Review

THE HIGHER TECHNICAL INSTITUTE

Number 27 September 1998 Nicosia Cyprus

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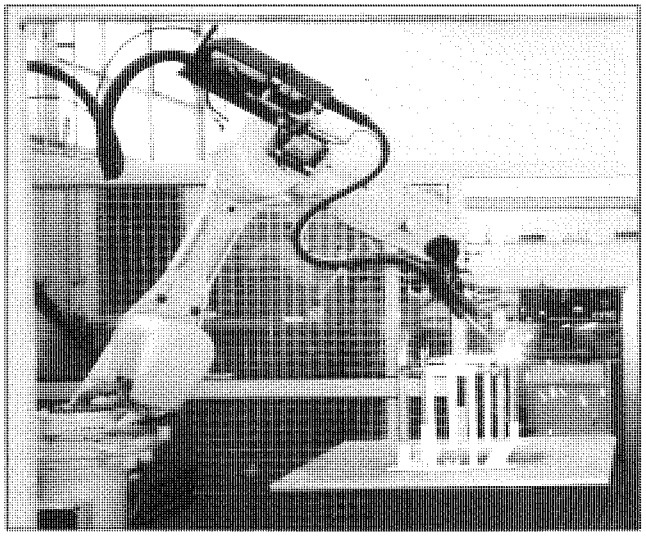

The Industrial Robot at HTI welding a coffee table. The Robot is used by students during their lectures and final year Projects. *Photo by Dr A. Stassis*

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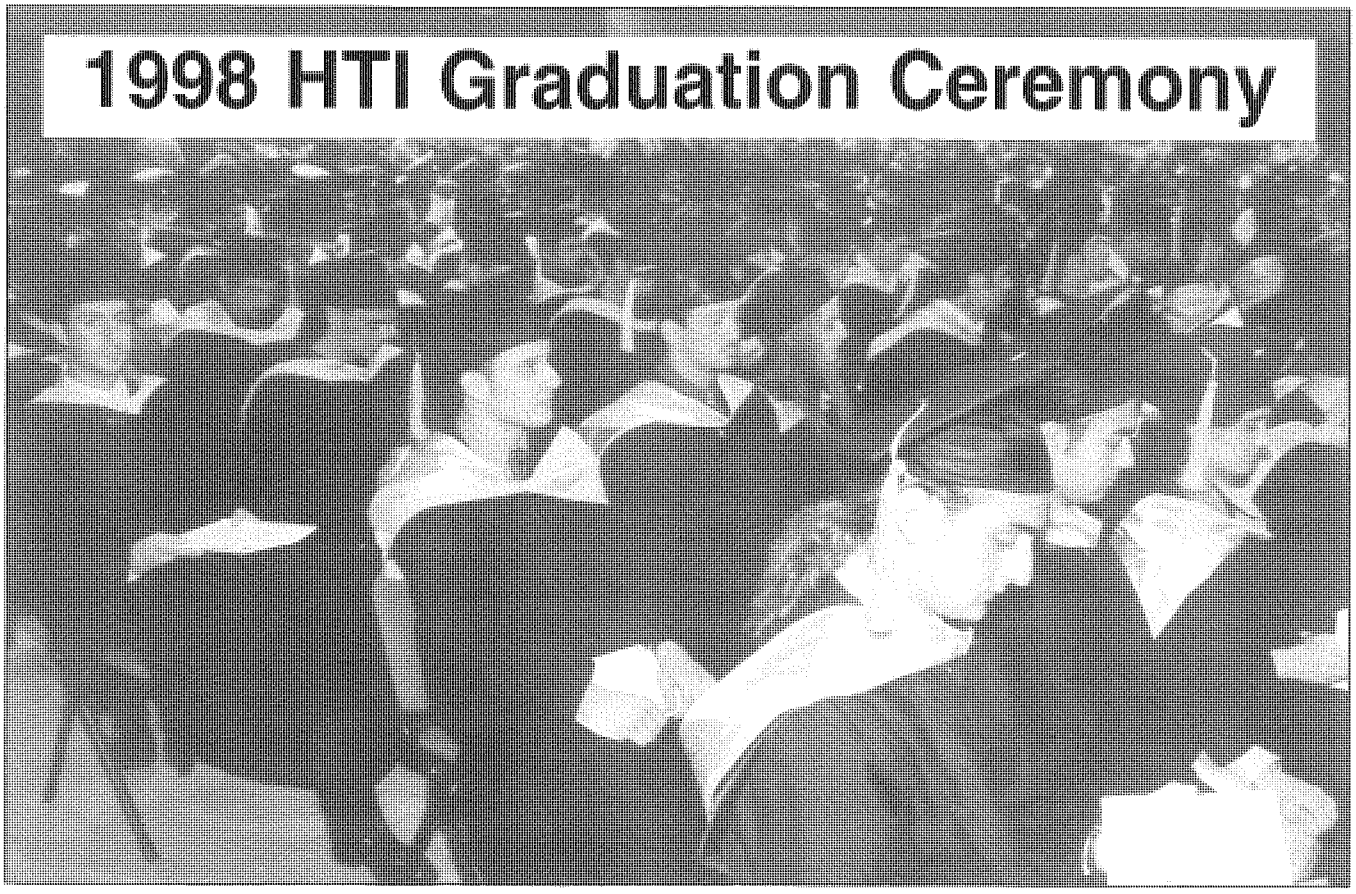
CONTENTS

1998 HTI Graduation Ceremony



The Higher Technical Institute held its 28th Graduation Ceremony on Friday, 10 July 1998 at the Cyprus International Conference in Nicosia.

The Minister of Labour and Social Insurance, Mr Andreas Moushouttas, attended the Ceremony, and, on behalf of the President of the Republic, awarded the Presidential Prize of £2.000 to the graduate of the Highest Overall Performance, Miss Maria Andreou.

Mr Moushouttas handed to the HTI Director, Mr Demetrios Lazarides, the sum of £2.000, the President's annual donation from his personal budget in aid of the needy students of the Institute.

Then the Minister proceeded with the award of the diplomas to the one-hundred and sixty-eight graduates while the HTI Director awarded the prizes sponsored by organisations and professional bodies to the graduates who excelled in their academic studies.

The Ceremony was also attended by the Director General of the Ministry of Labour and Social Insurance, Mr Nicos Symeonides, members of Parliament, the Second Counsellor of the Greek Embassy, Mr Andreas Papadakis, and other members of the diplomatic corps. Present were also government officials, representatives of the political parties, guests of the Institute and students' relatives.

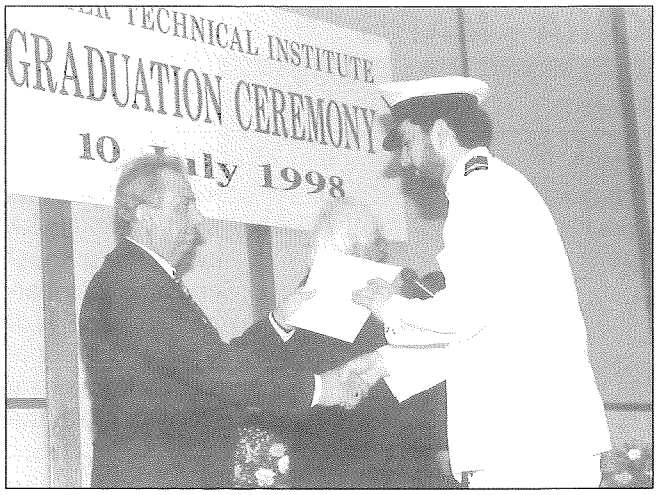
The President of the Student Union, Mr Charalambos Panayiotou, addressed the gathering and highlighted the students' efforts and demands for professional recognition and restructuring of the Higher Technical Institute.

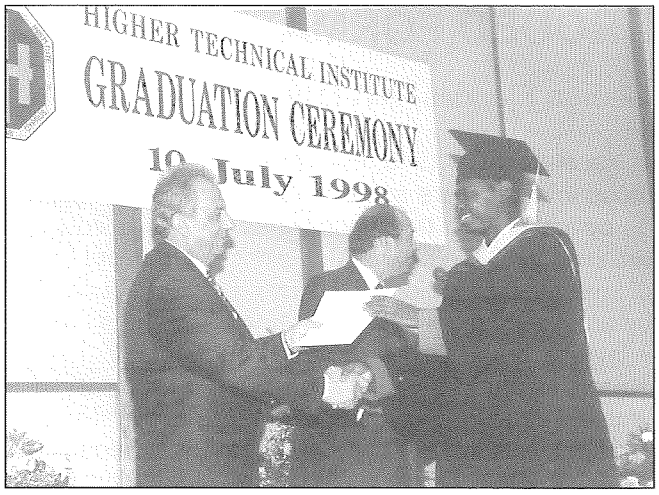
The main speaker was the HTI Director who thanked the dignitaries and all those who attended the Ceremony.

Mr Lazarides first outlined the academic achievements of HTI adding that a total of one-hundred and sixty-eight (168) students graduated from the regular programmes while three-hundred and sixty-nine (369) professionals updated their skills and knowhow by attending twenty-two (22) courses of short duration organised by HTI in co-operation with the Industrial Training Authority of Cyprus and other professional bodies or overseas educational institutions.

The Director next dwelt on the three major issues which dominated HTI affairs and sadly disturbed the Institute's smooth operation in the current academic year. These were (a) the Law Bill regarding the status and operation of HTI; (b) the students' demand for the creation of a suitable salary scale for HTI graduates within the Civil Service and (c) the students' protests and lockouts.

Mr Lazarides went on to enumerate the various efforts made by the Government and in particular by the Minister of Labour and Social Insurance, Mr Andreas Moushouttas, and the Minister of Finance, Mr Christodoulos Christodoulou, in order to find solutions to the three problems. Mr Lazarides concluded that the students' resort to strong measures and lockouts has had adverse effects on HTI reputation.





The Director also referred to a recent court decision which confirmed the legal status of HTI and its diplomas which are not only fully recognised but they also serve as an yardstick for the evaluation of the diplomas of other tertiary education colleges.

Next, Mr Lazarides underlined the fact that the Government has increased its financial support to the Institute. As a result this year the dream for a Sports Centre with international specifications has become a reality. The multi-purpose, eight-hundred seat Sports Centre is scheduled to be operational in December 1998. Its total cost amounted to £800.000.

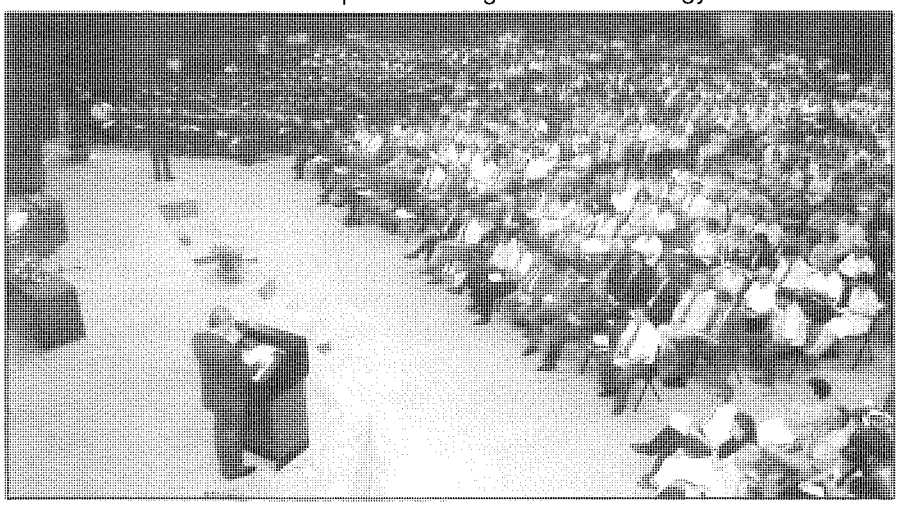
Additionally, another £250.000 were spent on the construction and furnishing of the new Library which is expected to be fully operational by September 1998.

It has also been budgeted that another £750.000 will be spent on laboratory and workshop equipment between 1997 and 1999 while £1.500.000 is expected to be spent on computer hardware and software.

Moreover, the budget allocated for research and staff development has been increased. This is a positive step for it permits more staff exchanges, it creates more opportunities for staff development and research involvement.

The Director then highlighted the Institute's participation in research programmes financed by the European Union like the INCO programme on harnessing solar energy for desalination purposes.

Recently, the Director disclosed, HTI has embarked on a new INCO programme in co-operation with other EU and Mediterranean countries. The new EU programme is called MED-POL and aims at developing a model for the efficient management of energy and water in remote areas using renewable energy resources.



Additionally, the Director said, HTI staff has continued being involved in various programmes of applied research as well as offering consultancy services to the Cyprus industry in particular in the area of testing and building materials.

Mr Lazarides concluded his speech on an optimistic note envisaging a promising future for the Higher Technical Institute. Our expectations for a brighter future, the Director added, are fully justified by the Institute's achievements over the years in the academic, research, and consultancy sectors as well as by its 3.799 graduates who have become the backbone of the Cyprus industry contributing in its technological upgrading and expansion.

Mr Lazarides, next, went on to thank first of all the President of the Republic, Mr Glafcos Clerides, for his generous personal contribution of £2.000 made annually to the benevolent fund for the needy students of the Institute as well as the organisations and individuals who offered prizes, scholarships or donations. Their contributions are gratefully acknowledged and their names are recorded in the Graduation Ceremony Programme.

Finally, Mr Lazarides, on behalf of the Ministry of Labour and Social Insurance and the staff of HTI, wished this year's graduates success and happiness both in their professional and personal life.

ERODED FORMATIONS ON CYDONIA - MARS

George Florides, HTI Dipl., MPhil, Senior Instructor, HTI.

In the summer of 1976, the spacecraft Viking 1 sent back to earth an image series of the surface of Mars. Among those images, were some that imaged a very interesting formation resembling a "Face". Dismissed by NASA as an optical illusion the "Face" on Mars was soon forgotten. Several years later it was rediscovered in the NASA archives by DiPietro and Molenaar who first published the results of their analysis in 1982. Since then a number of investigators, including Brandenburg, Hoagland, Carlotto and McDaniel have examined the "Face" and the near-by area, publishing their work. The investigation focuses on the Cydonia region, in Mars' northern hemisphere, at a latitude of 41° and a longitude of 10° west. The features under investigation include the "Face" and a set of objects located 10-20 km south-west of the "Face" which has been termed the "City". This area contains several unusual structures comparable in size to the "Face" and a number of smaller structures which together with the larger objects in the "City", appear to be arranged in an organised pattern (Figure 1).

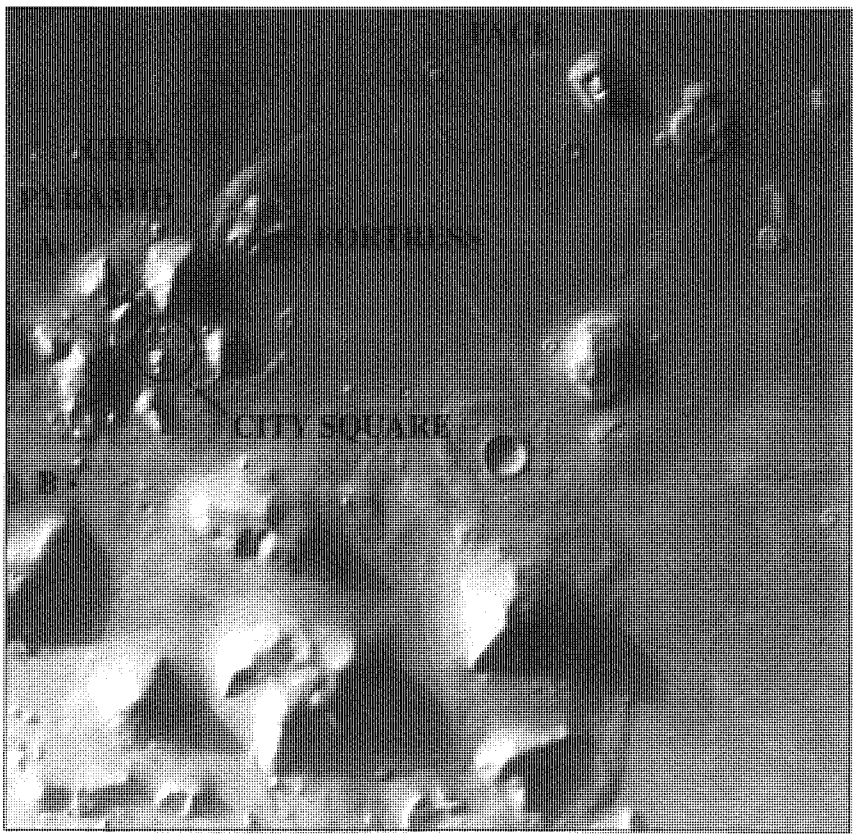


Figure 1. Part of Viking 1 image Number 35A72 indicating the "Face" and "City".

