the true manufacturer's upgrade policy.

References and Further information.

DeMaster, Dean, "Digital radiography offers major productivity gains over computed radiography: results of a time-motion study." Applied Radiology. March 2001.

Maidment, Andrew D. A. "The digital debate» Decisions in Imaging Economics. April 2001.

Manufacturers' web pages, including the following:

- http://www.airtechniques.com/
- http://www.hologic.com/
- http://www.lightyeartechnology.com/
- http://www.duerr.de/
- http://www.planmeca.com/
- http://www.trophy-imaging.com/
- http://www.schickteck.com/
- http://www.sirona.com/
- http://www.gendexxray.com/

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A DIGITAL LIBRARY OF X-RAY IMAGING IN EMERGENCY ORTHOPAEDICS

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Abstract
The objective of this paper is to present the methodology and protocols used for capturing, storing, compressing and transmitting X-ray images in emergency orthopedics. The study is carried out in support of the emergency orthopedics telemedicine system which has been designed, developed and implemented in the Orthopaedics Clinic of the Nicosia General Hospital. A digital library of X-ray images encountered in emergency orthopedics that are moderately difficult and difficult to interpret was created. The images were photographed with a 5 mega pixel digital camera, with a pixel spatial resolution of 100 micrometers. Images were then compressed using the jpeg2000 lossless and lossy compression. The original images and the compressed ones were presented at random to the orthopedics physicians, who could not differentiate the quality between the original, the lossless compressed and the lossy compressed images. Furthermore, scenaria of use of the emergency orthopedics telemedicine system using the GSM and GPRS wireless telephony channels are presented. It is anticipated that following the evaluation of the pilot phase that is carried out at present, the system will be expanded to cover the emergency orthopedics services for the whole island.

Keywords **– Telemedicine, digital, library, Orthopaedics, GPRS, mobile, wireless, image compression, jpeg2000.**

1. Introduction

Orthopaedic surgeons have nowadays the advantage, compared to the past, of using digital images, which are very useful in a multitude of applications and thus are very powerful tools in their everyday practise. Digital images, which are already integrated in many common medical devices, can be used for diagnostic and surgical patient care information, for case documentation as well as for medical education. In recent years digital images as well as wireless technologies [1] are essential tools in telemedicine systems thus allowing very fast and efficient communication between orthopaedists, which proves to be of extreme importance, especially in emergency cases. **The objective of this paper is to present the methodology and protocols used for capturing, storing, compressing and transmitting X-ray images in emergency orthopaedics. The study is carried out in support of the emergency orthopaedics telemedicine system which has been designed, developed and implemented in the Orthopaedics Clinic of the Nicosia General Hospital.** In recent years various Orthopaedics Telemedicine projects have been developed. One example is the "Web-based Home Telemedicine System for Orthopaedics" in USA [2]. This is a web-based system for asynchronous multimedia messaging between shoulder replacement surgery patients at home and their surgeons. A web browser plug-in was developed to simplify the process of capturing video and transferring it to a web site. The video capture plug-in can be used as a template to construct a plug-in that captures and transfers any type of data to a web server. Other examples include the "Remote Consultation in Orthopaedics" which deals with remote consultation with junior orthopaedic trainee based in a community clinic utilising real-time medicine [3]. Also, the "PH-Net project" for supporting local administrations and care provider's to analyse the different aspects of using ISDN network for the interconnection of healthcare telematics applications in UK. One of the objectives of this project is the analysis of the delay times needed to share clinical images from conventional x-ray, CT and MRI for a real interactive consulting service. Statistical tests (ROC curves) are applied to confirm that the diagnostic accuracy obtained on a computer monitor from the planned telemedicine applications remains comparable with the conventional diagnostic accuracy [4].

In the following section the emergency orthopedics system is presented, followed by section 3 which describes the digital library, image capture, compression, and image quality evaluation. Section 4 gives the results, and section 5 the concluding remarks.

2. Wireless Orthopaedics System

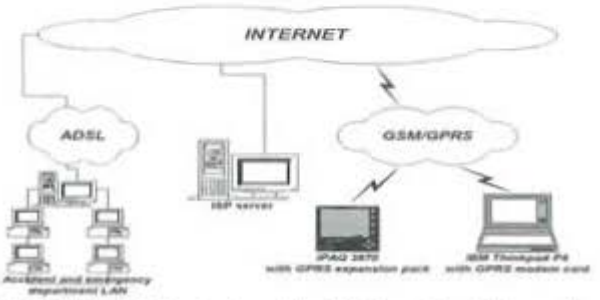


Fig. 1. Network infrastructure of the Wireless Tele Orthopaedics Support System.

2.1 Network infrastructure

A typical network infrastructure in support of the Wireless Orthopaedics System is given in Fig.1. The figure illustrates: (i) the accident and emergency departmental server at the hospital, (ii) a rural health center unit that is connected to the internet via ADSL, and (iii) an expert physician's mobile station consisting of a laptop PC or a handheld PC connected to the internet via GSM or GPRS. The performance of the system was evaluated using wireless communication channels in the transmission of medical images of varying size.

The system has been used since August 2003 on a pilot basis, in the Orthopaedics Clinic of the Nicosia General Hospital in Cyprus. The system provides the ability of digitally capturing and

transmitting Xrays as well as photographs and video to the expert from medical or paramedical personnel, using mainly wireless technologies and mobile computers as illustrated in Fig. 1.[5], [6], [7]. The system is implemented using the tools Borland Delphi 7, SQL Server and Macromedia Dreamweaver MX 2004.

2.2 Scenarios of use

The system can be used in order to obtain a second opinion when facing an emergency or a routine incident within the framework of the following scenarios:

i. Communication between a trainee physician with an expert one while being in the same hospital.
ii. Communication between a physician in a rural health centre and an Orthopaedics physician in a hospital.
iii. Communication between experts from anywhere and at any time.
iv. Communication from the operating theatre with an expert regarding the operation progress.
v. Communication between ambulance personnel and an orthopaedics physician.
vi. Communication between orthopaedics physicians in case of a possible transportation of a patient from one hospital to another, mainly in serious cases.

3. Digital library and image processing

3.1 The Orthopaedcs digital library

The Orthopaedcs Digital Library of the Orthopaedics Clinic of the Nicosia Hospital consists of 35 images covering all possible skeletal Xrays that orthopaedic surgeons may face in their everyday clinical practise, excluding spinal images. The Xrays were collected from the Accident & Emergency Department (A&E) as well as from the Fracture Clinic of the Nicosia General Hospital, with the aim to assess the performance of the Orthopaedics Telemedicine System. The categories of the Xrays were: shoulder, fore arm, wrist, knee, femur, foot, ankle, hand and pelvis. These were classified as "easy cases" and "difficult cases". The quality of the Xrays was not a decisive factor for their selection, since the source was mainly the usually very busy A&E Department.

3.2 Image capture

All Xrays were digitized using a 5 Megapixel digital camera, Nikon CoolPix 5700 model and were transferred to a Pentium IV, 1.8 GHz PC running Windows XP. The area of interest of each Xray was predetermined using a 25.60 x 19.20 cm rectangular frame. The resulting TIFF images had dimensions of 2560 x 1920 pixels, consisting of a total of 5 x 1024 x 1024 square pixels with a spatial resolution of 100 μm, and with each pixel having a 24 bits depth [8].

3.3 Image compression

Three different image compression standards were investigated that are briefly presented below: the JPEG2000, the JPEG, and the JPEG-LS.

A. JPEG2000 which was designed to overcome the limitations of the original JPEG standard and provide high-quality images at low bit-rates and provides a feature set vital to the medical imaging community. JPEG2000 has been selected for inclusion in the DICOM standard for medical image transfer includes . DICOM Supplement 61 was ratified in November 2001 adding JPEG2000 Transfer Syntaxes to the protocol. The benefits of jpeg 2000 which make it appropriate for use in the Orthopaedics Telemedicine Project are: 1. It offers greater compression while maintaining better quality than traditional JPEG. This helps reduce network bandwidth and storage requirements. 2. It is the only 16-bit grayscale lossy compression supported in DICOM. 3. Maintains diagnostic image quality. 4 Multiple resolutions in JPEG2000 means that only the data needed to view the image for a particular device or zoom need be sent over the network and loaded into memory. 5. Progressive display provides feedback to the user while the image is loading. 6. It offers Region Of Interest encoding and decoding. 7. It Supports 24 bit color, and 8, 12 and 16 bit grayscale image data. [9], [10]. For the JPEG2000 the JasPer implementation (ISO/IEC JTC1/SC29/WG1) [11] was used.

B. JPEG. The standard (ISO/IEC 10918-1) was used [12]. This standard Specifies processes for converting source image data to compressed image data, processes for converting compressed image data to reconstructed image data, coded representations for compressed image data, and gives guidance on how to implement these processes in practice. Is applicable to continuous-tone - grayscale or colour - digital still image data and to a wide range of applications which require use of compressed images. Is not applicable to bi-level image data.

C. JPEG-LS. The implementation LOCO [13] was chosen for the study (ISO/IEC 14495-1) [11]. This standard defines a set of lossless (bit – preserving) and nearly lossless (where the error for each constructed sample is bounded by a pre-defined value) compression methods for coding continuous tone, grayscale, or colour digital still images. This draft standard (a) specifies a process for converting source image data to compressed image data; (c) specifies coded representations for compressed image data; and (d) provides guidance on how to implement these processes in practice.

3.4 Image Quality Evaluation

In order to compare these image compression methods, their efficiency was measured with a criteria of compression rate, and also the quality of the compressed images was determined for a given compression rate. The peak signal to noise ratio (PSNR) between the original image and the rebuilt image was used. The peak signal to noise ratio is given by:

$$PSNR = 10 \log_{10} IMax^2 / \sqrt{MSE^2}$$

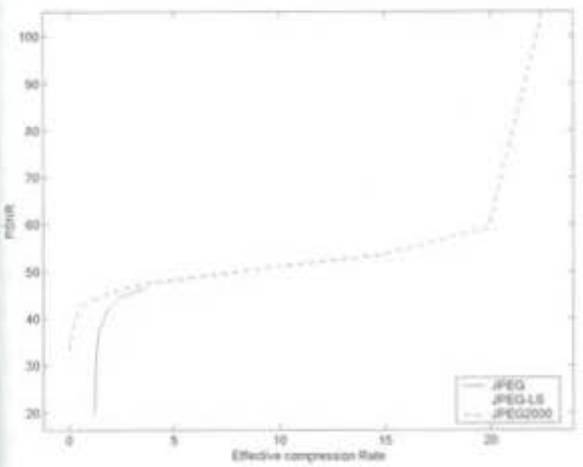
where:

$$MSN^2 = \sum_{i=0}^{i=N-1} \sum_{j=0}^{j=M-1} \left(I_{original(i,j)} - I_{compressed(i,j)} \right) (N * M)$$

and represents an unbiased measure of the fidelity of the rebuilt mage. The mean square error, MSE, measures the distortion brought by the compression technique, and is defined by the mean of the square distances between every pixel (i,j) of the original mage Originalij and each pixel of the rebuilt image Newij. The PSNR represents precisely the MSE, referenced with respect to the dynamics of the image in decibels (IMax2 is the maximum ntensity). The larger the PSNR, (in other words the smaller the error), the better the rebuilt image quality (that is to say "faithful" to the original image). This criterion is a statistical quantitative measure computed on the whole image. So the visual quality needs to be verified by looking for artefacts, block effects or other ittle distortion the PSNR cannot highlight, but which is awkward for a medical use.

4. Results

The comparison of quality between the three methods is given in he graph of fig.2 and in table 1. A criterion of value 30dB is considered to be the lower value for a good PSNR. Then, a visual evaluation is done for each compressed image, in order to detect echniques, which offer good PSNR but a bad diagnostic fidelity. For the proposed system, the time of transmission is important and has to be as short as possible. For this reason the file size o be transmitted is a good criterion of comparison. The effective compression rate CRe gives the size in bytes of final image over ize in bytes of original image (in %).



g. 2. Evolution of the quality with respect to the image size omparison between the three methods using the shoulder01 image. :

able I. PSNR in dB for different size of file

Filesize (KB)	PSNR *JPEG*	*JPEG-LS*	*JPEG2000*
200	44.5	36	46.5
100	41.8	31.41	44.55
50	-	26	42.95
20	-	-	40
2.3	-	-	30

JPEG offers quickly good efficiency regarding the Cre (the lowest quantification allows us to obtain a size of 214 kbytes), but the visual quality is not enough: the distortion, named block effect, is visible by a non expert from a compression rate of 1.43% (for a 70333 bytes file), even the PSNR is superior to 30dB (see Fig 3b). For a compression rate greater than 10%, JPEG-LS gives the best image quality, with regard to the PSNR (Fig 2). For a rate lower than 10%, JPEG 2000 becomes the optimal method.

fig. 4a JPEG - 31.81 dB – 63 584 bytes

fig. 4b JPEG-LS - 30.9 dB – 74 347 bytes

fig. 4c JPEG2000 - 32.28 dB – 2 454 bytes

The effect of distortion for each method is shown in fig. 3: When regarding the visual quality, distortion appears with JPEG-LS method from a compression rate of 3.79%, when the file size is 186 650 bytes and the measured PSNR 39.68 dB (Fig 3c).