The formations that look artificial include:

1. The "Face".

This is a formation approximately 2.5 by 2 km, that resembles a humanoid "Face" staring up into space. The "Face", according to Dr. Carlotto, who has done original enhancements of the images, possesses all of the salient features of a humanoid face, like eyes, ridge-like nose, and mouth. Also the proportions and relationships between facial features fall within conventional humanoid proportions. This fact is verified by the image 35A72 and image 70A13 (Figure 2), taken at slightly different sun angles. In 35A72 the sun angle is only 10 degrees above the horizon and therefore most of the right side of the "Face" is in shadow. In 70A13 the sun is at about 25 degrees and illuminates more of the "Face's" right side. This second image not only confirms the facial features first seen in 35A72, but also reveals the overall symmetry of the head, the extension of the mouth, and a matching eye on the right side. These features were not visible in 35A72 because they were in shadow.

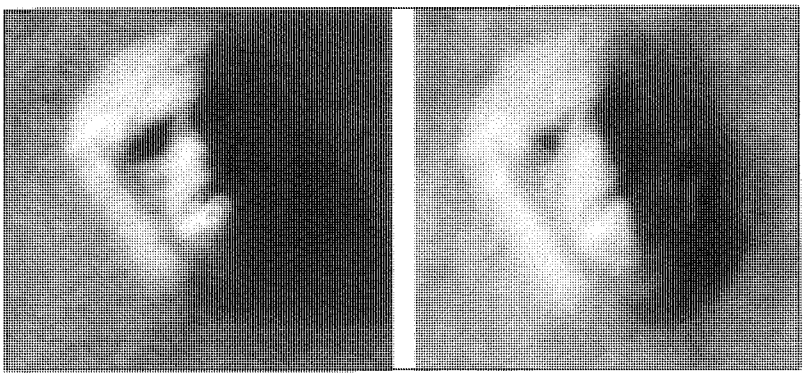


Figure 2. Enlargement and enhancement of the "Face" as imaged in 35A72 (left) and 70A13 (right).

The late Carl Sagan argued that there is a human tendency to see faces in nature, i.e., random features which the brain organises into facial forms. Dr. Mark Carlotto pointed out that although it is possible for natural rock formations to look like a face, they typically do not possess all of the necessary features and are usually not correctly proportioned. Also, the visual impression of the "Face", cannot persist over a wide range of sun angles and viewing geometry. To predict how the "Face" would appear under different lighting conditions and from other perspectives Dr. Carlotto used an image processing technique known as shape from shading and determined the three dimensional structure of the "Face" from its image. The results of this analysis showed that the impression of facial features is not a transient phenomenon and the facial features seen in the image are present in the underlying topography.

The platform on which the "Face" is placed also exhibits a high degree of architectural symmetry. If the "Face" formation is an artificial object constructed long ago, a certain amount of degradation must be expected and does not necessarily rule out the possibility that the object was originally much more symmetrical than it appears today.

2. The "D&M pyramid".

The second anomalous-looking object, called the "D&M pyramid" after its discoverers Vincent DiPietro and Gregory Molenaar, is shown in Figure 3. This formation has a more-than-passing resemblance to a four-sided, or possibly a five-sided pyramid. The three faces to the west, which are not coated with debris, appear remarkably smooth and triangular, separated by seemingly linear edges. The hypothesis that the "D&M Pyramid" is the result of geomorphological processes requires that some mechanism be proposed to account for its formation. This mechanism must be evaluated in terms of its ability to produce landforms with the same general morphology as the object under study. All observations to date of the geophysics of Mars, its gravity, meteorology, geomorphology, etc., indicate that Mars is a place where the laws of physics and principles of geomorphology as we understand them apply, with minor variations due to gravity and atmospheric density and content. As a result, no known natural mechanism can account for the "D&M Pyramid's" formation.

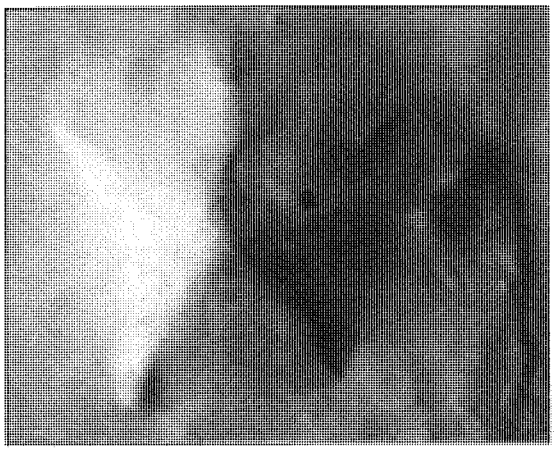


Figure 3. The "D&M pyramid"

3. The "Fortress".

This object has been called the "Fortress" because of its resemblance to such a structure. The Fortress is a geometrically shaped object in the north-eastern portion of the "City", closest to the "Face". The straight sides and sharp angles of the "Fortress" (Figure 4) are in stark contrast to the sculpted appearance of the "Face". In the two available images (35A72 and 70A11) of this object, straight sides or walls are visible.

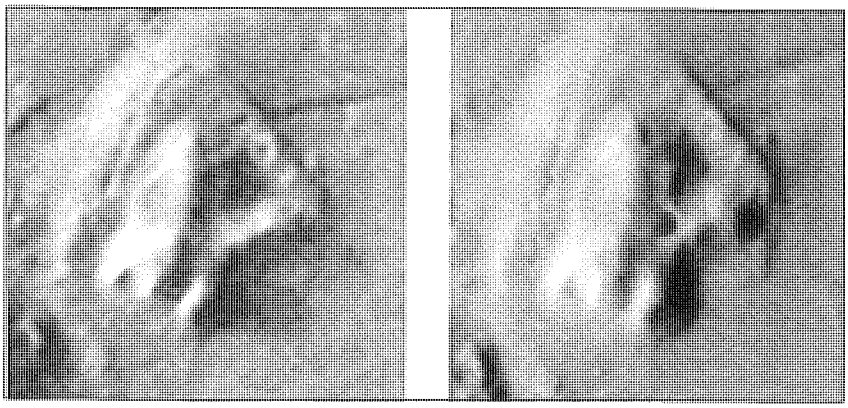


Figure 4. Two images of the "Fortress", from 35A72 (left) and 70A11 (right).

The "Fortress" is the important feature in assessing the artificiality of this collection of objects in Cydonia since it contains internal detail that is hard to explain geologically.

The "Fortress" and the adjacent pyramidal object are similar in size, overall shape, and orientation. Dr. Carlotto suggested that because of this similarity it is possible that if the "Fortress" is artificial, it might have been an enclosed pyramidal structure that collapsed inwards and also that the pyramid next to it might also be hollow.

Figure 5. The "Fortress" and an adjacent pyramidal object

The possibility that the above mentioned formations may be artificial, leaded Dr. Hoagland and others to form pressure groups that forced JPL and NASA to change their policy and try to re-photograph these areas on Mars.

On March 26 JPL/NASA announced that Cydonia would be one of the priority targets for the Mars Global Surveyor (MGS) spacecraft during the month of April 1998. The new on board camera was capable of producing images with a resolution of 10-50 times better than the earlier Viking images. On April 4, it captured the first image. Yielding to pressure for rapid release, JPL/NASA took the unprecedented step of releasing raw, unprocessed imagery to the Internet, hours before good quality, contrast-enhanced images could be attained. Unfortunately, many individuals and media, inexperienced with handling raw images without processing, jumped to conclusions announcing that the "Face" is just a hill. A few hours later JPL/NASA published a processed image that can be compared to the first

"raw" one in Figure 6. This third image was taken from the spacecraft being in a near-polar orbit, with the high-resolution camera. The image is a 4.4-km wide, 42-km long roughly north-south strip across the Cydonia region, in a band that included the "Face" near its center. The spacecraft's orbit passed well to the west of the Cydonia region on this occasion, producing a viewing angle much lower than in any previous imaging having useful resolution. For this reason the eastern half of the "Face" is almost completely hidden behind the nose bridge. This new image shows only the western half of the "Face", the half also prominent in Viking imagery. The lighting conditions corresponded to late morning by local time at Cydonia. However, with the Sun well to the south of the Martian equator and Cydonia 41 degrees to the north, sunlight was also from a low angle to the south-east. Its altitude above the horizon was 25 degrees lighting the "Face" from the chin.

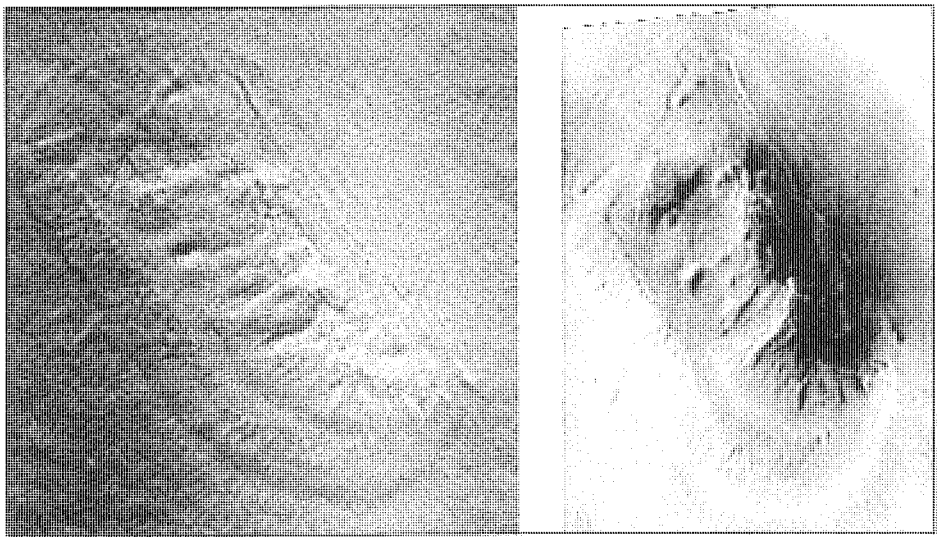


Figure 6. "Raw" image (left) compared to the processed JPL/NASA image (right).

Dr. Hoagland immediately after the release of the data commented on the extraordinarily poor quality of this initial Mars Surveyor image, as well as on the technical history of the "raw" data. He presented persuasive evidence that the image released might not be "raw data" at all but in fact, a second generation, reduced-resolution copy of the original Cydonia image. Responding to the criticisms, JPL apologised and corrected the initial announcement, stating that the image dimensions were not 1024x19200 pixels, 4.42 km x 82.94 but 1024 x 9600 pixels, 4.42 km x 41.5 km, and that the error was due to a typographical mistake. As Dr. Hoagland stresses, this correction means 400% reduction of the image resolution of what it was expected, radically reducing the ability to identify any artificial sub-structures present in the image. Another very important point he mentions, is that the "raw" frame has extremely limited grey scale (only about 42 grey values are represented out of a possible 256), resulting in an extremely "noisy" imaging enhancement, effectively eliminating meaningful comparisons with the previous Viking data. A simple comparison between the new "Face" image and an equally-lit image (70A13), taken 22 years earlier, reveals an apparently completely different scene. The old image is clearly, even to the naked eye, much brighter, and has far more contrast, than the Mars Surveyor record of the same scene, although the MS camera is a far better privately-developed camera.

Although the new image does not reveal the east side of the "Face", it does give the impression of symmetry and shows some extra details that were not seen on the previous images.

In science, as Dr. Tom Van Flandern states, an improbable event that has already happened is called "a posteriori" (after the fact), and generally is taken to have no significance no matter how unlikely it might appear. By contrast, if a certain distinct, highly improbable event is specified in all its detail "a priori" (before the fact), and it happens, that is considered significant, and we are obliged to pay attention. As all this pertains to the "Face" on Mars at Cydonia, the discovery of the face-like object was an a posteriori event. No one predicted it. But once our attention was drawn to this object, anything else found out about it that is highly improbable but related to the artificiality question, becomes a priori.

At Cydonia, almost everything we see in the new, high-resolution "Face" image fulfils highly unlikely a priori predictions. A greatly impressive and highly improbable feature which was found is the "nostrils" (Figure 7).

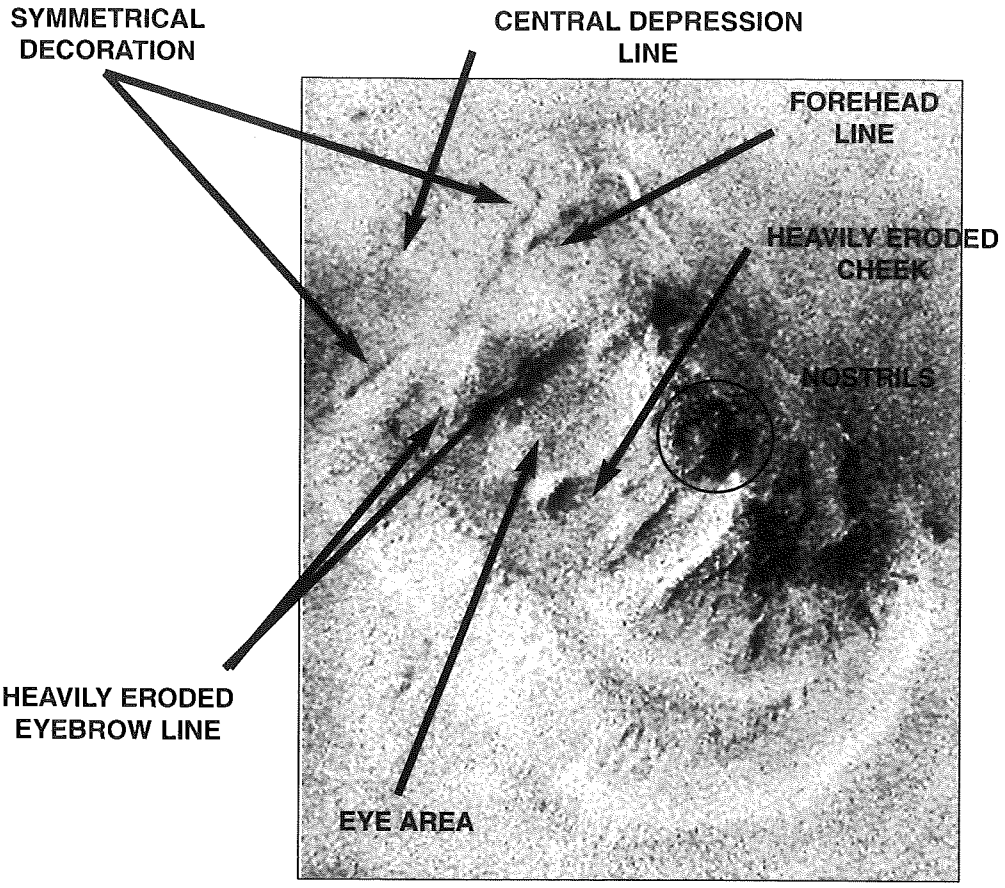


Figure 7. Negative JPL/NASA image indicating the "Nostrils" and "Hair decoration"

The fact that the relative size, positioning, and orientation is correct for nostrils, makes this feature a significant a priori prediction. The additional fact that no other nostril-like features can be found around this area, means that this single feature would be strong evidence for the artificiality hypothesis by itself.

The next very important fact is the confirmation of the symmetrical decoration lines on the hair, on top of the forehead line (Figure 8). The symmetrical decoration lines on the hair where successfully spotted by Dr. Carlotto after a special enhancement of the two Viking images. The new image, also shows a central depression line on the hair, vertically to the forehead line. A feature that will make it easier to determine if the "Face" is artificial or not, is the double symmetrical curved line, marking the end of the hair. Although specialised software is needed for quality enhancements, a simple improvement of the original image (Figure 8), shows that it is improbable that any geological- weathering force can produce this kind of symmetry and at the same time, on the same ground, produce the symmetrical decoration lines and the central depression. A final comment is that the whole formation is heavily eroded, indicating its old age.

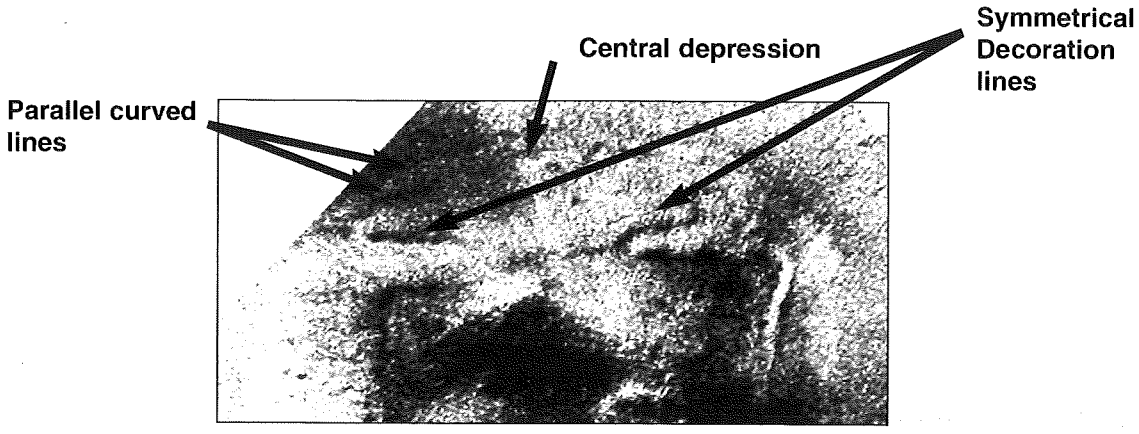


Figure 8. Enhancement of the hair

The second JPL/NASA attempt to image the Cydonia area was released on April 14. The aim was to image the "City Square". This attempt was unsuccessful and instead of this location the image registered the area approximately between A and B indicated in Figure 1. Although this area did not arose any interest beforehand, Dr. Hoagland identifies Giza scale Pyramids depicted on the image (Figure 9).