With JPEG2000 technique, the visual distortion has been detected by non medical expert from a Cre of 0.1% (the image is 4905 bytes and presents a PSNR of 36.15 dB). The distortion brought by JPEG2000 is named the 'rice grain' effect (Fig 3d), and it creates in fact fuzziness in the image.

Also this distortion is finer, and more difficult to detect. The images shown in Fig 3 represent a region of interest in the whole image, and are presented here with a zoom of approximately 1:1.5. Even if the distortion seems to be important, the general aspect of the whole image at 30 dB (Fig 4) is quite correct, if we consider the telemedicine application. This visual evaluation which gave good preliminary results was later validated by the experts.

JPEG compression generates a visual distortion at a low compression rate, which can be very disturbing for a medical pre-diagnosis. For high compression, JPEG-LS offers bad result in term of PSNR (less high than the JPEG one). But, its general visual quality is quite good: the visual distortion is less awkward than the JPEG one, and the details and contours are finer as in JPEG2000 image. Figure 4 demonstrates that JPEG2000 has the best efficiency in term of reducing the file size (2kbytes versus 74 kbytes with JPEG-LS with about the same quality). A compromise has to be found between the quality of the X-ray image and the time of transmission. If quality is the highlighted criteria, we choose JPEG-LS compression.

fig.3a. fig. 3b. fig. 3c. fig 3d

Fig. 3: (a) Original (4 918 KB), (b) JPEG - 37.2 dB – 70 KB, (c) JPEG-LS - 34.1 dB 105 KB, JPEG2000 - 36.15 dB – 5 KB

For a PSNR of about 30 dB, this method produces a file of 75 kbytes (that is a Cre equal to 1.5%). If the transmission time is critical, JPEG2000 offers a compression of 0.05%, that is 2460 bits.

Numerous experiments have been carried out using the Digital Library in order to assess the Telemedicine System. All 14 orthopaedic surgeons of the Ortopaedic Clinic of the Nicosia General Hospital participated in the assessment experiments. For each Xray doctors were shown the original TIFF image mixed with all the corresponding jp2 compressed lossless as well as lossy images and were asked to assess their quality in a scale 1-5. The assessment of all doctors coincided in every single case: All images were marked with the maximum grade (5), since the bone structure looked identical.

5. Concluding remarks

The TIFF images obtained were finally converted into jpeg 2000 format (.jp2), which proves to be satisfactory with regards to the quality compared to the original TIFF image. The original images and the compressed ones were presented at random to the orthopedics physicians, who could not differentiate the quality between the original, the lossless compressed and the lossy compressed images. So it can be concluded that the jp2 lossy file format can be used for sending the medical images (Xrays and photos) using the Orthopaedics Telemedicine System with excellent results. In most cases with high quality compression applied, the final result is visually indistinguishable to the human eye. Due to its excellent coding performance and many attractive features, there is a very large potential application base for JPEG 2000. Some possible application areas include: image archiving, web browsing, document imaging, digital photography, medical imaging, telemedicine and remote sensing.

Finally it is important to note that the Xrays which will be digitized by orthopaedics doctors must be of excellent quality, since all the rest steps of the process will be based on the quality of the Xray itself.

ACKNOWLEDGEMENTS

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References

[1] Journal of American Academy of Orthopaedic Surgeons Vol 11, No. 6, November/December 2003, pp. 373-379

[2] "Web-based Home Telemedicine System for Orthopaedics" http://icsl.ee.washington.edu/projects/emedicine

[3] "Remote Consultation in Orthopaedics", http://www.teis.port.ac.uk/jsp/search/activity.jsp?project=60

[4] PH-NET project http://www.tecno.ior.it/research/medical_physics/projects/phnet

[5] S. Voskarides, C.S. Pattichis, R. Istepanian, E. Kyriacou, M.S Pattichis, C.N. Schizas, Mobile Health Systems: A Brief Overview Proceedings of SPIE AeroSense 2002: Digital Wireless Communications IV, Ed. by R. M. Rao, S. A. Dianat, M. D. Zoltowski Vol. 4740, Orlando, Florida, USA, pp. 124-131, 2002

[6] S. Ch. Voskarides , C.S. Pattichis , R. Istepanian , C. Michaelide , C.N. Schizas "Practical Evaluation of GPRS use in a Telemedicine System in Cyprus" 4th International IEEE EMBS Special Topic Conference on Information Technology Applications in Biomedicine April 2003, Birmingham, UK.

[7] C.S. Pattichis, E. Kyriacou, S. Voskarides, M.S. Pattichis, R. Istepanian, C.N. Schizas, Wireless Telemedicine Systems: An Overview, IEEE Antennas & Propagation Magazine, Vol. 44, No 2, pp. 143-153, 2002.

[8] Nicon web page, http://nikon.com

[9] LeadTools Technologies web page, http://www.leadtools.com

[10] JPEG 2000 web page, http://www.jpeg2000info.com

[11] ISO/IEC JTC1/SC29/WG1 WG1N1523 JPEG 2000 Part I Committee Draft Version 1.0. 1999

[12] ISO/IEC 10918-1 Digital image compression and coding of continuous-tone still images.

[13] ISO/IEC 14495-1 Lossless and near-lossless and coding of continuous-tone still images (JPEG-LS).

[14] M.J. Weinberg, G. Seroussi, G. Sapiro, "The LOCO-I Lossless Image Compression Algorithm : Principles and Standardization into JPEG-LS", Hewlett-Packard Laboratories Technical Report No. HPL-98-193R1, November 1998. IEEE Trans. Image Processing, Vol. 9, August 2000, pp. 1309-1324.

[15] Online dictionary for computer and Internet technology definitions, http://www.webopedia.com/

EXERCISE AND TYPE II NON-INSULIN DEPENDENT DIABETES MELLITUS

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Diabetes mellitus is a clinical syndrome characterized by abnormal carbohydrate metabolism. It was separated into two major distinct syndromes; Type-I and Type-II. Type-I diabetes is caused by autoimmune destruction of the pancreas leading to severe insulin deficiency. Consequently, a sudden onset of severe hyperglycemia, and rapid progression to keto-acidosis develops and if left untreated may cause death. The exact etiology of Type-II diabetes is unknown, but physical inactivity appears to expose a genetic predisposition by two possible mechanisms. First, physical inactivity causes a positive caloric imbalance accompanied by an increase in the storage of fat by the adipose tissue, and the simultaneous hypertrophy of the fat cells. The density of the insulin receptors decreases causing a decrease of free fatty acid (FFA) absorption. The increase in plasma FFA concentration elevates the formation of glucose by the liver and the decrease of glucose clearance by the skeletal muscle. FFA may precipitate in muscle tissue and further increase insulin resistance. This forces the pancreatic beta cells to increase insulin production. Eventually, beta cells can no longer sustain the increased demand, which results in the development of insulin secretion impairment.