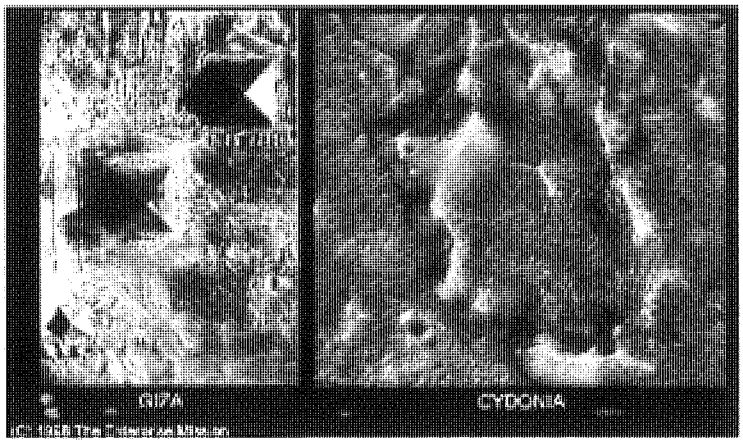


Figure 9. The Enterprise Mission slide, comparing the Giza and Cydonia Pyramids

The third JPL/NASA attempt to image the Cydonia area was released on April 24. The image includes the "Pyramid" of the group that has come to be known as "The City," and among other features the "City Square (Figure 1). Figure 10 shows that the "Pyramid" has at most five sides, and is quite irregular.

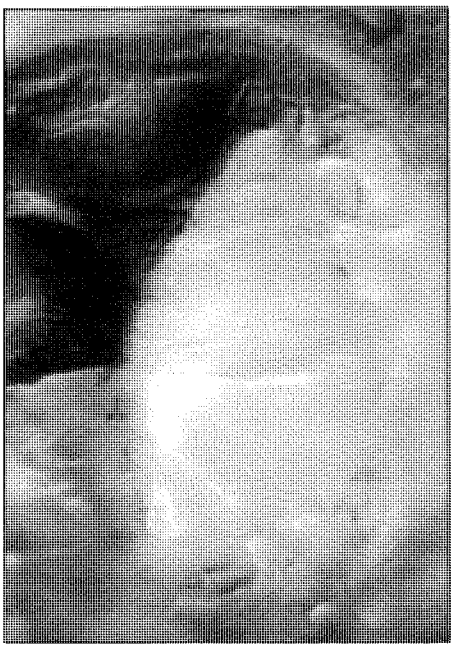


Figure 10. The "Pyramid".

The illuminated side in this image is the side that was shadowed in the Viking images and apparently this side is relatively undamaged and is faceted. Nevertheless, the overall impression is again one of an entirely natural and irregular faceted mountain. This implies that many of the formations in the larger surrounding area, are obviously natural mountains that exhibit similar facets or sharp-edged triangular sides and that the "City" objects are of a similar kind and are not unusual geological features. At the NE corner of the "Pyramid", an odd rectangular formation, which is suggestive of a terraced ledge, can be noticed (Figure 11).

Figure 11. The NE corner of the "Pyramid" and surrounding area.

According to Dr Stanley V. McDaniel, this together with some other, difficult to explain geologically, structures on the near-by area, may be artificial.

Dr Hoagland and others have also published enlargements of various parts of the above images that reveal highly geometric surface structures, with rectangular side-walls which may be artificial (Figure 12).

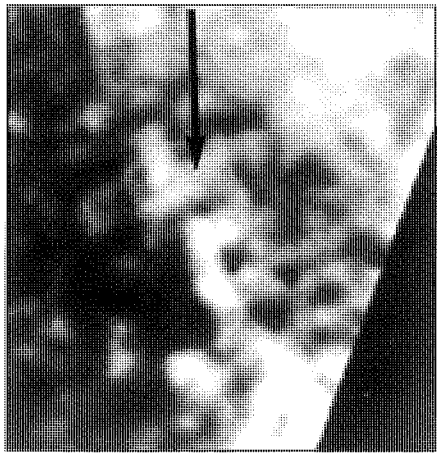


Figure 12. Rectangular side-walls on geometric structures

It has to be strongly emphasized that, if there was once a complex of artificial structures in this area, no one expected to find shopping malls and freeways dotting the Cydonia landscape. Erosion would have destroyed them all. The problem confronting the planetary search for extraterrestrial intelligence is one that demands extremely careful study of features and great care in differentiating eroded natural formations from possibly eroded artificial ones. It seems evident from this perspective that these newly identified features to the north of the "Pyramid" need careful investigation from both geological and archaeological perspectives.

The above presentation indicates that not all information is made known to the public and also that not enough details are yet collected through the Space program. Therefore, definite answers as to what the Cydonia area represents cannot yet be given.

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THE MIDDLE MANAGER IS BECOMING AN ENDANGERED SPECIES

Savvas Savvides HTI Dipl., MBA, I.Eng, FIIE(Elec), Workshop Superintendent, HTI

1. INTRODUCTION

The traditional organisation is a multi-level hierarchical bureaucratic one with a rigid structure, build around the one big brain approach: Management thinks and the workers do. The traditional organisation separates management and workers into two distinct roles. Management defining work methods and processes and exercising top down control and authority through formal hierarchical organisational structure. Workers on the other hand being the executing force, considered as headless workforce without opinion or initiative.

The reasons behind the application of the bureaucratic structure are easily understood when a close look is taken at the environment prevailing. The traditional environment was characterised by a closed economy, strict regulations, life long employment, strong Trade Unions with collective bargaining at its zenith, minimum international competition, stable technology and markets. The environmental change was gradual and slow, technology was not fully developed and management had to control operations and employees through people. So the tall organizational structure with the many management levels, tight control and detailed procedures comes as no surprise.

Recent developments in technology are causing gradual changes in the traditional organisation structure. Computer aided design/manufacturing, systems and information technology together with the developments in telecommunications and networking not only contribute to enormous potential for business improvement but also makes conventional business management practices obsolete.

Organisational structures are changing as a result of technology revolution, globalisation of markets and workforce dynamics. There is a trend towards a flatter more fluid modular type of organisation broken down into autonomous multiskilled self managed groups for quick responsiveness to customers and market changes.

2. WHY IS DELAYERING OF ORGANISATIONS TAKING PLACE

We are living in a competitive age. Organisations are trying to be kept in the business. Successful organisations are those that manage to cut down their operational and production costs and at the same time they can offer prompt delivery and high quality products or services to their customers at competitive prices.

Trends nowadays are to eliminate unnecessary layers of management and supervision (delayering) turning the organisation to a more flexible flattened, and leaner which is more responsive to customer. This is achieved by empowering the employees giving them authority, decision making and organising them in autonomous groups, to

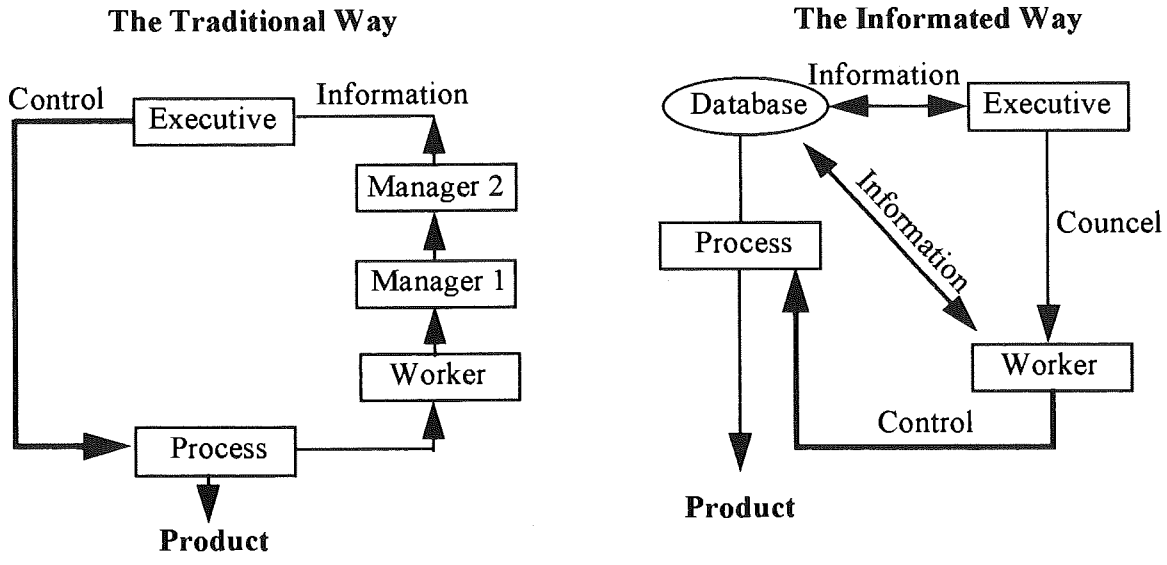

Figure 1: Control Systems : Old and New

make them more responsive to customers and at the same time having the management backing and counseling them rather than controlling and supervising. This makes the organisations more efficient, competitive and most importantly more effective in achieving their goals and targets. In the long run this is beneficial to the organisation itself, the employees and the society in general.

With the introduction of information technology skills, jobs and organisational control processes change radically. As shown in figure 1 the database is an equalizing source of knowledge for all parties.

In the "informated" organisation, workers have access to all the information necessary to perform their jobs and when empowered they can easily perform tasks previously done by supervisors and middle managers. In this way middle managers and supervisors become obsolete and thus delayering takes place.

The middle managers are representing a group of managers that involve senior managers, first-line managers and first-line supervisors. In the traditional organisation they collect information, keep records, write reports and are mainly the link between the workforce on the one hand and the executive management on the other hand. With the information technology and especially the networking of computers and the on-line facility, teleconferencing etc, information that should be previously processed and worked out by the middle managers it is now immediately and readily available at the executive manager computer. This allows quick response and even corrective measures to be taken at once. At the same time the same or other information if required is available at the first line worker station. This makes the intermediary role of the middle manager obsolete and most of its job content taken over by the new information technology system. Statistics and information retrieval that was done by the middle manager in the past it is now done by the computer with a higher speed and most importantly 100% reliable and free from mistakes.

The roles of the executive and the first line worker are now changing and a different relation must be developed between the two in order to have an operational system. In addition the first-line worker must be well educated, trained and empowered in order to be able to take the necessary decisions for improved effectiveness of the organisation.

When computers were first introduced in companies their use was to automate existing business processes in order to speed them up but speeding up those processes could not address their fundamental performance deficiencies. The key to success is not embedding outdated processes in silicon and software but "re-engineering" of business. In other words use the power of modern information technology to radically redesign the business processes in order to achieve dramatic improvements in their performance.

Every company operates according to a great many unarticulated rules. Re-engineering strives to break away from the old rules about how to organise and conduct business. It involves recognising and rejecting some of them and then finding imaginative ways to accomplish work. From the redesigned processes, new rules will emerge that fit the times. By redesigning the processes redundancies of staff occur. Among those redundancies are in most cases those of the middle manager.

In the past organisations were expanding and as long as markets and revenues grew they erected hierarchies to support managers who managed managers. With growth rates leveled off and competition increased companies are losing their stability. Growing consumer demands for responsiveness and quality, force firms to cut down their costs in order to remain in the business and function efficiently and effectively. A method that is used extensively by companies is among other measures the downsizing in staff thus cutting among other staff and the middle management ranks by delayering and getting decision makers "closer to the customer".

3. HUMAN RESOURCE MANAGEMENT (HRM) IMPLICATION ON DELAYERED ORGANISATIONS

A forward-looking human resource orientation is needed in order to manage the change by filling the gap that is created by delayering in a re-organised and restructured organisation. In addition measures must be taken in order to retain, motivate and use effectively the surviving staff from such a change.

The flattened organisation resulting after delayering is much different than the tall hierarchy organisation. Flattened organisations are more proactive than reactive.

The HRM policy choices in M. Beer model regarding employee influence, human resource flow, reward systems and work systems must be seriously considered. These policy choices must be revised accordingly to suit the new

situation of a delayered organisation. The target always being the balance on the long term consequences of these policy choices for the employee well-being, the organisation effectiveness and the societal well-being. HRM policies developed must enhance employee commitment and competence, be cost effective and at the same time must generate and sustain congruence between management and employees.

The following are some examples of the HRM policy areas that must be seriously considered in order to manage effectively the change caused by the delayering in the organisation.

The people who do the job make the decisions as well. Improved performance is for the good of the organisation and of all its stakeholders, including owners, employees customers and the public at large. Therefore bottom-line employees must be empowered and at the same time trained and developed to meet the requirements of the new challenging situation. In addition the organisation must provide the means and processes (which may be more flexible) in order to ensure success. Training and development is also needed to the remaining managerial staff.

As the layers of middle manager are removed the number of people reporting to each remaining manager will increase and instead of 5 to 8 may go up to 15 or 18. The anticipated ratio in the future may be even higher 1:30 or even 1:50. If the existing situation of centralised control continues to be applied, managers will be overloaded, stressed, demotivated and inefficient. It is quite important in this case that managers are trained to delegate authority, empower, trust and coach their people. It is then that the organisation efficiency and effectiveness is achieved, through real commitment of all staff.

A new policy must also be developed in the job design. Job descriptions must define the key result areas but will not act as strait-jacket restricting initiative and unduly limiting responsibility. Jobs must be defined and roles described in ways which facilitate and underline the importance of teamwork. Job designs must cater for autonomy based on the increased use of information technology covering individuals or autonomous working groups.

Development of new recruitment, appraisal and promotion policies for the flattened organisation. Recruited staff must be in accordance with new person specifications, adaptable and 'fit' the corporate culture. Pre-employment education will have to be broad and the need for a range of basic skills will be essential as well as background foundation knowledge that will enable quick training and retraining. Knowledge of computers and hands on experience will be essential.

The system for assessing and improving performance will concentrate on measuring and developing all-round excellence. The highest ratings will be given to those who can make things happen, manage change and adjust rapidly to new challenges and opportunities.

The traditional idea of career development through promotion and move laterally to higher posts is in a way disappearing or limited in the delayered organisation. Dual career ladders may be developed allowing top performing employees to advance just as far and as fast as their managerial colleagues as specialist in the work they do. New reward systems policies must be designed. In flattened organisation where organisational structure requires better teamwork among employees, group bonus or incentive schemes may be more appropriate.

The new flattened organisational structure must be more flexible. No rigid boundaries will exist between departments. In such organisation the HRM manager may not anymore exist but definitely there must be HR policies.

4. CHIEF EXECUTIVE PLANS TO MANAGE THE CHANGE CAUSED BY DELAYERING

The chief executive's duty is to manage the change. In other words the chief executive must make sure that the plans for the change are prepared involving all needed (Unions and Employees if necessary, including outside consultants if required). The organisation policy decisions and the targets set to be achieved with the change must be always in mind when the plan is prepared. Once the plan for the delayering is finalised it must be put forward for action.

Delayering is causing a wave of redundancies. It is quite important for the senior executive to handle the situation so that the least of inconvenience is caused to the organisation. Uncertainty is a very negative factor on all employees so clear-cut steps must be followed.

Once the delayering plans are finalised and the decision to proceed is taken it must be communicated to the employees at once. At the same time generous redundancy settlements involving voluntary redundancy where possible, outplacement benefits, i.e. redundancy counseling and help to find alternative work; generous relocation allowances, retraining facilities; guarantee, if feasible, on loss of pay or status; and a measure of choice about relocation or transfers if possible within other subsidiary organisations must be announced. Of course voluntary redundancy or early retirement scheme may result to situations where you lose the most capable employees. The same may happen if the LIFO (Last In First Out) principle is applied.

Talented middle managers that are phased out by delayering may be retained either for managing special projects or pushed down and retrained accordingly.

Accentuate the positive benefits to the surviving employees which may include increased responsibility, more clearly defined duties, empowering, removal of barriers to communication, new challenges and opportunities, greater security in a more effective and prosperous organisation or the chance to learn new skills.

5. CONCLUSIONS

By delayering the effort is to make the organisation more efficient and effective by cutting down unnecessary layers and obviously cutting costs. This in the long run will have a positive impact on the organisation, the employees and the society.

Information technology can capture and process data and expert systems can to some extent supply knowledge, enabling people to make their own decisions. As the doers become self-managing and self-controlling, hierarchy and the slowness and bureaucracy associated with it disappears.

HRM has to develop a culture in which people "knowledge workers", doing work are perceived as more important than those supervising work. Career paths recruitment and appraisal procedures, training and development programmes, job design procedures, promotion policies and other management systems must be revised accordingly in order to fill the gap created by delayering.

The managerial role is changing from one of controller and supervisor to one of supporter and facilitator.

The chief executive's role is to plan the change and make sure the change is applied with the least of inconvenience to the organisation, the employees and the society. Additionally the senior executive must develop a strategic intention towards strong human resource support programs, retraining and constant attention to the management of survivors.