The second mechanism is that physical inactivity exacerbates the natural tendency towards insulin resistance in skeletal muscle. Hence, a given muscle glucose uptake requires a greater insulin secretion demand, therefore stimulating the beta cells. The increased insulin production sequentially leads to the hypertrophy of the fat cells, by driving lipid storage, which further imposes insulin resistance. Type-I and Type-2 or Non-insulin dependent diabetes mellitus (NIDDM) are associated with retinopathy, nephropathy, microvascular disease, neuropathy, and arteriosclerosis.

As mentioned above, diabetes is associated with a plethora of persistent physiological and cellular defects. Defects that physical training may prevent, delay or correct in diabetes. Exercise training has been shown to improve the function of the liver, adipose tissue, the pancreas, and skeletal muscles in NIDDM. Physical training has been found to cause: an increase in muscle mass, an increase in blood flow, biochemical changes, changes in muscle type, and changes to the capillary density of skeletal muscles. Increased skeletal muscle mass increased the available glucose storage area, thereby facilitating glucose clearance from circulation and decreasing the amount of insulin required to maintain normal glucose level. Also, a higher metabolic rate is associated with greater muscle mass that burns more glucose. Finally, trained individuals have been found to have an improved insulin vasodilatory response indicating that exercise can potentially improve vascular deficiency induced by hyperglycemia.

Biochemical defects associated with insulin resistance include: 1) reduced ability to translocate glucose receptors and a reduced number of proteins of the insulin signaling cascade; 2) impaired glucose transporter system; 3) reduced activity of enzymes controlling the phosphorylation and disposal of intracellular glucose; and 4) alterations in plasma membrane phospholipids. Shaw et al. (1998) reported improved skeletal muscle insulin cascade phosphatidylinositol 3-kinase (PI 3-kinase) activity after seven days of hard exercise training. Skeletal muscle GLUT-4 protein in diabetic Zucker rats has also been found to increase with training, therefore, compensating for its defective translocation and consequently improving insulin-stimulated muscle glucose transport. Glucose metabolisms' enzymes such as hexokinase glycogen synthase, and oxidative enzymes that appear to be suppressed with diabetes, have an enhanced activity post-exercise; therefore, assisting the disposal of glucose. Moreover, membrane phospholipids are positively related to insulin action . Changes in fatty acid composition are known to alter membrane fluidity and membrane insulin receptor density , which can affect GLUT-4 fusion and intrinsic activity . It is possible that insulin receptor activation with exercise may improve insulin action by altering membrane structure.

Exercise training has also been shown to assist glucose clearance by improving muscle fiber type in diabetics. NIDDM patients have been shown to have a lower percentage of Type-I fibers and an elevated percentage of Type-II, especially type IIb . Exercise conversion of fibers from IIb to IIa, and the increase of capillarization in both IIa and I improves glucose clearance; thereby contributing to better control of glucose.

Finally, it is imperative to understand that the above benefits can best occur when the most effective level of exercise stimulus (i.e. type of exercise, frequency, duration, and intensity) is adopted. So to achieve this, the exercise program has to be designed and monitored by an exercise specialist who is in frequent contact with your doctor.

Bibliography is available upon request.

HIGHER TECHNICAL INSTITUTE
FOOTWEAR TECHNOLOGY CENTRE

The Centre was established at the HTI in 1975 with the aid of the UNDP with the aim of assisting the footwear and leather industries. It has a well equipped laboratory capable of carrying out laboratory tests on a wide range of materials used in the footwear and leather industries as well as finished products.

The Centre has recently purchased the Soling abrasion machine, adding to its range of equipment, details of which are listed below.

During the last year, the Centre has carried out 575 tests on materials and finished products in its related fields.

The Centre also carries out technical consultancy work to Government departments, manufacturers and importers in its field of expertise.

Drawing up of technical specifications and offering quality control services are also carried out by the Centre. Over the last year, technical specifications were drawn up for specialized boots (trekking boots) and training shoes used by the staff of the Civil Defense Administration and the Police Department respectively.

HIGHER TECHNICAL INSTITUTE FOOTWEAR TESTING LABORATORY

Revised list of tests

TEST NO.	TESTING EQUIPMENT	TEST METHOD	PROPERTY TO BE MEASURED
1	Lastometer STD 104 Instant lastometer STD 190	BS 3144/8	a) Ball distention at grain crack (mm) b) Load at grain crack (Kg)
2	Monsanto tensometer Type W	BS 5131/5.4	Peel strength of adhesive joints at room temperature (N/mm)
2a	Monsanto tensometer Type W	BS 3424 part 5 method 7C	Tongue tear strength (N)
2b	Monsanto tensometer Type W	BS 5131/2.6	Split tear strength (N/mm)
2c	Monsanto tensometer Type W	BS 3144/5, IUP/6	a) Tensile strength (N/mm_) b) Elongation at break (%)
2d	Monsanto tensometer Type W	BS 3144/6, IUP 8	Slit tear strength (N)
2e	Monsanto tensometer Type W	CYS EN ISO 13934-1:99	a) Breaking load (N/50mm width) b) Elongation at break (%)
2f	Monsanto tensometer Type W	BS EN ISO 2062:1995	Breaking load of threads (N)
2g	Monsanto tensometer Type W	BS 5131 sec.3.7:91	Breaking load of laces (N)
3	Cantilever tensiometer STM 163 (Heated chamber)	SATRA AM 1	Peel strength of adhesive joints at elevated temperatures (N/mm)
4	Sole adhesion tester STD 185 Preset adhesion tester STD192	BS 5131/5.1	Sole bond strength (Kg)
5	Vacuum forming m/c STM 329	----------	Plastic forms (each)
6	Finish heat resistance tester STD 111	BS 3662/5	Resistance to heat (°C)
7	Dead load hardness tester Wallace H1	BS 903/ A26:95 method N, ISO:48	Hardness of soling material (IRHD)
	Pocket hardness tester Wallace H2	BS 903/ A57:89 ISO 7619	Hardness of soling material (IRHD)
8	Finish rub fastness tester STM 102/103	BS 3662/8&9, BS 1006 UK-LC	Resistance to rubbing, dry & wet (Grey scale)
9	Insole backpart stiffness tester STD 177M1	SATRA PM 59	Longitudinal stiffness of back part of insole
9a	Insole backpart stiffness tester STD 177M2	SATRA PM 88	Torsional stiffness of back part of insole
10	Dome plasticity apparatus STD 110M	BS 3144/10	Shape retention or set (%)
11	Finish adhesion tester STD 112M	SLF 11	Adhesion of finish, dry & wet (g/cm)
12	Wrinkleometer STD 119M	BS 5131/3.4	Resistance to wrinkling after shortening of material (%)
13	Upper material flexing m/c STM 101	BS 3424 Part 9/11C	Resistance to flexing, dry & wet
14	Shoe flexing m/c STM 184M	SATRA PM 92	Resistance of complete shoe to flexing
15	Ross flexing m/c STM 141M	BS 5131/2.1	Resistance of sole to flexing (strip)