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A NATIONAL SURVEY FOR THE IMPLEMENTATION OF QUALITY MANAGEMENT SYSTEM STANDARDS IN CYPRUS

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INTRODUCTION

Systems are one of the three basic elements at the Total Quality Management (TQM) concept. Through this article, for the first time in Cyprus, an attempt will be made to present the results of the first part of a National Survey for the implementation of Quality Management System Standards in Cyprus. The purpose of the research was to investigate through a questionnaire and interviews the benefits gained and up to what extent by the implementation of Quality Management Systems. Measuring the performance of an organisation can succeed this. In the current research this was achieved by the use of performance indicators.

TOTAL QUALITY MANAGEMENT AND SYSTEMS

TQM is both a philosophy and a practical working process for companies committed to growth and survival. Its a journey with no destination because is based on the never ending process of continued improvement.

To support this process, TQM is guided by seven basic principles as follows: [Smith S. 1991].

* The approach : Management led
* The scope : Company - wide
* The scale : Everyone is responsible for quality
* The philosophy : Prevention not detection
* The standard : Right First Time
* The control : Cost of Quality
* The theme : Continued improvement

A TQM organisation is one that is totally committed to quality and focuses all their processes to the customer, continues improvement on the use of the scientific methods/techniques. Perfection is the goal and preventing mistakes to occur instead of detecting them. Also through the use and mobilise expertise of work force, the decision based on facts and finally the feedback from every process they are trying to do thinks right first time.

All the above mentioned could be achieved through the universal participation of everyone, everywhere, individual and teams.

The whole process has as a result not only satisfied customers but in some case exceeding expectations. More specific there will be a better image of the organisation, increase of productivity, cost reduction, certainly of operations, morale, teamwork - unity and improved management resulting to satisfying internal and external customers.

There are three factors/elements that dictate how a TQM organisation functions and how that organisation is perceived. These have been described as people, tools, systems [Angeli I, 1993]. Success comes from the right balance between these factors which should be supported.

QUALITY MANAGEMENT SYSTEMS

It is beyond the scope of this article to explain the meaning and importance of the implementation of QM systems standards to the success on every organisation. What will be presented, are the benefits of the implementation of such as systems, which are likely to be very new for the Cyprus case.

In a similar research [Angeli I 1993] executed in 1992, only a small proportion of organisations had written instructions and used QM systems (usually multinational). But none of them was certified with any international standard in Cyprus by that time.

The great need (not simultaneous recognition of the importance of implementation of QM systems) for QM systems came after the continues reduction of competitiveness, market share and profitability of the Cyprus Manufacturing Industry in 1988.

Too many attempts were made, are made, and will be made to stop the declining trend of manufacturing industry. The majority of those attempts were sporadic coming from individual, disorganised and the most important there were not a part of a strategic plan to upgrade the industry, in spite of the fact that there were survey experts reports and strategic plans. So the great majority of all activities were centered on how to save the industrialists from being drawn by giving them lifesavers instead of teaching them how to swim.

Some of them understand and listen to the market messages the European Union and the Cyprus Standard Organisation and with their own initiatives they have adopted the scientific approach and implemented QM systems. The first and the only available corrective action which come into their mind or promoted was the international quality system standard ISO 9000. Very few knew other methods or TQM by that time. [Angeli I. 1993]. The rate of certifications with ISO 9000 is exponential for the total life of five years of the standard in Cyprus. There are now 40 organisations with ISO 9000 certificates from CYS, ELOT, BSI, DIN etc.

After five years of life of the standard in Cyprus is time to investigate whether the standard and the way the Cypriot Industrialists implement it brought the expected results, benefits, improvements, and up to what extend. Does the standard add any value to the quality of the product or service? This report will not only give some answers to the above questions but it will also cover some other elements such as implementation cases, usefulness, reasons for certifications, problems and drawbacks etc.

RESEARCH METHODOLOGY

The whole research was carried out under the supervision of Higher Technical Institute and the University of Glamorgan in collaboration with the Cyprus Standards Organisation. The three institutions supplied the researchers with the appropriate means to carry out the research. A special questionnaire (26 questions) was prepared and used for the purpose of this research. Old questionnaires of similar surveys in Cyprus and abroad were used. Also the aims and objectives as well as the directive lines were seriously considered.

The survey targeted the 100% of the certified organisations with any QM system standard. After the preparation of the list an appointment for an interview was arranged either with the Director or the Quality Manager of the company. This enabled the researchers to have personal conduct with responders.

The results of the first part of the survey were completed on April 1998. The second part of the survey (June - September 1989) was targeting the same amount of British companies. In completion of both surveys a comparison of the two countries will be possible leading to reliable results and massages for both countries especially for Cyprus. The most important results were selected and presented in this article offering valuable information to Cyprus Industry and those companies that are now on the decision stage.

RESULTS AND DISCUSSION

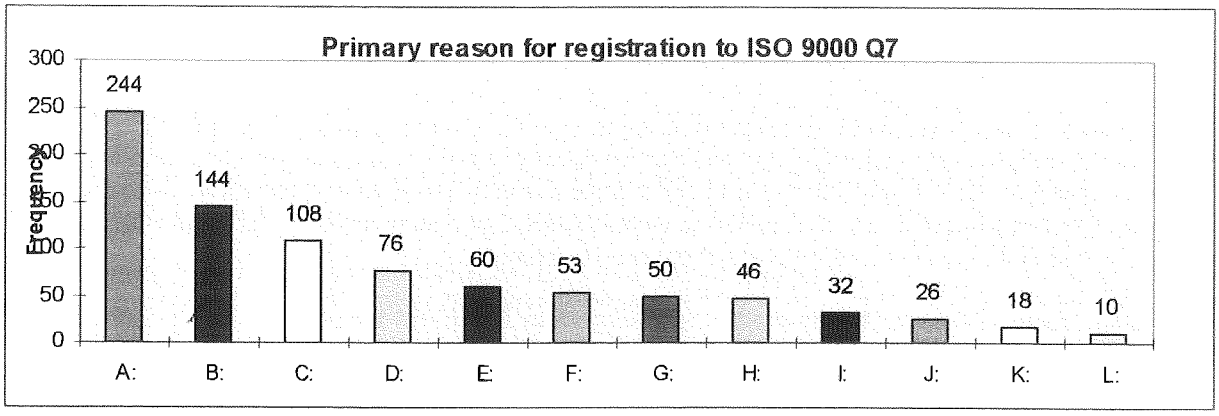
a) general characteristics

The research which lasted two months (March-April) 36 Cyprus companies participated from 8 different sectors, 60% manufacturing, 40% from service industry. The responders, mainly directors, were coming from certified companies with ISO 9002 80% and ISO 9001 20%. The great majority of organisations receive their certificates after 1996 (83%). This is why in the relevant question about years of experience on quality , 60% declare they have more than 5 years experience, 15% 3-5 years and 25% 0-3 years.

They were asked to rank the primary reason for registration to ISO 9000. The cumulative numbers of each reason is shown on Figure 1; the top 3 are quality benefits, marketing advantage and management benefits.

b) Suppliers/subcontractors

The importance of the standard is also demonstrated in the selection of their important suppliers and subcontractors. Cypriot industrialists always ask for ISO 19%, sometimes 75%, and only 6% never ask. They ask for it but 72% of them do not think that the country of origin of the certificate has a role to play neither the certifying body 62%. This is not happening in Europe where they accept certificates issued only by Qnet.



INDEX

A: Quality benefits
B: Marketing advantage
C: Management benefits
D: Reduced cost of production
E: Part of larger strategy
F : Direct request from customer
G: Competitive pressure
H: Need for a EU goverment requirment
I : Gain new customers
J : Profitability reasons
K: Regulation / Registration

Figure 1: Primary reason for registration to ISO 9000

c) Organisational needs coverage of the standard

It is well known that the standard covers at its great extent the majority of any organisational needs. The 12 different organisational needs investigated are covered by the standard very well at a range of 40 to 90%, medium from 15 to 40%, poor from o to 15% and 0 to 54% no relation (design 54, economics 53%).

d) Organisational performance

The most important question was the one investigating if and up to what extent the system standards improved the performance and benefits of each particular organisation. By using performance indicators used in similar surveys one can identify in Figure 2 where and how much there is improvement in percentages. The results are very encouraging. Taking the worse case of improvements that ranges from 0 to 20%, the percentage of organisations falling into that category are from none to 30%. The rest 70% gained greater percentages of improvements.

Similar survey in the UK [Manchester, 1995] showed that on average there is an increase of 40% on sales in certified companies and 7% in national levels.

The profitability and performance of an organisation can be measured through quality costs as specified by the British Standard BS 6143 part 1&2. Considering the above standard organisations were asked to state whether the four cost categories were increased or decreased. The detail results of those costs are shown on Figure 3. The results were the expected ones and are very close to other similar surveys and calculations of organisations that are at the first stages of any quality improvement program. There was an increase on costs adding value to the products or services (appraisal and prevention costs) and decrease on those which are not conforming to company or customer requirements/specifications. One of the quality gurus Philip Crosby divides those costs into two categories, the Price Of Conformity POC and Price Of Non Conformity PONC.

The major purpose of the implementation of a quality system is to improve the quality and service offered to the customer and increase market share and profitability. Those two indicators were reported and their results are shown on Figure 4 for market share and 5 for product quality.

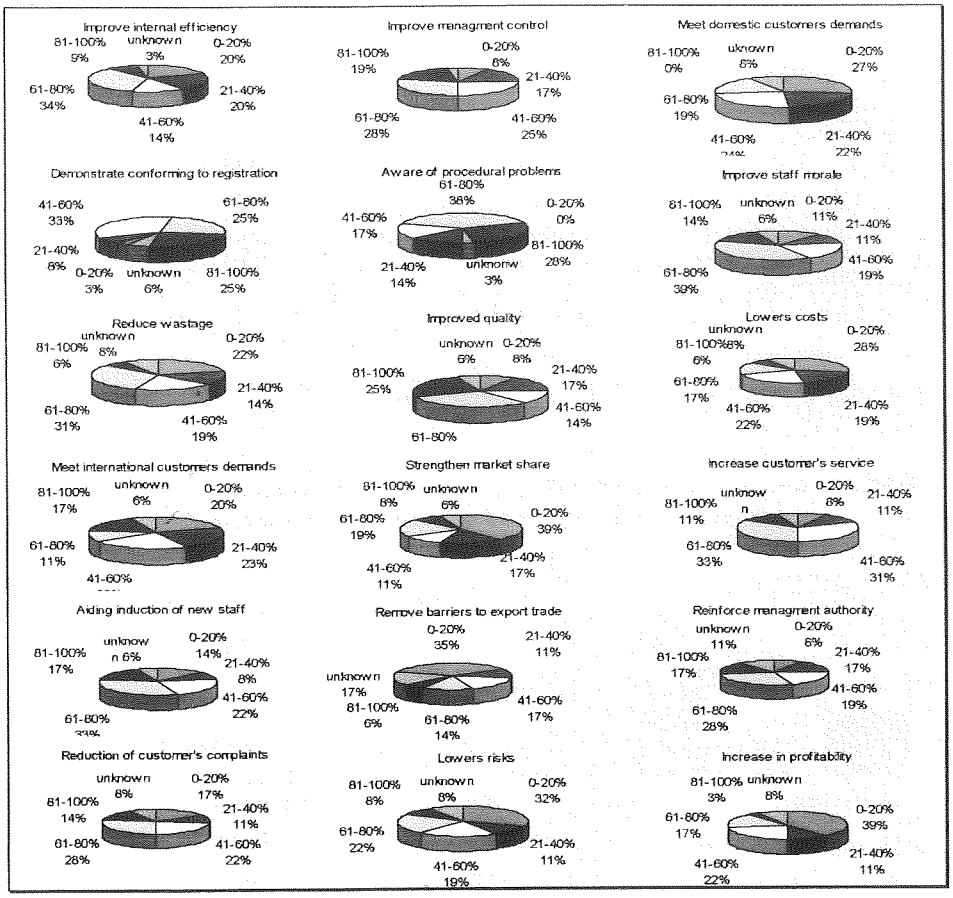


Figure 2: How much the performance/benefits of an organisation were improved with the implementation of international standards

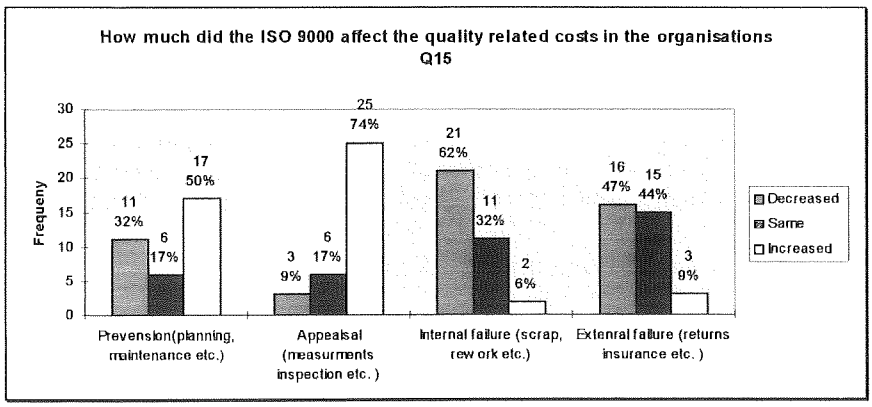


Figure 3. Changes on Quality Costs

e) Importance and future of standards

QM systems are quite new in Cyprus compared with product certification. That is why 80% of respondents believe that both certificates are of equal importance to quality assurance. They were also asked to evaluate the importance external factors /bodies are paying to the QM systems. The results of the 8 statements are too many but very briefly Cypriot industrialists believe or agree that:

- Foreign customers increasebly request ISO 9000 certification 70%
- Foreign customers are unwilling to accept ISO certificates issued by bodies other than their own national certification bodies 17%
- It is costly to secure certification from a certification body operating internationally 62%
- ISO 9000 will do little to expand on international trade 33%

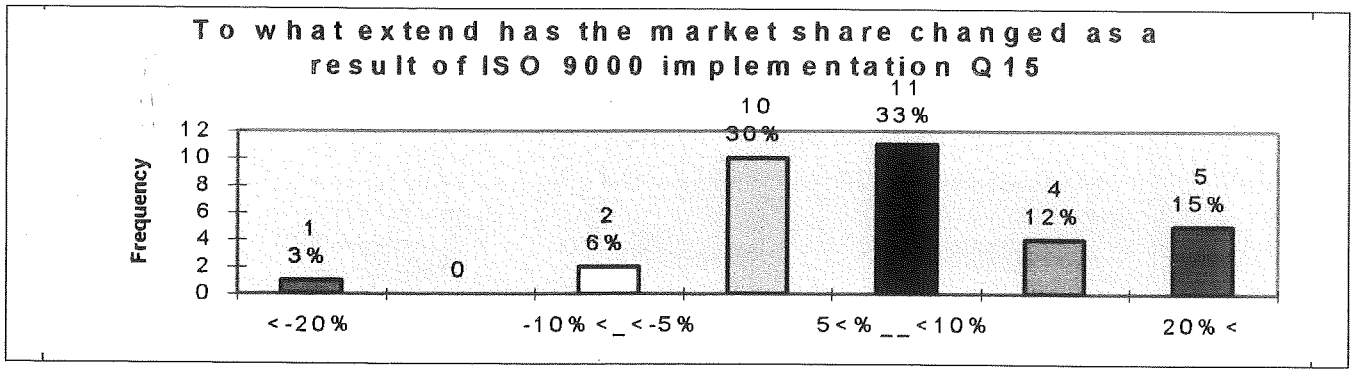


Figure 4. Changes in market share

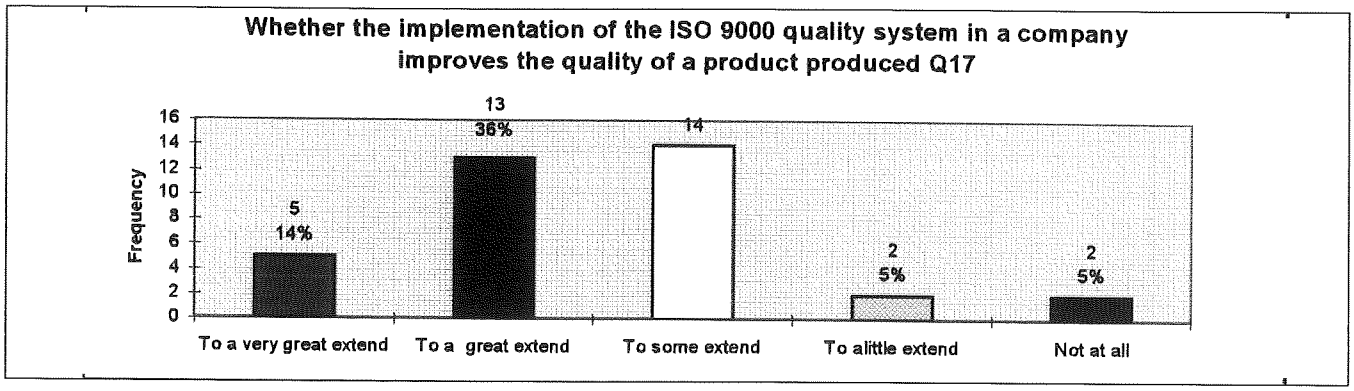


Figure 5. Improvement of product quality

- Exporters face problems because ISO 9000 registration certificates are not always recognised in foreign countries 22%
- ISO 9000 registration helps domestic producers to compete against imported products 69%
- Small companies benefit more than large companies from ISO registration 33%
- If all companies registered to ISO 9000 certification it will be the beginning of itís elimination 39%

Awareness of QM systems is considered to be the cornerstone for the acceptance and implementation of quality systems. It seems that the great majority of organised bodies, industries, government, consultants, chambers, educational establishmentsí etc are aware of the ISO 9000 series. Exceptions are unions and industries as a whole.

e) Direct and indirect costs for registration and certification

I) Registration and certification costs.
The range of the above costs is large starting from £500 to £4000 with an average of £1530. Response rate 66%.
II) Consultancy fees
This cost start from zero (no consultant was needed) and it rises up to £25000 with an average £8000. Response rate 66%.
III) Man-hours
An important expenditure is the time utilised by management or employees for the preparation of documents and certification. These man-hours could be 200 to as high as 12000 with an average of 2000 hours. The response rate was only 40% due to difficulties in calculating time or keeping records. Those companies answered the above question were requested to convert the above time into money. So the minimum is £2000 and maximum £34000 with an average of £9500. It is important to mention that the cost of man-hours is well above the summation of certification and consultancy fees costs.
IV) Miscellaneous
Something, which is difficult to measure, is indirect cost related with certification, that is why only 11 out of 36 organisations gave data. Those costs ranges from £500 to £20000 with an average of £4000.

CONCLUSIONS

In the previous pages some of the most important results of the research were presented. It is very difficult to deal with the results of the 25 questions. Those results could only be seen on the major project report [Kasinides E. 1998]. Further more the second part of the research in the UK has not been completed yet. So no comparisons between the two countries (the top in registered firms and one of the smallest) can be made.

There is no doubt that the research was successful, accurate and the positive results and messages will contribute very much to the systems standards improvement and better image and to those who are the decision stage to go for it or not. Those result performance indicators will help the Cypriot industrialists to take the right decision for them based on scientifically collected statistical data.

The main conclusions of this research are summarised very briefly below in the way they appeared in the questionnaire:

1) The organisation experience in the field of quality is limited to 0 and 10 years.
2) The primary reason for registration is quality benefits, marketing advantage, and management benefits.
3) ISO 9000 series are well known but the other quality related standards are of limited knowledge.
4) The majority certified companies prefers suppliers or subcontractors that are registered.
5) The majority feels that ISO 9000 certificates are of equal value regardless of country of origin and registration body.
6) Half believe that there should be variation of the standard to be provided for specific industry and business sections.
7) The standard covers the majority of organisational needs. Some of them are not covered.
8) There are improvements in performance and benefits through the implementation of QM system standards in all 18 areas selected for investigation.
9) In general the positive quality costs (prevention, appraisal) were increased but the negative costs (internal & external failure) with impact to customers were decreased.
10) The majority of organisations had increased their market share.
11) The quality of products and services improved to the great majority of firms.
12) The implementation of ISO 9000 showed some disadvantages and problems. Approximately 45% of organisations answered that they faced those problems from 0 to 20 to the scale of 100.
13) The great majority of firms believe that product certification is of equal importance as system certification.
14) The industrialists believe that customers will ask for ISO, accept certificates, have certification from abroad, the ISO will expand, will help domestic producers to compete foreign, large companies benefit more.
15) Registration certification fees, min £500 max 4000 average 1530
    Consultancy fees, min 0 max 25000 average 8000
    Man-hours expenditure min 200 hours max 12000 average 2020
    Man-hours converted to money min £2000 max 36000 average 9500
    Other resources/expenses min £500 max 20000 average 3900

In conclusion, quality management systems are the beginning of any quality initiative and the cornerstone where the whole building of TQM will depend on, reinforced by people and tools. Systems by their own can not lead organisations to excellence and market leadership. What is needed is the basic principle of TQM, which always should be considered with quality systems 'Continued Improvement'

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THE DESIGN OF LOW VIBRATION DOUBLY SALIENT MOTORS

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Abstract Structural Finite Element Analysis is uded to investigate potential improvements in the design of low vibration, doubly salient switched reluctance motors (SRMs). The natural modes of vibration of a 4-pole round-stator are examined. The dynamic response of the machine stator when electromagnetic forces are applied at the stator poles is fully examined in this paper. The 4-pole, round-stator switched reluctance motor is compared with a common square-stator motor as well as a novel square-stator structure, in which the poles are positioned at the square corners. Other machine design cues aimed at reducing vibration, such as addition of pole fillets and the choice of suitable back iron width, are investigated.

1. INTRODUCTION

Variable speed, doubly salient, switched reluctance motors [1,2] offer substantial benefits in many applications, owing to their simple and rugged construction, reliable operation and high efficiency. However, the technology has not yet fulfilled its potential due to the increased vibration that some designs exhibit during operation, in comparison to competing motors.

This paper will employ Static Electromagnetic as well as Modal and Time History Structural Finite Element Analysis to investigate the characteristics of a switched reluctance machine (though the procedures adopted are equally applicable to other types of machines). Finite Element Analysis (FEA) is now considered to be the most established computer-based numerial method for solving problems ranging from electromagnetics to thermal, structural etc. The paper presents a detailed analysis of the dynamic response of the machine stator, when a force of an impulsive nature is applied at the 'electrically excited' stator teeth. The manner in which a vibration mode is 'excited' by a radial force pattern is presented. The vibration modes and 'forced responses' of a 4-pole, round-stator switched reluctance motor are compared with a common square-stator responses' of a 4-pole, round-stator switched reluctance motor are compared with a common square-stator motor as well as a novel square-stator structure, in which the poles are positioned at the square corners.

Aspects of machine design which, when adopted, can reduce vibrations are also examined in this paper. The more conventional 4-pole round stator is employed to investigate the effect of the stator yoke thickness (back-iron width) on the natural frequencies of vibration of the stator, as well as the stator forced response. In addition, the potential benefits of including fillets at the stator pole corners are also investigated.

2. SWITCHED RELUCTANCE MOTOR CONFIGURATIONS

The simplest switched reluctance motor and power converter is single phase, the most common forms being the 2/2 and 4/4 configurations (where the numbers refer to the stator teeth / rotor teeth respectively). Single phase motors can operate at very high speeds before their performance is limited by excessive eddy current losses.
A 2-phase 4/2 machine is also a low cost switched reluctance alternative; it is the minimum configuration that avoids zero torque zones and can be driven by low cost converters.

If features such as forward / reverse operating capability, high starting torque and smooth torque profile are required, 3-phase 6/4 and 12/8, 4-phase 8/6, and 5-phase 10/8 motors may be used.

This paper will investigate the structural characteristics of 4-pole stators, commonly found in the 1-phase 4/4 and 2-phase 4/2 motor configurations.

3. INTRODUCTION TO NOISE AND VIBRATION IN SWITCHED RELUCTANCE MOTORS

The possibility of increased vibration levels in switched reluctance motors arises from the pulsed nature of torque production in the motor. Recent research efforts [3-6] have, in summary, demonstrated the following:
(a) In SRM operation, opposite stator poles forming a 'phase' are excited simultaneously. Phase excitation generates not only tangential forces but also radial, which deform the stator. Stator vibration is the main source of acoustic noise in SRMs.
(b) The frequency of the phase current pulses injected in the motor, in relation to the natural frequency of stator vibration, play an important role in the amplitude of vibration.
(c) A step change in the voltage applied to a motor phase winding, causes a step change in the variation of radial force acting on the stator with time, and leads to vibration.
(d) Significant stator vibration is produced when the phase current is commutated. A smaller vibration is also produced when the phase current is first turned on and when current chopping begins. This is because the largest step change in the gradient of the radial force occurs at the current commutation point. At the phase current commutation point the radial force changes suddenly from increasing to decreasing and the stator first tends to accelerate outwards, away from its compressed state, initiating a large vibration. The stator vibration is such that the instantaneous value of acceleration decreases and becomes negative and then subsequently oscillates as a damped vibration.

4. ELECTROMAGNETIC AND STRUCTURAL FINITE ELEMENT ANALYSIS OF SWITCHED RELUCTANCE MOTORS

In general, vibrations produced by the SRM can be reduced either by performing Modal and Time History Structural Analysis and systematic improvement of the stator design, or by adopting electronic control methods (such as smoothing of the current waveform or active noise cancellation). The former method is used in this paper.

Electromagnetic and Structural FEA can help to evaluate different motor designs by examining their adherence to the mechanical and electromagnetic requirements. An optimum motor design for a specific task (such as a low vibration or/and high efficiency motor) can be produced by assessing tradeoffs in mechanical and electromagnetic design.

The Static Electromagnetic FEA program can compute the MMF required to establish the **B**-field in the motor. Electromagnetic forces acting on the stator and rotor can be readily evaluated within the FEA environment. Subsequently Modal Analysis of the stator structure (in Structural FEA) can be used to identify the natural frequencies and modes of vibration.

The dynamic response of a stator design can be examined using the Structural FEA Time History module, whereby a force function is applied on the structure and the resulting deformation is analysed. In this paper, the results of Structural FEA on 4-pole motor structures (used in 1-phase 4/4 and 2-phase 4/2 motors) are presented, in the pursuit to determine which structure exhibits less vibration compared to alternative designs. Systematic improvements on the SRM stator design are subsequently carried out.

4.1. Analysis of the 4-pole round-stator design

4.1.1. Electromagnetic Analysis of the round-stator 4-pole motor.
A 4-pole round stator was selected, 90 mm in diameter with a tooth width of 16.4 mm and a back iron which of 7.3 mm. The dimensions of the structure were set to be more appropriate for 2-phase 4/2 motor operation. A two-dimensional electromagnetic finite element model of the 2-phase 4/2 motor (with stator dimensions as described) was created by describing the projection of the three-dimensional geometry onto a two-dimensional plane cross section. Two independent finite element meshes were created and subsequently 'stitched', namely the stator and rotor meshes. The finite element mesh was created such that solutions to the problem at different rotor positions could be obtained by allowing the rotor to rotate, in steps of one degree, with respect to a fixed stator position. A plot of the vector potential distribution in the motor at the 38° position as obtained from FEA is shown in Fig. 1.

In order to compute the maximum radial force acting on the stator poles, the rotor was placed in the aligned (90°) position and maximum current was injected to establish the **B**-field in the motor. Electromagentic force was

obtained by evaluating the Maxwell stress integral, defined (for the x-oriented force, F_x, for example) as

$$F_x = \frac{1}{\mu_0}\int_l \frac{1}{2}(B_x^2 - B_y^2)\underset{\sim}{x} + B_x B_y \underset{\sim}{y} \tag{1}$$

over an appropriate arc in the airgap region, and computing the Maxwell Stress integral. The maximum radial force acting on the excited stator poles was calculated to be 10 N/mm stack length (at the aligned position).

The radial force was computed at other rotor positions, such as the 'unaligned' position as well as positions within the 'overlap region' (the region where the stator and rotor poles overlap). It was found that within the overlap region, where significant torque is produced, the radial force increased linearly with position to reach a maximum at alignment, provided the iron did not operate deep in the saturation region.

4.1.2. Modal Analysis on the round-stator 4-pole motor

A free-free model of the stator was used for investigating the natural frequencies and mode shapes of the stator. Solution to this problem involves a search for non-zero solutions of the equation

$$[M]\{\ddot{x}\} + [K]\{x\} = 0 \tag{2}$$

where

$[M]$ is the mass matrix
$[K]$ is the stiffness matrix
$\{x\}$ is the displacement
$\{\ddot{x}\}$ is the acceleration

If it is assumed that a solution of the form

$$\{x(t)\} = \{x\}e^{t\omega t} \tag{3}$$

exists, then

$$\{\ddot{x}\} = -\omega^2\{x\}e^{t\omega t} \tag{4}$$

and Eqn. 2 becomes

$$([K]-\omega^2[M])\{x\}e^{t\omega t} = 0 \tag{5}$$

for which the non-trivial solution is

$$|[K]-\omega^2[M]| = 0 \tag{6}$$

giving N values of ω^2. Subsituting this into Eqn. 3 gives a set of $[\Psi]$ and $[\omega^2_r]$ eigenvalues and eigenvectors where ω, is the natural frequency corresponding to the $\{\Psi\}_r$ mode shape.

The first 12 natural modes of vibration of the round stator 4-pole SRM are shown in Fig. 2. The analysis was actually more extensive and computed the first 17 modes (up to 40 kHz), in order to take into account the effects of high frequency mode shapes later in the analysis. The second mode shape is an oval type shape found at 2376 Hz (Ref. Fig. 2 - mode 2). Characteristic of a round stator SRM is an oval shape mode, changing to triangular (5581 Hz), then square (11154 Hz) etc. i.e. there is a gradual increase of the sides of a polygon with ascending natural frequencies.

The SRM can be 'excited' and made to vibrate on a particular mode shape, if the electrical excitation pattern (dictated by the number of phases and the number of poles per phase) coincides with a particular mode shape. For example, mode 2 in Fig. 2 can be 'excited' in the 2-phase 4/2 motor, in which two opposite stator poles are energised (electrically) at any time. Mode 6 would be 'excited' if the structure operated as a 1-phase 4/4 SRM, in which all four poles are energised at the same time. Mode 2 (2-phase operation) and mode 6 (as the possibility of 1-phase operation presents equal interest) will subsequently be investigated in detail.

4.1.3. Time History Analysis on the round-stator 4-pole motor (Forced Vibration)

The Time History Analysis Module of the Structural FEA program may be used to examine these 'forced vibration' patterns. Using 'Time History', force functions may be applied at selected points on the stator structure for a predetermined period of time. The structure is subsequently left free to vibrate and the 'response' of the structure to the forces applied can be examined.

An n degree of freedom system, with dynamic loads, F_n, applied at different points, can be described as

$$\ddot{x}_i + 2\zeta\omega_i\dot{x}_i + \omega_i^2 x_i = \Psi_{1i}F_1 + \Psi_{2i}F_2 + \ldots\Psi_{ni}F_n \tag{7}$$

The corresponding solution to this system, i.e. the time-domain response is given by

$$\begin{aligned} y_1 &= \Psi_{11}x_1(t) + \Psi_{12}x_2(t) + \ldots + \Psi_{1n}x_n(t) \\ y_2 &= \Psi_{21}x_1(t) + \Psi_{22}x_2(t) + \ldots + \Psi_{2n}x_n(t) \\ y_n &= \Psi_{n1}x_1(t) + \Psi_{n2}x_2(t) + \ldots + \Psi_{nn}x_n(t) \end{aligned} \tag{8}$$

where

y_i is the response
ψ_{ii} are the mode shape factors
$x_i(t)$ are time varying functions.

Figure 3 (a) illustrates 'photo' responses (i.e. responses at certain instants) of the 4-pole motor (operating as a 2-phase 4/2) to a force of 10 N. The force was entered in the form of a rectangular pulse function of finite duration (Ref. Fig. 4 (a)), applied at the edges of two opposite stator poles. It can be seen that the stator vibrates in an oval shape, similar to natural mode 2. It is therefore demonstrated that a vibration mode will be 'excited' when the radial forces on the stator poles deform the stator into that natural vibration mode. Figure 3(b) illustrates 'photo' responses of the 4-pole motor operating as a 1-phase 4/4. The stator now vibrates in the 'square' shape mode (natural mode 6).

Vibration of the stator principally in the natural mode excited, does not preclude the presence of other modes (with a smaller amplitude) in the vibration. The complete response of the 2-phase 4/2 system, i.e. the stator displacement against time graph is shown in Fig. 5 for two rectangular pulses of different duration applied. It has been found that, although the dominant mode of vibration is the oval, the shorter the pulse, the greater the relative amplitude of higher order harmonics is (Ref. Fig. 5(b)), distributing the energy in a wider frequency band.

4.2. Square-stator designs

Many companies show preference on square stator SRMs for particular applications, and common practice has it that poles are positioned in the middle of each square side. Keeping in mind that any comparison of different SRM designs should be carried out on an equal 'torque per unit volume' basis, a square stator structure was formed with a cross-sectional area, stator bore, yoke thickness and pole width equal to that of the round stator, as shown in

Fig. 6(b). A further configuration, proposed by the authors, was modelled in which the poles were positioned diagonally (in the corners of the square) as shown in Fig. 6(c) (hereafter called 'diagonal-pole square stator').

Table 1 illustrates a comparison of the natural frequencies of vibration between the round stator, 'regular square stator' and 'diagonal-pole square stator' SRMs. The shaded frequencies in Table 1 represent the mode shapes which correspond to the excitation pattern of the 2-phase 4/2 and the 1-phase 4/4 motors (the higher frequency corresponding to the 1-phase 4/4 excitation pattern).

The pure 1-phase excitation mode is at 13 kHz for the 'square diagonal-pole' structure. Therefore, upon application of a force function, reduced relative displacement is expected from this proposed structure operating in 1-phase mode, especially against the 'regular square structure' , in which the 1-phase natural mode pattern occurs at 6kHz. The 'regular square stator' has, however, a natural 2-phase excitation mode of marginally higher frequency.

4.3. Forced Response Considerations

4.3.1. Rectangular force pulses

In order to determine the relative maximum displacements of these structures, the 'forced vibration' patterns were examined i.e. a force (in the rectangular pulse form) was applied at the stator poles and the deformation was recorded.