HIGHER TECHNICAL INSTITUTE FOOTWEAR TESTING LABORATORY

Revised list of tests

TEST NO.	TESTING EQUIPMENT	TEST METHOD	PROPERTY TO BE MEASURED
15a	Ross flexing m/c STM 141M	BS 5131/2.1	Resistance of sole to flexing (whole sole forepart)
16	Heel fatigue tester STM 156	BS 5131/4.9	Resistance of ladies heels to impact
17	The bottom leather grain crack tester STD 132	BS 3144/7	Resistance of soling leather to cracking crack index)
18	Compression set apparatus STD 401	BS 903 part A6	Compression set of soling material (%)
19	Soling leather abrasion m/c STM 140M	SATRA PM 84	Abrasion resistance of leather soling (mm/1000 throws)
19a	Soling abrasion m/c	ISO 4649, CYSEN 12770:00	Abrasion resistance of soling (relative volume loss in mm_)
20	Satrafoil	----------	Sole pressure distribution (each foil)
21	Thickness gauge	BS 3144/3	Thickness measurement of leather (mm)
		EN 344 4.5.1	Thickness measurement of coated fabric and textile (mm)
22	Electronic weighing balance and measuring cylinder	----------	Density/Specific gravity (g/cm_)
23	Electronic balance	----------	Weight (g)
24	Bally penetrometer	BS 3144/21, IUP 10	a) Penetration time (minutes) b) Water absorption (%) c) Water penetration (g/h)
25	Impact tester	EN 344 5.3	Impact resistance of safety footwear (mm clearance after impact)
26	Gloss determination tester	ISO 2813	Gloss determination
27	Textile water penetration apparatus (Hydrostatic tester)	CYSEN 20811:92	Resistance of fabrics to water penetration (cmH_2O)

LIST OF HTI RESEARCH PROJECTS – 2004

CIVIL ENGINEERING DEPARTMENT

Measures of optimal RES (Renewable Energy Resources) Integration Design in Architecture and Urban Planning
Dr D. Sergides

Stability and Stress analysis of Tan Miller Dam in Austin, Texas, USA
Dr Ch. Papaleontiou

Flexural Strengthening with Carbon Fiber-Reinforced Polymer Composites of Beams
Mr P. Pelecanos

Use of Sludge as a Soil Conditioner: Environmental Effects on Soils in terms of Macro and Microelements Concentration
Dr N. Kathijotes

Seismic protection techniques. (European programme)
Dr Chr. Chrysostomou

COMPUTER STUDIES DEPARTMENT

e-Manufacturing/Rapid Prototyping
Dr M. Ioannides

Generation of a computer program for the geometric and topological DNA chain of any 3D object.
Dr M. Ioannides

Qualitative reasoning and modeling of reasoning techniques for a single and multiple agents.
Ms Chr. Panayiotou

ELECTRICAL ENGINEERING DEPARTMENT

Digital Signal Processing
Mr. D. Lambrianides

Switching Function Algebra: Analysis of Power Electronic Circuits
Dr Chr. Marouchos

Mobile Transmission for Intelligent Telecardiology Management System
Mr S. Voskarides

Study of various fields of Engineering Education
Dr M. Kasinopoulos

MECHANICAL ENGINEERING DEPARTMENT

Background Work for the Development of Noise Models for the Road/Highway Traffic in Cyprus
Dr P. Eleftheriou

Water Purification
Dr P. Eleftheriou

Thermochemical Processing for the Synthesis of Nanostructured Composite Powders and the Consolidation into Net-shaped parts and Thermal Deposition
Dr N. Angastiniotis

Fault diagnosis in gas cylinders using computational intelligence techniques
Mr C. Christodoulou.

Intelligent Robotic Control
Dr C. Neocleous, Mr P. Demetriou

Predict Future Failure of a Plant by Condition Monitoring
Dr V. Messarites

The use of granular material for suppressing structural vibration, acoustic wave propagation and impact energy.
Dr A. Stassis

Mechanical Rubish Collector from the Embankments of Highways
Dr L. Lazari

Hierarchy of actions for improvement. A case study on CAF.
Dr I. Angeli

Solar energy laboratory and e-Learning (European)
Dr I. Michaelides, Dr P. Eleftheriou

Investigation of the creativity/inventiveness of engineering students
Dr C. Neocleous

GENERAL STUDIES DEPARTMENT

The pedal curve and Surface
Dr Chr. Demetriadi

Femtosecond laser microstructured gratings and microstructure optical fibres
Dr K. Kalli

Investigation and characterization of the Type 1A fibre Bragg gratings in germanosilicate optical fibers.
Dr K. Kalli

Second order driving force approximation for diffusion and reaction processes in porous catalysts.
Dr P. Christodoulides

Kinetic Parameters Estimation in Non-Linear Adsorption Systems
Dr P. Christodoulides

ENGINEERING PRACTICE DEPARTMENT

Hydrogen Fueled Internal Combustion Engines
Mr. I. Antoniou

Design of hybrid photovoltaic-thermal collectors.
Dr S. Kalogirou

Building Construction: Traditional Practices and Memories of the past
Mrs Chr. Antoniou

Optimisation of Building Design Characteristics for Houses in Cyprus
Mr E. Evangelou, Mr G. Alexandrou

Thermal load of buildings and ground heat exchangers
Dr G. Florides, Dr S. Kalogirou

Thermal analysis of windows constructed in Cyprus
Dr S. Kalogirou, Dr G. Florides

Kalogirou, S., 2004, **Optimisation of Solar Systems Using Artificial Neural Networks and Genetic Algorithms**, *Applied Energy*, Vol. 77, No. 4, pp. 383-405.