Initially, pulses of different widths were applied to the structures, at the two opposite stator poles. This corresponds to the 2-phase 4/2 excitation pattern. Maximum displacement figures in the two axes of the 2-dimensional plane, as well as the stator pole displacement, were recorded in each case. It was observed that with a very long rectangular pulse, the 'regular square stator motor' deflected the least. This was expected because this structure has the highest frequency of vibration in that particular mode and, as the pulse was long, most of the energy was distributed in lower frequencies. On the contrary, with a very short pulse, the energy is distributed in a wider frequency band and the 'diagonal-pole square stator' exhibited lower displacements, though the signal contained higher frequency harmonics. The displacements of the structures at these two extremeties are summarised in Table 2.

Model runs were also performed on the 1-phase 4/4 excitation pattern, i.e. a force was applied at all four poles. Simulations with pulses of varying widths demonstrated that the 'diagonal pole stator' always deflected the least. Results from these simulations are shown in Table 3.

4.3.2. Two-slope ramp force functions

The two-slope ramp force function (Fig. 4(b)) is a very good approximation of the radial force function acting on the stator teeth during a step. As observed in Electromagnetic FEA (Ref. Section 4.1.1.) the radial force increases continously during the region of overlap between the stator and rotor poles. At commutation the force decreases (with a steeper ramp) back to zero. A rotor speed of 20,000 rpm was selected to implement the ramp function for the 1-phase (all poles excited) and 2-phase (two opposite poles excited) excitation modes.

Figure 7 depicts the 'response' of each structure to a ramp pulse applied at two opposite poles (2-phase excitation mode) and all four poles (1-phase excitation mode). It can be observed that upon application of the force, the structure is displaced radially inwards to reach a maximum displacement just before the current is commutated. The structure then moves back towards its original state and is then released to vibrate freely.

With the 20,000 rpm pulse the 'square diagonal-pole' structure exhibits the smallest displacement in 1-phase mode and is far superior to the 'regular square' and the 'round' structures. This trend has actually been confirmed using pulses of varying rotor speeds up to 20,000 rpm. In 2-phase mode, the response of the three structures does vary with the pulse width (which is dictated by the rotor speed) and no single structure seems to offer far superior performance compared to the others. With the 20,000 rpm pulse presented in Fig. 7 the 'diagonal-pole square' exhibits the smallest displacement.

4.4. Discussion of the results

4.4.1. Modes of vibration requiring further investigation

It was previously stated that the principal source of vibration in the SRM is the stator deformation due to radial

forces. There are, however, modes of vibration (such as mode 5 of Fig. 2) identified by the authors, which may be excited by a combination of radial and tangential forces, exerted on the stator poles during the torque producing periods. In the region of overlap between the stator and rotor poles, the tangential force is at its peak, while the radial force is increasing continously. If the phase is commutated at positions well within the overlap region, the force acting on the poles at that instant will be the resultant of the radial and tangential componets and may well 'excite' mode 5. Such modes need to be further investigated in the future.

4.4.2. Copper loss consideration

When carrying out structural FEA studies, it is also important not to lose sight of the final goal of the designer, which is to design a motor producing a pre-defined Torque per unit Volume, possibly with a pre-defined efficiency. Therefore, any structure must be scrutinised for the space it offers to phase conductors, as the conductor area dictates the principal source of loss i.e. copper loss. Concentrating on the two different square stator designs, it is safe to assume that flux paths, flux densities and MMF drops will be similar. It is also evident that the overall copper area of the 'diagonal-pole square stator' is smaller compared to that of the 'regular square', hence the concern for greater copper loss arises. However, if the 'useful' winding area is considered, this handicap is not significant: Coils are usually pre-wound on bobbins and slotted onto the poles, as shown in Fig. 8. Calculations based on this assumption show that the 'regular square' area is 149 mm^2 against 140 mm^2 for the 'diagonal-pole'.

It is more difficult to extract useful comparisons between the round and square stator structures, as they are fundamentally different. Although, for illustration purposes the cross-sectional area, stator bore and yoke thickness of these structures were kept equal, a more optimal square stator design may require a smaller stator bore and/or narrower poles. However, circular stator structures *do seem* to offer better steel/copper utilisation. The present design has a much greater useful copper area available (173 mm^2) than the two square stator designs.

4.4.3. Improvements on the stator structures

It is acknowledged that in practice all structures would need to be optimised, electromagnetically and structurally. For example, in the 'regular square stator' structure, the unused copper area could be filled with iron and this would reduce vibration. The addition of pole fillets would also reduce the displacement of each structure, by varying amounts. A small fillet on the 'diagonal pole stator' was found to further reduce the displacement of the structure under dynamic excitation by a significant 25%. Finally, the electromagnetic design of a 1-phase 4-pole would differ from the design of a 2-phase 4-pole in that the tooth width of the former would generally be smaller (owing to the presence of 4 rotor poles) and the back-iron width optimised for 90° flux paths.

The principal aim of this study was to demonstrate how different considerations (such as number of poles per phase, excitation pattern etc.) must be taken into account during the stage of structural design of the stator.

5. IMPROVEMENTS ON REGULAR, ROUND STATOR DESIGNS

Motor design features and modifications that can lead to reduced vibration and noise are examined in this section of the paper. It was decided to use the common 4-pole round stator structure for this study, so it can be made useful to a wider audience.

Motor design features for reduced vibration have been suggested in the literature [4,7], though their effectiveness has not been quantified. One way of reducing stator vibration is to increase the stator back-iron width (stator yoke thickness) y_s. In terms of electromagnetic design the back-iron width, y_s, is set as a function of the stator pole width, t_s. The back-iron width should be sufficient to carry the peak stator flux without saturating. With these considerations in mind, in the 4-pole 2-phase configuration y_s should approximately equal $t_s/2$. In some high speed applications y_s may even be designed to be smaller than $t_s/2$. The 4-pole round stator examined in earlier sections has a yoke width, $y_{s1}=0.45t_s$. Two further models were examined in which $y_{s2}=0.5t_s$ and $y_{s3}=0.55t_s$. Each of these models, shown in Fig. 9, was examined in Structural FEA. A Modal Analysis of these structures was performed before the Forced Vibration Module was employed in order to examine their response to an applied force.

Table 4 shows the results of this study. The natural mode of vibration corresponding to the 2-phase excitation pattern (i.e. the oval shape) is quoted together with the maximum displacement of each structure to a two-slope ramp function coresponding to a speed of 20,000 rpm. The 'oval' natural frequency of vibration increases with increasing back iron width, which implies a decrease in the stator vibration. This is confirmed by the reduction in stator displacement under force (Refer to Table 4).

One further design feature that can reduce stator vibration is the addition of fillets at the stator pole corners. This feature was also extensively investigated using Structural FEA. An attempt was made to pinpoint a fillet of such radius that would provide a reduction in stator displacement comparable to that attained by increasing the back-iron width from 0.45 t_s to 0.5 t_s. This was achieved with a fillet of radius R=3.8 mm. As shown in Table 4, the 'oval' natural mode of vibration occurs at the same frequency (2.8 k Hz) and the displacement (deformation into the 'oval' shape) when oppossite poles are excited is also the same.

The penalty incurred in the attempt to reduce stator vibration is the increase in the stator weight and, probably more important, the decrease in copper winding area (which leads to a reduction in the motor efficiency). It was therefore appropriate to compare the winding area offered by the two structures (i.e. the structure with y_s=0.5t_s and the structure with y_s=0.45t_s and R_{fillet}=3.8mm which offered similar improvement). The structure with the increased yoke width was found to offer a total winding area (equal to the total slot area divided by 2) of 215 mm^2 compared to 229 mm^2 of the structure with the fillet insert. If the 'usable' area is considered (i.e. assuming the use of bobbin coils) the areas reduce to 160 mm^2 and 167 mm^2. Hence the fillet insert can be equally effective in reducing the vibration levels with a small saving in weight and copper space as well.

It must be stated that the structure with the pole fillets attains a structural rigidity similar to that of the structure with the increased yoke width (y_s=0.5t_s) only in the axis of vibration that is of interest in this study (which corresponds to the 2-phase oval excitation pattern). Other modes of vibration of the structure with the increased yoke width still occur at a higher frequency. For example, the 1-phase vibration mode occurs at 12675 Hz compared to 12037 Hz for the structure with the pole fillets.

6. CONCLUSION

The paper demonstrated the use of Electromagnetic and Structural Finite Element Analysis in the investigation of stator vibration in switched reluctance motors. A detailed discussion of 4-pole motor structures (including a novel 'diagonal - pole structure') was presented. An investigation into the dynamic response of the structures upon application of a force function was laid out. One clear conclusion from this study is that the proposed 'square diagonal-pole' structure exhibits significantly less vibration when operating in 1-phase mode (all poles simulaneously excited) and should therefore be employed in low noise applications, with no significant reduction in motor efficiency.

Other aspects of machine design for reduced stator vibration, such as the addition of pole fillets and the choice of suitable back iron width, have been investigated. It was found that in the 2-phase excitation mode, the addition of pole fillets can result in a more effective use of iron compared to an increase in the back-iron width, resulting in a lighter motor that will exhibit less copper loss.

The paper has demonstrated that during the stage of structural design of a doubly salient switched reluctance motor, the number of phases, the number of poles per phase (and the resulting excitation pattern) and speed range of the motor must be carefully considered.

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TABLES AND FIGURES

TABLE 1. NATURAL FREQUENCIES OF VIBRATION FOR THE ROUND STATOR, REGULAR SQUARE AND SQUARE DIAGONAL MOTORS.

Mode No.	Round Stator Motor Natural Frequencies (Hz)	Reg. Square Motor Natural Frequencies (Hz)	Square Diag. Motor Natural Frequencies (Hz)
1	1990	1592	2278
2	2376	2851	2363
3	5580	5299	5944
4	5581	5299	5944
5	8578	6001	8324
6	11154	9926	13035
7	15915	12684	15785
8	15918	12684	15785
9	18097	17808	17005
10	19579	23159	17831
11	24970	27863	21935
12	24973	27955	21935

TABLE 2. STATOR VIBRATIONAL DISPLACEMENTS UNDER RECTANGULAR PULSE FORCE FUNCTIONS (2-PHASE EXCITATION)

Stator Structure	Long Duration Pulse	Short Duration Pulse
	Maximum Displacement (mm)	Maximum Displacement (mm)
Round	6.1 E-03	5.7 E-03
Regular Square	4.3 E-03	6.5 E-03
Square Diagonal	5.2 E-03	4.7 E-03

Duration of Long Pulse = 7.5 ms
Duration of short Pulse = 0.075 ms
Damping = 0.1

TABLE 3. STATOR VIBRATIONAL DISPLACEMENTS UNDER RECTANGULAR PULSE FORCE FUNCTIONS (1-PHASE EXCITATION)

Stator Structure	Long Duration Pulse	Short Duration Pulse
	Maximum Displacement (mm)	Maximum Displacement (mm)
Round	4.6 E-04	6.9 E-04
Regular Square	2.5 E-03	4.6 E-03
Square Diagonal	1.7 E-04	2.7 E-04

Duration of Long Pulse = 7.5 ms
Duration of short Pulse = 0.075 ms
Damping = 0.1

TABLE 4. STATOR VIBRATIONAL DISPLACEMENTS UNDER A RAMP FORCE FUNCTION (2-PHASE EXCITATION)

	Max. Pole Displ. (mm)	Vibr. Displ. (mm)	Freq. (Hz)
Original Round Stator	8.68 E-03	5.57 E-03	2376
Modified $y_s = 0.5\ t_s$	6.78 E-03	3.44 E-03	2814
Modified $y_s = 0.55\ t_s$	5.10 E-03	1.40 E-03	3272
Original stator with fillet	6.77 E-03	3.43 E-03	2807

Duration of Pulse = 0.74 ms (20,000 rpm)

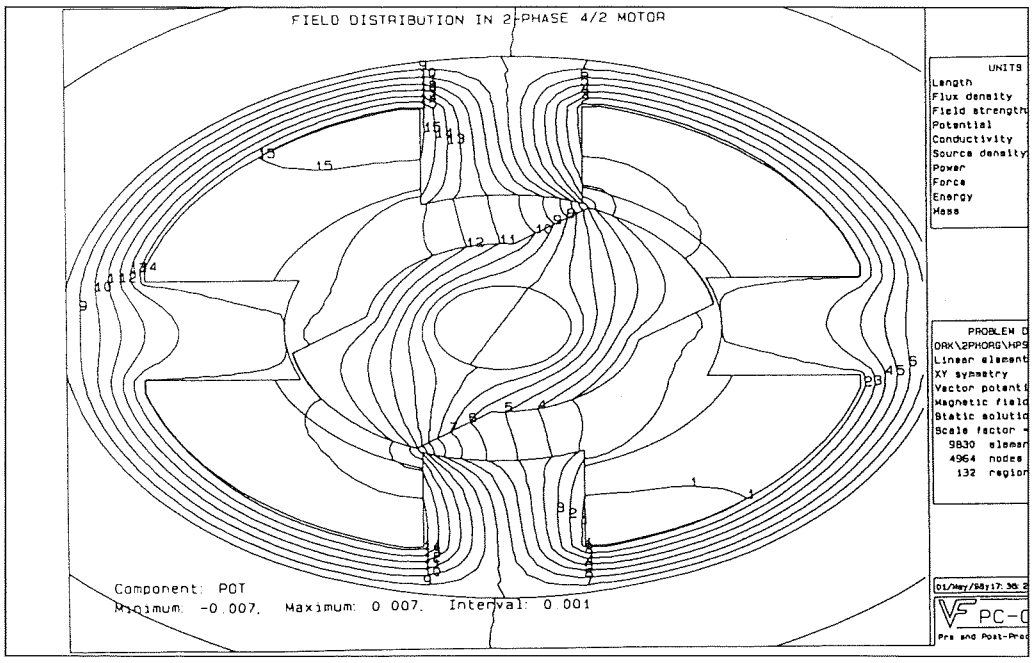


Figure 1. Plot of magnetic vector potential distribution in the round stator 4/2 motor (Electromagnetic FEA).

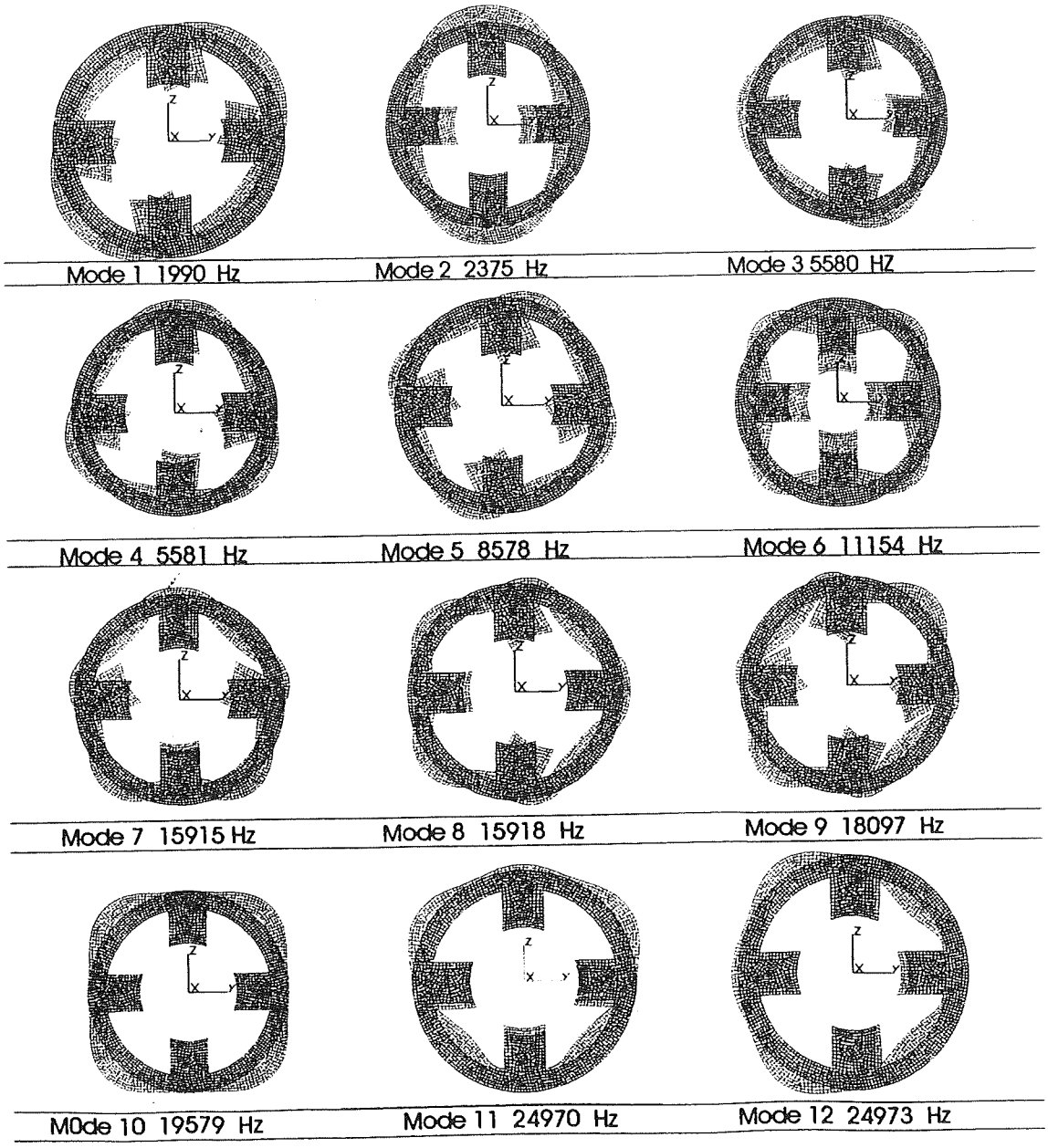


Figure 2. The first 12 natural modes of vibration of the round stator motor (Modal Analysis Module-Structural FEA)