Kalogirou, S., 2004, **Environmental Benefits of Domestic Solar Energy Systems**, *Energy Conversion and Management*, Vol. 45, No. 18-19, pp. 3075-3092.

Kalogirou, S., 2004, **Solar Thermal Collectors and Applications**, *Progress in Energy and Combustion Science*, Vol. 30, No. 3, pp. 231-295.

Florides, G. and Kalogirou, S., 2004. **Measurements of Ground Temperature at Various Depths**, *Proceedings of SET 2004, 3rd International Conference on Sustainable Energy Technologies on CD-ROM*, Nottingham, UK, 2004.

Kalogirou, S., 2004. **Environmental Impact of Domestic Solar Water and Space Heating Systems**, *Proceedings of the World Renewable Energy Congress VIII on CD-ROM*, Denver, Colorado.

Kalogirou, S. and Tripanagnostopoulos, Y., 2004, **Design Aspects and Applications of Hybrid PV/T solar systems**, *Proceedings of the World Renewable Energy Congress VIII on CD-ROM*, Denver, Colorado.

Kalogirou, S., Tripanagnostopoulos, Y. and Souliotis, M., 2004, **Performance of a Solar Space Heating System Employing Collectors with Colour Absorber**, *Proceedings of the World Renewable Energy Congress VIII on CD-ROM*, Denver, Colorado.

ACCREDITATION OF THE PROGRAMMES OF STUDIES IN MECHANICAL ENGINEERING AND MARINE ENGINEERING

The Courses of Mechanical Engineering and Marine Engineering of the HTI have both obtained accreditation against the academic requirements of the Engineering Council (U.K.) document, Standards and Routes to Registration (SARTOR) Edition 3, on the Incorporated Engineer register through the Institute of Marine Engineering Science and Technology (IMarEST) and the Institution of Incorporated Engineers (IIE).

The above accreditations were granted by the said Institutions, following the recommendations of a joint IIE and IMarEST accreditation visiting panel that visited the HTI on the 23-25 November 2003.

JOURNAL PAPERS 2004

H. Dobb, **K. Kalli** and D.J. Webb
"Temperature insensitive long period grating sensors in photonic crystal fibre"
Electronics Letters Volume: 40, Issue: 11, 27 May 2004, Pages: 657 - 658

A.G. Simpson, **K. Kalli**, K. Zhou, L. Zhang, and I. Bennion
[Special Issue on Optical Fibre Sensors]
"Blank beam fabrication of regenerated type IA gratings"
Measurement Science and Technology Volume 15, 2004, Pages 1665 - 1669

A.G. Simpson, **K. Kalli**, K. Zhou, L. Zhang, and I. Bennion
"Formation of type IA fibre Bragg gratings in germanosilicate optical fibre"
Electronics Letters, Volume: 40, Issue: 3, 5 Feb. 2004, Pages: 163 – 164

CONFERENCE PAPERS AND INVITED PRESENTATIONS

K. Kalli
[Invited presentation]
"Advances in components for telecommunication and sensing applications based on photonic crystal fibers"
NASA-University Photonics Education and Research Consortium (NUPERC). 2nd Photonic Sensor Workshop, 2nd/3rd June 2004. Co-sponsored by NASA Langley.

K. Kalli
[Invited presentation]
"Tunable optical filters based on single mode polymer optical fibers incorporating Bragg gratings"
NASA-University Photonics Education and Research Consortium (NUPERC). 2nd Photonic Sensor Workshop, 2nd/3rd June 2004. Co-sponsored by NASA Langley.

H. Dobb, **K. Kalli**, D.J. Webb
[Invited presentation]
"Temperature insensitive long period grating sensors in photonic crystal fibre"
Photonics North, September 2004, Ottawa, Canada

Ç. Themistos, M. Rajarajan, B.M.A. Rahman, K. Grattan, **K. Kalli** and M. Komodromos
Design issues for directional coupler-based optical microring filters on InP waveguides"
Integrated Photonics Research, June 2004

D. J. Webb, T. Allsop, H. Dobb, **K. Kalli**, T. Earthgrowl, V. Mezentsev, A. Gillooly, I. Bennion
"Sensing applications of long-period gratings in various fibre types"
European Workshop on Optical Fibre Sensors 04, June 2004

H. Dobb, T. Allsop, D. Webb and **K. Kalli**
"Gratings in novel fibre geometry for applications in shape sensing"
SPIE Photonics Europe 2004, EPE110 Optical Sensing, April 2004

A. Fernandez Fernandez, A. Gusarov, F. Berghmans, **K. Kalli**, V. Polo, H. Limberger, M. Beukema and P. Nellen
"Round-robin for fibre Bragg grating metrology during COST270 action"
SPIE Photonics Europe 2004, EPE116 Reliability of Optical Fiber Components, Devices, and Systems, and Networks II, April 2004

A. G. Simpson, **K. Kalli**, L. Zhang, K. Zhou and I. Bennion
"Type 1A fiber Bragg grating photosensitivity and the development of optimum temperature invariant Type1-Type1A strain sensors"
SPIE Photonics Europe 2004, EPE110 Optical Sensing, April 2004

C. Themistos, M. Rajarajan, B.M.A. Rahman, K. Grattan, **K. Kalli** and M. Komodromos
"Design issues for directional coupler-based optical microring filters on InP waveguides"
Integrated Photonics Research, June 2004

D. J. Webb, T. Allsop, H. Dobb, **K. Kalli**, T. Earthgrowl, V. Mezentsev, A. Gillooly, I. Bennion
"Sensing applications of long-period gratings in various fibre types"
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A. Fernandez Fernandez, A. Gusarov, F. Berghmans, **K. Kalli**, V. Polo, H. Limberger, M. Beukema and P. Nellen
"Round-robin for fibre Bragg grating metrology during COST270 action"
SPIE Photonics Europe 2004, EPE116 Reliability of Optical Fiber Components, Devices, and Systems, and Networks II, April 2004

A. G. Simpson, **K. Kalli**, L. Zhang, K. Zhou and I. Bennion
"Type 1A fiber Bragg grating photosensitivity and the development of optimum temperature invariant Type1-Type1A strain sensors"
SPIE Photonics Europe 2004, EPE110 Optical Sensing, April 2004

C. Themistos, **K. Kalli**, M. Komodromos, M. Rajarajan, B.M.A. Rahman, and K.T.V. Grattan
"Design issues for directional coupler- and MMI-based optical microring resonator filters on InP"
SPIE Photonics Europe 2004, Integrated Optics and Photonic Integrated Circuits, April 2004

Michaelides I., Eleftheriou P., and Müller D. A remotely accessible solar energy laboratory - A distributed learning experience. Proceedings, REV2004 Conference on Remote Engineering and Virtual Instrumentation, Villach, Austria, 28-29 September 2004.

RESEARCH PROJECTS

European Union Programme (COST270) 2002-2005
"Reliability of optical components and devices in communications networks and systems".

Eureka 2003-2005
"Optical filter based on Bragg gratings in polymer optical fibres"

Higher Technical Institute – Promotion of Research 2004-2005
"Type 1a fibre Bragg gratings in germanosilicate optical fibres"

Higher Technical Institute – Promotion of Research Fund 2003-2004
"Femtosecond laser microstructured gratings and microstructure optical fibres"

PARTICIPATION OF STAFF IN SHORT COURSES/CONFERENCES AND EDUCATIONAL EXCHANGE PROGRAMMES FOR THE YEAR 2003-2004

SHORT COURSES/CONFERENCES/SEMINARS ATTENDED BY HTI ACADEMIC STAFF

1. Dr Pavlos Christodoulides, Lecturer in the General Studies Department, attended ***The Dynamics and patterns at the interfa between Mathematics, Mechanics and non-linear Physics*** conference, Nice (France), 16-18 June 200

2. Dr Christis Chrysostomou, Lecturer in the Civil Engineering Department, attended the 3rd European Conference of Structural Cont and presented a paper on the ***"Seismic protection of an aqueduct by innovative techniques"***, Vienna, Austria, 12-15 July 200

3. Dr Christis Chrysostomou, Lecturer in the Civil Engineering Department, presented the paper ***"Seismic risk assessment of Nicosi Cyprus"***, in the 13th World Conference on Earthquake Engineering, Vancouver, B.C. Canada, 1-6 August 200

4. Dr Christis Chrysostomou, Lecturer in the Civil Engineering Department, attended the meeting of the partners of the ***Seism Performance Assessment & Retrofit Research project***, Italy, January 2004.

5. Dr Marios Kassinopoulos, Lecturer in the Electrical Engineering Department, attended the International Conference on Engineeri Education, ***ICEER 2004,*** Czeck Republic, June 2004.

6. Dr Soteris Kalogirou, attended the ***World Renewable Energy Congress VIII***, Denver Colorado, 28 August – 3 September 200

7. Mr Charalambos Chrysafiades, Senior Lecturer in the Electrical Engineering Department, visited London, UK, 3 – 7 November 200 under the Socrates - Arion Programme.

8. Dr Despina Serghides, Senior Lecturer in the Civil Engineering Department, gave lectures in the Summer Academy for Mediterranea Solar Architecture, Rome, Italy. (Intensive training Workshop for professionals, graduates and senior students), 26 July - 6 August 200

9. Dr Despina Serghides, Senior Lecturer in the Civil Engineering Department, attended the ***"Eurosun 2004"*** International solar conferenc organized by ISES – Europe, Freiburg , Germany, 20 – 23 June 2004.

10. Dr Ioannis Michaelides, Head of the Department of Mechanical Engineering, participated in the 1st International Conference on Remo Engineering and Virtual Instrumentation (REV 2004), Villach, Austria, 28-29 September 2004. Dr Michaelides presented a paper entitled: ***remotely accessible solar energy laboratory – A distribute learning experience"***, co-authored by Dr. Polyvio Eleftheriou (HTI) a Dr Dieter Mueller (Bremen University).

11. Dr Ioannis Michaelides, Head of the Department of Mechanical Engineering and Dr Polyvios Eleftheriou, Senior Lecturer in t Mechanical Engineering Department, participated in the **"MARVEL"** Project Meeting under the "Leonardo da Vinci" programme, Athe Greece, 22 – 23 March 2004.

12. Mr Spyros Spyrou, Senior Lecturer in the Electrical Engineering Department, attended the six-day ***World Congress on Medic Physics and Biomedical Engineering***, organised by the International Federation for Medical and Biological Engineering (IFMBE) a the International Organisation for Medical Physics (IOMP), 24 – 29 August 2003, Sydney, Australia.

13. Mr Spyros Spyrou, Senior Lecturer in the Electrical Engineering Department, attended a one-day seminar on: ***Harmonization wi the EU-A Challenge for Cyprus: EU Justice and Home Affairs,*** organised by the European Institute of Cyprus Seminars and the INE PEO Cyprus Labour Institute-EMS, at the Holiday Inn Hotel, Nicosia, 10 September 2003.

14. Mr Spyros Spyrou, Senior Lecturer in the Electrical Engineering Department, attended a three-day workshop on: ***Diagnosis Learning Needs,*** organised by the Cyprus Academy of Public Administration (CAPA), at the CAPA Building, Nicosia, 24 Septemb 2003.

15. Mr Spyros Spyrou, Senior Lecturer in the Electrical Engineering Department, attended the ***Eastern Mediterranean Regional Meeti of WHO Collaborating Centres***, organised by EMRO, Cairo, Egypt, 13 – 15 October 2003.

16. Mr Spyros Spyrou, Senior Lecturer in the Electrical Engineering Department, attended the three-day ***II Mediterranean Conferen on Medical Physics: "The Analogue to Digital Migration of the Hospital Working Environment"*** Organised by the Europe Federation of Organisations for Medical Physics (EFOMP) in collaboration with the Cyprus Association of Medical Physics and Biomedic Engineering, Mediterranean Hotel, Limassol, Cyprus, 28 – 30 April 2004.

17. Mr Spyros Spyrou, Senior Lecturer in the Electrical Engineering Department, attended the five-day conference ***Medicon and Health Telematics 2004: "Health in the Information Society"***. Organised by the International Federation for Medical and Biological Engineering (IFMBE), Ischia, Naples, Italy, 31 July – August 2004.

18. Dr Kyriacos Kalli, Lecturer of Physics in the General Studies Department, attended the ***Photonics Europe,*** France, 26 – 30 April 2004.

19. Dr Kyriacos Kalli, Lecturer of Physics in the General Studies Department, attended the ***Innovative Optical Fiber Research Workshop,*** Old Dominion University, USA, 1 – 4 June 2004.

20. Dr George Florides, Senior Instructor of the Engineering Practice Department, attended the 3rd International Conference on ***Sustainable Energy Technologies***, UK, 28 – 30 June 2004.

21. Dr George Florides, Senior Instructor of the Engineering Practice Department, attended the ***IBSA*** (International Building Performance Simulation Association), Holland, 11 – 15 August 2003.