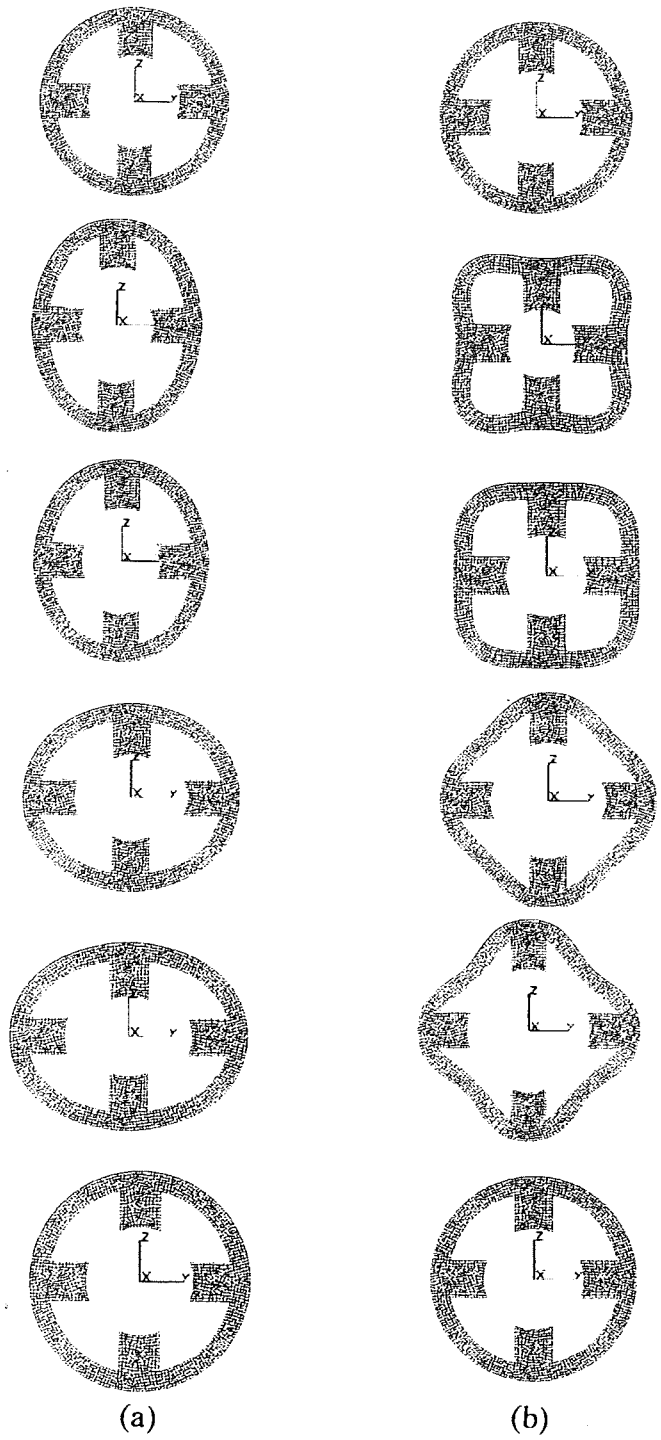


Figure 3. 'Photo-responses' of a 4-pole motor:
(a) operating as a 2-phase 4/2 motor
(b) operating as a 1-phase 4/4 motor

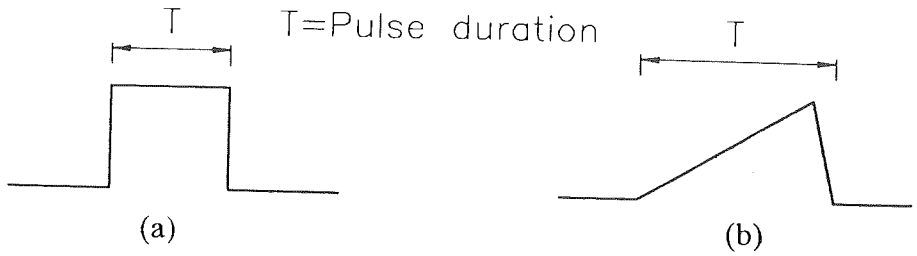


Figure 4. Types of force functions used in Time History Structural FEA.
(a) Rectangular pulse
(b) Two-slope ramp.

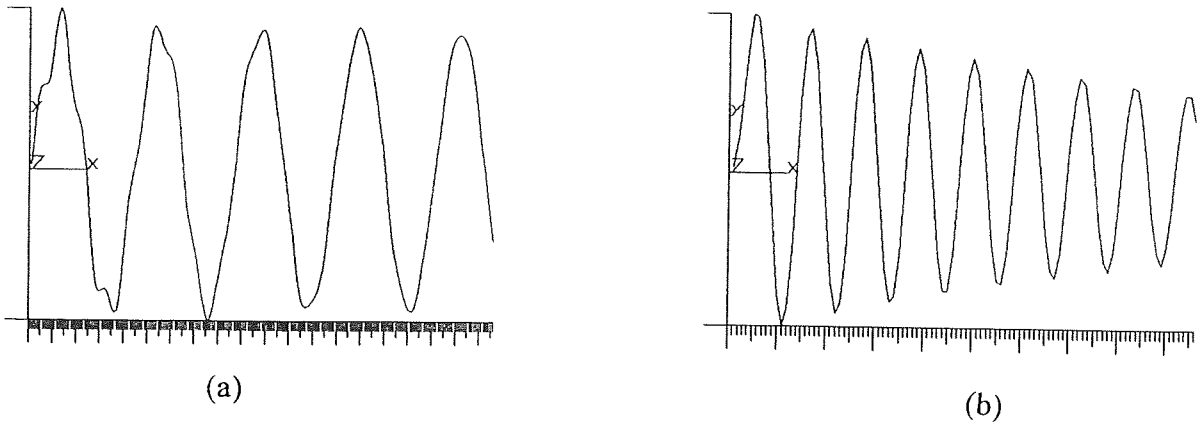


Figure 5. Plot of the stator displacement against time for the round stator motor, operating as a 2-phase 4/2.
(a) Rectangular pulse duration = 0.1 ms
(b) Rectangular pulse duration = 0.2 ms

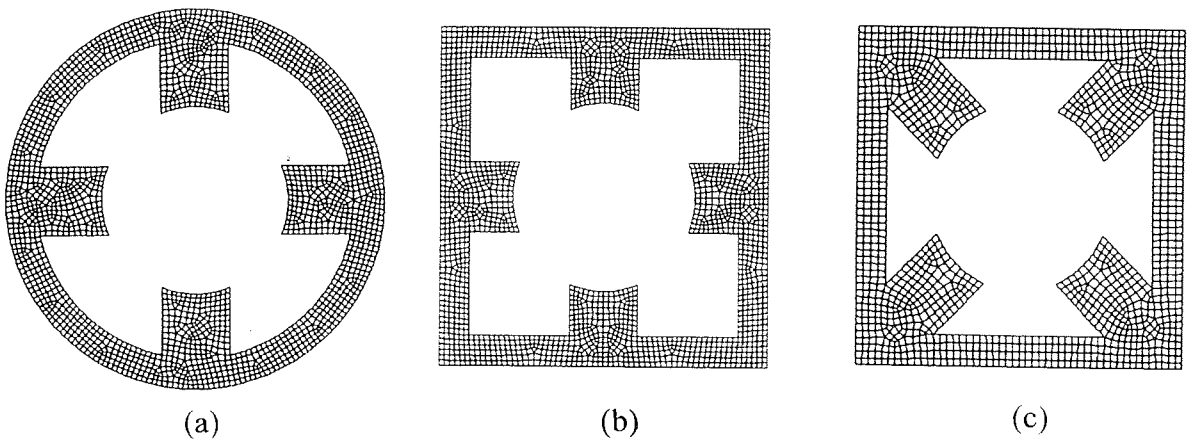
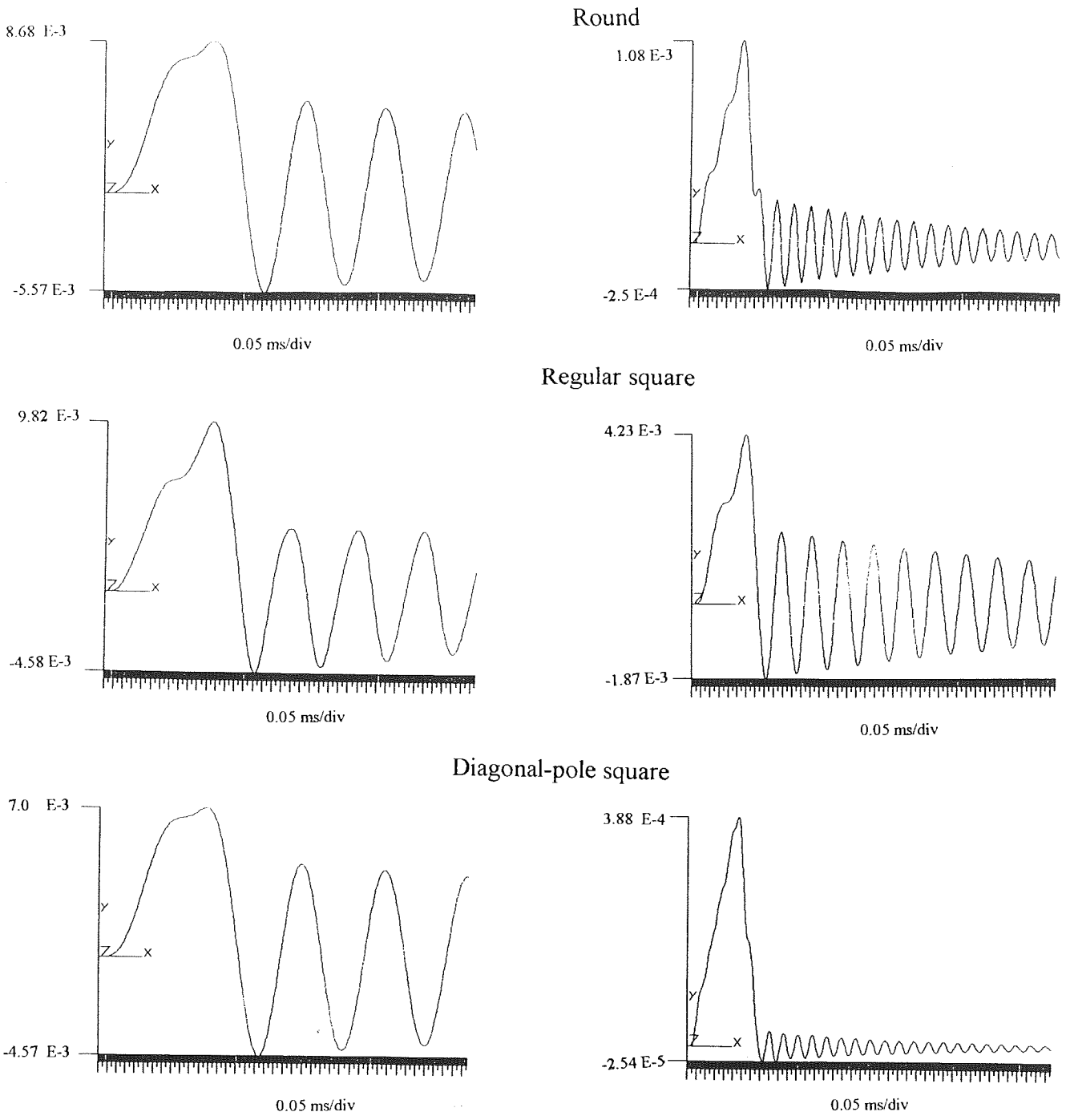


Figure 6. The three stator structures examined in Structural FEA.



(a) 2-phase excitation (duration of ramp pulse = 0.74 ms) (b) 1-phase excitation (duration of ramp pulse =0.37 ms)

Figure 7. Response of the 'round', 'regular square' and 'diagonal-pole square' structures to a ramp function corresponding to 20,000 rpm.

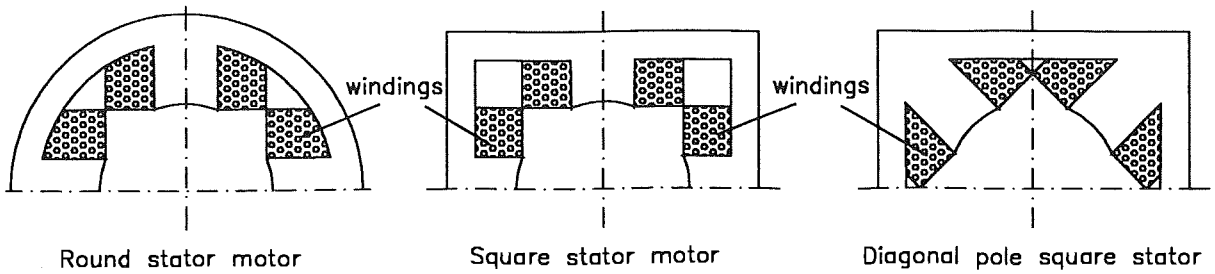
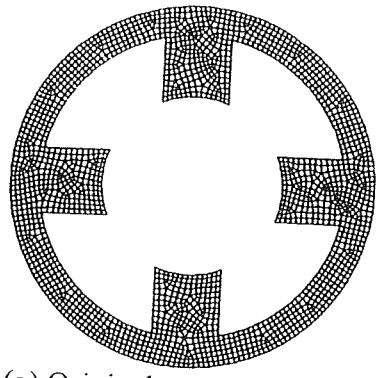
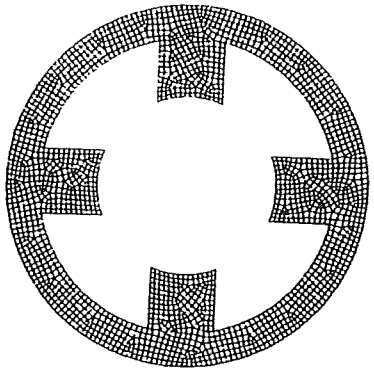


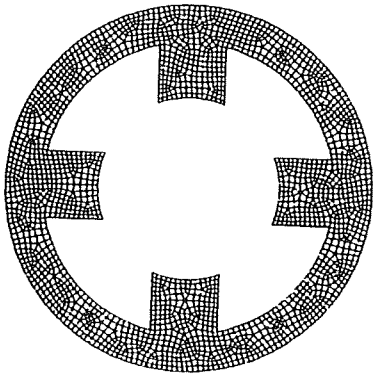
Figure 8. Slot filling in 4-pole motors.