22. Dr Marinos Ioannides, Lecturer in the Computer Studies Department, attended the International Symposium: ***New Perspectives to Save Cultural Heritage***, Antalya, Turkey, 30 September – 4 October 2003.

23. Mrs Maria Theodorou, Lecturer in the Computer Studies Department, attended the: ***Introduction to Object Oriented and Component Based Development,*** UK, 1 – 5 December 2003.

24. Mr Panikos Massouras, Lecturer in the Computer Studies Department, attended the ***International Conferences on Information Security***, organised by the Cyprus Computer Society, 24 - 25 October 2003.

25. Mr Panikos Massouras, Lecturer in the Computer Studies Department, attended the ***Benchmarking Cyprus on e-Europe Readiness***, organized by CITEA and the Cyprus Computer Society, 28 May 2004.

26. Dr Ioannis Angeli, Lecturer in the Mechanical Engineering Department, gave a presentation on ***Quality Forum 2004***, Athens, May 2004.

27. Dr Costas Neocleous, Senior Lecturer in the Mechanical Engineering Department, attended a Summer School on: ***Neural Networks in Supervised Classification Regression and Data Mining,*** Porto, Portugal, 11 July 2003.

28. Dr Costas Neocleous, Senior Lecturer in the Mechanical Engineering Department, participated in the UNESCO Study Visit and attended: ***The European Credit Transfer System (ECTS) in the European Union Education Directory***, Brussels, Belgium, 5 – 11 November 2003.

29. Dr Costas Neocleous, Senior Lecturer in the Mechanical Engineering Department, attended the: ***Canadian/American Credit Point System (CPS)***, McGill University, Montreal, Canada, 9 – 15 November 2003.

30. Dr Nicholas Kathijotes, Lecturer in the Civil Engineering Department, attended: ***Ecological Problems of Industrial Regions*** and presented a paper on "Reclamation of Mining Areas", Russia, 10 – 12 March 2004.

31. Dr Andreas Stassis, Lecturer in the Mechanical Engineering Department, attended: ***Computer Aided Engineering (Dynamics),*** UK, 13 – 14 May 2004.

32. Mr Savvas Savvides, Head of the Engineering Practice Department, attended a ***EurEta General Assembly***, Board and Registration Committee, Finland, Helsinki, 10 – 13 June 2004.

33. Mr Stylianos Kyzas, Instructor in the Engineering Practice Department, was awarded a Fulbright Scholarship in the USA, with the title: ***Engineering Practice Maintenance of Buildings at the IIAM*** (Institute of Infrastructure Asset Management) R.P.I (Renselaer Polytechnic Institute) of Albany N.Y., 2 May - 29 May 2004.

34. Mr Nikos Papanastasiou, Lecturer in the Mechanical Department, organised a Course on: ***"Cad Design",*** in cooperation with the Student and Graduate Association of HTI, Nicosia, March 2004.

35. Mrs Anastasia Mouskou-Peck, Lecturer of English and Technical Report Writing in the General Studies Department, attended a course on: ***Introducing Creativity into Language Teaching***, Institute of Education, London University, 15-16 June 2004.

36. Dr Nicos Angastiniotis, Lecturer in the Mechanical Engineering Department, attended: ***Standard Thermal Analysis,*** Germany, 4 - 5 November 2004.

37. Dr Ioannis Angeli, Lecturer in the Mechanical Engineering Department, gave a presentation at the 7th Cyprus Quality Forum, Nicosia September 2004.

VISITS/EDUCATIONAL EXCHANGE PROGRAMMES

1. Dr Pavlos Christodoulides, Lecturer in the General Studies Department, participated in the Staff Exchange programme at the ENS de Cachan (France), 3 – 6 November 2003.

2. Dr Marios Kassinopoulos, Lecturer in the Electrical Engineering Department, visited the Institute Universite de Technology (IUT) Tours, France, January 2004, and taught under the Socrates programme.

3. Mr Andreas Kkolos, Lecturer in the Civil Engineering Department, participated in the Staff Exchange programme of City University, London, 27 – 31 October 2003.

4. Dr Soteris Kalogirou, Instructor of the Engineering Practice Department, taught: ***"ICT tools for PV System Engineering"*** at a Summer School organized by TEI of Patras, 1-10 July 2004. The programme was financed by Socrates, in which HTI is a partner, and TEI Patras a Coordinator.

5. Mr Charalambos Chrysafiades, Senior Lecturer in the Electrical Engineering Department, visited TEI Perea, Greece under the Socrates – Erasmus Programme, 9 – 13 February 2004.

6. Mrs Chrystalla Antoniou Vassiades, a Senior Instructor in the Engineering Practice Department attended a course on: ***"The repair of old Buildings"*** organised by SPAB (Society for the Protection of Ancient Buildings) London, UK, 11-16 October 2004.

7. Dr Chrystalla Demetriades, Lecturer in the General Studies Department, participated in the Staff Exchange Programme at Vaasa Polytechnic, through Socrates – Erasmus, Finland, 26 March – 2 April 2004.

8. Mrs Maria Theodorou, Lecturer in the Computer Studies Department, participated in the Staff Exchange Programme at Vaasa Polytechinic, Finland, from 26 March - 2 April 2004, under the Socrates – Erasmus programme.

9. Dr Kyriacos Kalli, Lecturer of Physics in the General Studies Department, participated in the HTI Staff Exchange programme and visited Photonics Research Group, Aston University, Birmingham, UK, 19 – 23 January 2004.

10. Mr Constantinos Loizou, the HTI Acting Director and Mr Theodoros Symeou, Lecturer in the Mechanical Engineering Department, attended the Annual Conference of the International Association for Student Exchange, Austria, 17 – 24 January 2004.

11. Mr Panayiotis Pelecanou, Lab Assistant in the Civil Engineering Department, participated in the Staff Exchange Programme in Puskarov Institute, Bulgaria, 17 – 23 November 2003.

12. Mr Sotos Voskarides, Lecturer in the Electrical Engineering Department, participated in a Staff Exchange Programme in Orleans, Bourges, France, 15 – 19 December 2003.

13. Mr Michalis Poullaides, Senior Lecturer in the Civil Engineering Department, participated in the Staff Exchange Programme in the Surrey University, UK, 30 October - 7 November 2003.

14. Mr Panikos Massouras, Lecturer in the Computer Studies Department, visited the South Karelia Polytechnic, Finland, through the Erasmus Programme, 25 April – 1 May 2004.

15. Dr Despina Serghides, Senior Lecturer in the Civil Engineering Department, attended a course in ***Bioclimatic Architecture*** in the framework of "Eurosun 2004" International Solar Conference, Freiburg , Germany, 20 – 23 June 2004.