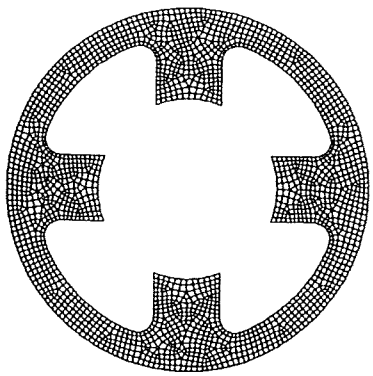
(a) Original round stator ($y_{s1} = 0.45\ t_s$)



(b) $y_{s2} = 0.5\ t_s$

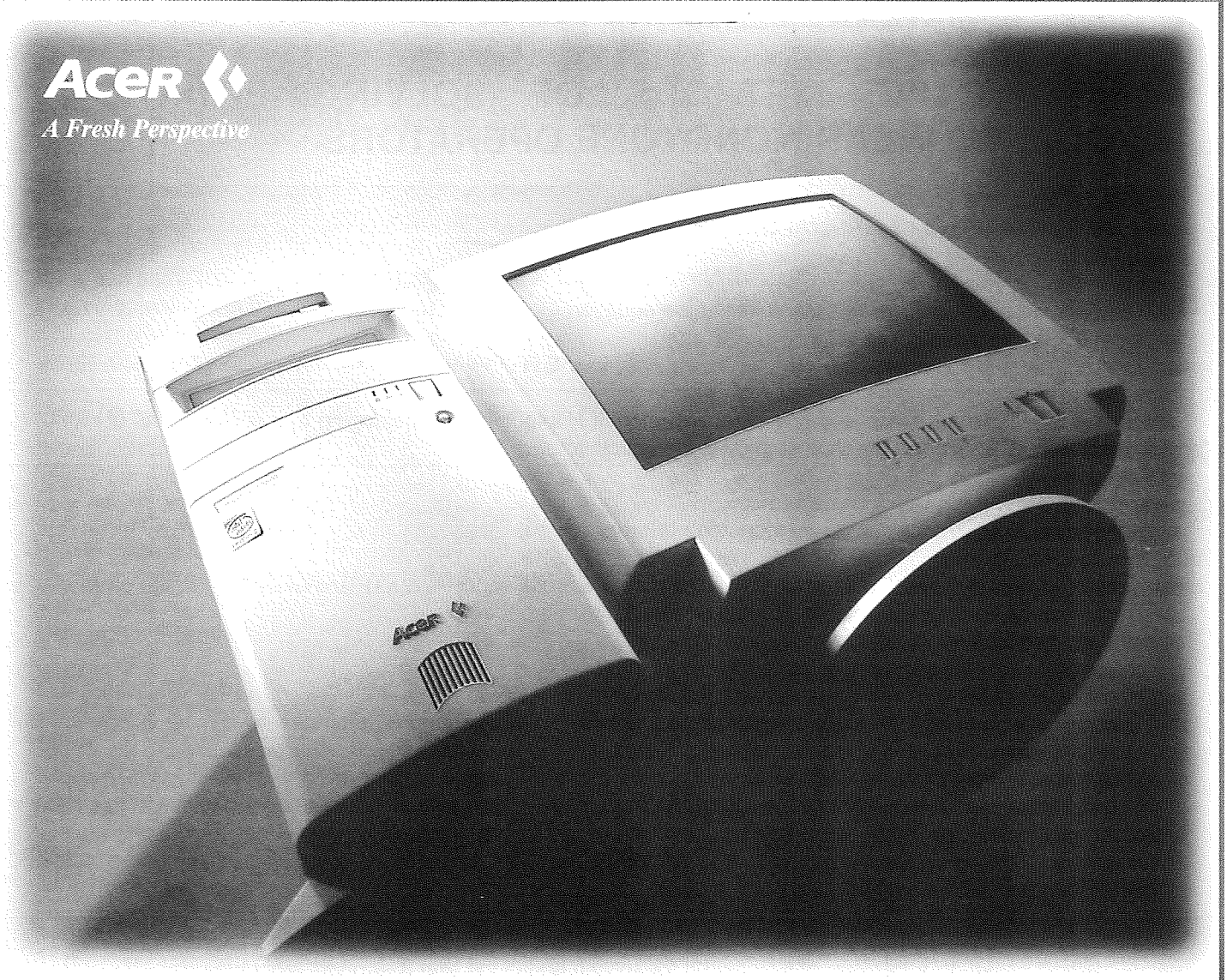


(c) $y_{s3} = 0.55\ t_s$



$= 0.45\ t_s$ and pole fillet radius = 3.89 mm.

Figure 9. The 2-phase, 4-pole structures used for the evaluation of improvements.



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CONSTRUCTIVE METHODS OF SOLVING EQUATIONS INVOLVING LINEAR MONOTONE OPERATORS

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In this paper we shall consider the solvability of the equation

$$Kx = \psi,\ x,\ \psi \in H$$

where H is a real Hilbert space and K a linear mapping of H into itself and belonging to a special class of monotone mappings. The method we shall employ is constructive.

Definition 1.
A linear mapping $K:H \to H$ is said to be monotone of order γ, if

$$(Kx, x) \geq C_\gamma \|Kx\|^\gamma \|x\|^{2-\gamma} \ldots\ldots (1)$$

where $x \in H$ από $C_\gamma > o$, $o \leq \gamma \leq 2$.

Remarks:
1. This class of monotone operators was introduced by M.M. Lavrentiev and B. Imomnazarov [1].

2. When $\gamma=0$, we have that $(Kx,x) \geq C_o \|x\|^2$
   i.e. K is strongly monotone (positive definite) linear mapping. This is also the case when $\gamma<1$, since in this case

$$\|Kx\| \geq C_\gamma \|x\|$$

It turns out that when $\gamma=1$, K is, also, strongly monotone. It is shown in [1], by using a variant of the contraction mapping principle that K is surjective, from which it follows that it is strongly monotone. We shall consider an atternative method based on a theorem of Kolomy [2] for solving equations with K strongly monotone.

THEOREM 1:
Let H be a real Hilbert space and $K:H \to H$ a linear operator satisfying

$(Kx,x) \geq C_1 \|Kx\| \|x\|$, $C_1>0$.....(2)

and $x \in H$.
Let $f \in H$ and

$$x_n = \sum_{k=1}^{n} b_{k-1}\ y_{k-1} \ldots\ldots\ldots\ldots (3)$$

$$\psi_{k+1} = \psi_k - b_k K\psi_k,\ k=0,1,2, \ldots. (4)$$

$\psi_0 = f$ and

$$b_K = \frac{(K\psi_k, \psi_k)}{\|K\psi_k\|^2} \ldots\ldots\ldots\ldots (5)$$

Then the sequence $\{x_n\}$ tends strongly to the unique solution of the equation

$Kx=f$ ..... (6)

Proof:
Since $y_n = y_o - K\left(\sum_{k=1}^{n} b_{k-1}\, y_{k-1}\right)$

$=\psi_0 - Kx_n$
$=f - Kx_n$

If we can show that $\psi_n \to 0$ (strongly), then, since K has a bounded inverse by the result in [1], $\{x_n\}$ tends strongly to an element x_o such that $Kx_o = f$

If suffices, therefore, to show that $\psi_n \to 0$ (strongly).

From (4) we have that

$\|\psi_n\|^2 = \|\psi_{n-1}\|^2 + b^2_{n-1}\, \|K\psi_{n-1}\|^2 - 2b_{n-1}(K\psi_{n-1}, \psi_{n-1})$

and using (5) we get that

$\|\psi_n\|^2 = \|\psi_{n-1}\|^2 - b_{n-1}\,(K\psi_{n-1}, \psi_{n-1})$

Using (2) we get that

$\|\psi_n\|^2 \le \|\psi_{n-1}\|^2 - C_1\, b_{n-1}\, \|K\psi_{n-1}\|\, \|\psi_{n-1}\|$

Since

$$C_1 b_{n-1}\, \frac{\|K\psi_{n-1}\|}{\|\psi_{n-1}\|} = C_1\, \frac{(K\psi_{n-1}, \psi_{n-1})}{\|K\psi_{n-1}\|\, \|\psi_{n-1}\|} \ge C_1^2$$

it follows that

$$1 - C_1\, b_{n-1}\, \frac{\|K\psi_{n-1}\|}{\|\psi_{n-1}\|} \le 1 - C_1^2$$

and substituting back in (7) we have that

$\|\psi_n\| \le (1 - C_1^2)^{1/2} \|\psi_{n-1}\|$.

Since $0 < C_1 < 1$, it follows that

$\|\psi_n\| \to 0$. The uniqueness part we shall prove later.

REMARK:

For $1 < \gamma \le 2$, K need not be surjective. To see this, let H be a separable Hilbert space with an orthonormal basis $\{e_i\}$.

For $x \in H$, $x = \sum_{n=1}^{\infty} c_n\, e_n$, $\sum_{n=1}^{\infty} C_n^2 < \infty$

we define a linear operator by

$$Kx = \sum_{n=1}^{\infty} \frac{C_n}{n+1} e_n$$

Then we have that

$$(Kx, x) \sum_{n=1}^{\infty} \frac{C_n^2}{n+1} \quad \ldots\ldots\ldots\ldots \quad (8)$$

and

$$\|Kx\|^2 \sum_{n=1}^{\infty} \frac{C_n^2}{(n+1)^2} \quad \ldots\ldots\ldots\ldots \quad (9)$$

Since

$$\sum_{n=1}^{\infty} \frac{C_n^2}{n+1} > \sum_{n=1}^{\infty} \frac{C_n^2}{(n+1)^2}$$

it follows that

$$\frac{\sum_{n=1}^{\infty} \frac{C_n^2}{n+1}}{\sum_{n=1}^{\infty} C_n^2} \geq \frac{\sum_{n=1}^{\infty} \frac{C_n^2}{(n+1)^2}}{\sum_{n=1}^{\infty} C_n^2}$$

For $1<\gamma\leq 2$

$$\frac{\left(\sum_{n=1}^{\infty} \frac{C_n^2}{n+1}\right)^2}{\left(\sum_{n=1}^{\infty} C_n^2\right)^2} \geq \left[\frac{\sum_{n=1}^{\infty} \frac{C_n^2}{(n+1)^2}}{\sum_{n=1}^{\infty} C_n^2}\right]^{\gamma} \quad \ldots\ldots\ldots\ldots \quad (10)$$

Substituting for (Kx,x), $\|Kx\|$ and $\|x\|$ we obtain $(Kx)\geq\|Kx\|^{\gamma}\|x\|^{2-\gamma}$
But it is easily seen that K is not sunjective.

Next we show that if K is monotone of order γ, with $0<\gamma<2$, then K is injective.

Lemma 1
Let H be a real Hilbert space and $K:H\rightarrow H$ be monotone of order γ with $0<\gamma<2$. Then K is injective.

Proof: Let w be an element of H such that $Kw=o$ and suppore that $w\neq o$. We shall derive a contradiction.
Let $t\in R$, $t>o$. Then

$(K(x+t\omega), x+t\omega)\geq C\gamma\ \|Kx+tK\omega\|^{\gamma}\ \|x+t\omega\|^{2-\gamma}$

Since K is monotone it follows that its null space is orthogonal to its range. Hence the last inequality simplifies to give

$(Kx,x)\geq C_{\gamma}\ \|Kx\|^{\gamma}\ \|x+tw\|^{2-\gamma}$

Since $w\neq o$, then by choosing t we can make the right hand side arbitrarily large while the left hand side remains constant. This contradiction shows that $w=o$.

Remarks:

1. If follows that if the range of K is closed and $0<\gamma<2$, since K is injective, then K is surjective.
2. It is stated without proof in [1] that, for $0<\gamma\leq 2$, K is injective.

As we have seen this is the care for $0<\gamma<2$ but for $\gamma=2$ this need not be the case. For example any orthogonal projection P on H satisfies
$(Px,x)= \|Px\|^2$ but is not injective.

THEOREM 2

Let $K:H \to H$ be a linear operator which is monotone of order γ, with

$1<\gamma\leq 2$. Let $f \in R(K)$. Then the sequence, $\{x_n\}$, given by

$$Xn=(\frac{1}{n} I + K)^{-1} (f),\ n=1,2, ...$$

tends strongly to a solution of the equation $Kx=f$

Proof:
Since, for fixed n, $\frac{1}{n} I+K$ is a strongly monotore mapping it follows that the equation

$$\frac{1}{n} x_n + Kx_n=f \ldots\ldots\ldots\ldots (I)$$

has a unique solution, x_n, for each $n>0$.

Since f is an element in the range of K, there exists an $x_o \in H$ such that

$$Kx_o=f \ldots\ldots\ldots\ldots (12)$$

It follows from (11) and (12) that

$$\frac{(x_n, x_n-x_o)}{n} + (Kx_n-Kx_o, x_n-x_o)=o$$

and using the monotonicity of order γ of K we get that:

$$\|x_n\|+C_\gamma \frac{\|x_n\|^{\gamma-1}}{n^{\gamma-1}} \|x_n-x_o\|^{2-\gamma}\leq\|x_o\|$$

Thus, since $1<\gamma\leq 2$, we must have that $\|x_n\|\leq\|x_o\|$

i.e. $\{x_n\}$ is bounded.

From (12) we have, for any two solutions x_n, x_m that

$$\left(\frac{x_n}{n}-\frac{x_m}{m}, x_n-x_m\right)\leq o \ldots\ldots\ldots (13)$$

If follows that (see lemma 2 below), $\{x_n\}$ converges to an element x^* strongly

Since K is continuous, if follows that $Ax^*=f$

In the care $1<\gamma<2$ the sequence $\{x_n\}$ converges to the unique solution of
$Kx=f$, since in this case K is injective.

In the case $\gamma=2$ and since the set of solutions of $Kx=f$ is closed and convex, it has an element of smallest norm, it follows that $\|x^*\|\leq\|x_o\|$ i.e. $x^*=xo$

Lemma 2 [3]

Let H be a real Hilbert space, $\{x_n\}$ a sequence in H and t_n a sequence of positive numbers such that
(i) $\{x_n\}$ is bounded
(ii) $\{t_n\}$ is strictly decreasing
(iii) $(t_n x_n - t_m x_n, x_n - x_m) \leq o$, for all n and m

Then there exists an $x \in$ - H such that $x_n \rightarrow x$ (strongly)

REMARK

1. The solution of the equation Kx=f with K as in theorem2 can be obtained by using Komoly's method, since for fixed n>o, we have that

$$\left(\frac{x}{n} + Kx, x\right) \geq \frac{1}{n} \|x\|^2$$

2. ST. Maruster [4] has shown that the sequence generated by
$x_{n+1}=x_n-t_n$ $(Kx_n=f)$, with $f \in RCK)$, $o<t_k<2C$ converges strongly to a solution of Kx=f, where K is assumed to have the zero as an eigenvalue and K satisfying
$(Kx, x) >, c \|Kx\|^2$, c>o

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MODERN SCIENCE IN THE BIBLE

Fulfilled Prophecies and Internal Evidences

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THE GREATEST DEMONSTRABLE EVIDENCE for the inspiration of the Scriptures, apart from the final, unanswerable proof of personal experience, lies in the fact that hundreds of prophecies contained in its pages have been remarkably fulfilled. In attempting to refute the evidence from predictive prophery, critics have gone to absurd lengths. They have ought to explain away the fulfillments as coincidence, or have arbitrarily set the dates of the writing of the prophecies as subsequent to their fulfillment or in most cases have simply ignored them. These attempts, however, have always been based on a process of rationalization rather than on demonstrable fact and, for the most part, have met utter defeat.

Bible prophecies are not vague and rambling, as is almost always true of certain supposed extrabiblical prophecies, such as those of Mother Shipton, Nostradamus, and others. Rather they deal with specific places, people and events and their specific fulfillment can easily be checked by reference to subsequent history.

For example, consider the prophecy against that great city of antiquity, Tyre of the Phoenicians. It is found in Ezekiel 26, and first describes the coming capture of the city by Nebuchadnezzar (vv. 7-11). This was later fulfilled quite literally. However, the judgment forecast in verses 4-5: "They shall destroy the walls of Tyrus, and break down her towers: I will also scrape her dust from her, and make her like the top of a rock. It shall be a place for the spreading of nets in the midst of the sea," seemed unfulfilled. History tells us that most of the people of Tyre escaped with their valuables to an island half a mile from the shore, where they built a new Tyre which was still great and powerful for almost 250 years. But finally Alexander the Great finished what Nebuchadnezzar had begun. In his campaign of conquest through the East, the people of Tyre refused to surrender to him, and he seemingly had no way to reach the island city to capture it. However, he devised the ingenious plan of building a causeway from the mainland. The Macedonians then literally scraped the dust of the old mainland city and laid her stones and timber and dust in the midst of the water (see v. 12) to build the causeway. (Note the change from the "he," Nebuchadnezzar, in v. 11 to "they" in v. 12, indicating different conquerors). The causeway was thus built from the remains of the old city and the island city was captured and sacked. Verse 21 says: "I will make the a sought for, yet shalt thou never be found again, saith the Lord God." The mainland city of Tyre, against which the prophecy was directed, was never rebuilt. There are not even ruins or mounds to mark the spot, which can only be approximately located from the writing of ancient historians. The causeway and island now form a desolate peninsula, which is used only by fishermen, for the purpose of "spreading their nets" for drying.

Tyre's sister city of Sidon had the following prophecy uttered against her: "Behold, I am against thee, O Sidon .... For I will send pestilence into her, and blood into her streets; and the wounded shall fall in the midst of her with the sword upon her on every side" (Ezek. 28:22, ASV). No fate of extinction was foretold for Sidon and even today it is a city of about 20,000. However, it has one of the bloodiest histories any city ever had. It was almost destroyed by the Persians, was the scene of many fierce battles during the Crusades, and during the wars between the Druses and the Turks, and later between the Turks and the French. In 1840, Sidon was again the scene of bloodshed when it was bombarded by the fleets of three nations.

Two sister cities, close together and equal in importance were thus the subjects of two very different prophecies. Each has been fulfilled to the letter. That would have been impossible except to the letter. That would have been impossible except as directed by God, who alone "knows the end from the beginning".

Many other cities have been singled out by the prophets. We could not begin to discuss here the detailed fulfillment of all these predictions. However, some of the cities and the corresponding prophecies are listed below for the reader's reference:

Thebes, Egypt (the "No" of Scripture) -Ezekiel 30:14-16
Memphis, Egypt (the "Noph" of Scripture) -Ezekiel 30:13
Ashkelon, Philistia -Zechariah 9:5
Ekron, Philistia, also Gaza, Philistia-Zephaniah 2:4

Bethel-Amos 3:14-15
Samaria-Micah 1:6-7
Jericho-Joshua 6:26
Capernaum, Bethsaida and Chorazin-Matthew 11:20-23
Babylon-Isaiah 13:19-22

All these and many other prophecies directed against specific cities either have been or are being fulfilled with meticulous accuracy.

Many countries also have been the subject of prophecy. Edom, or Idumea, was a nation that was located next to the Jews in Palestine. Although the Edomites were descended from Esau and were thus related to the Israelites, they were extremely idolatrous and treacherous and were constantly warring with the Hebrew nation. Their land was very rugged and their capital city, Petra, had a seemingly impregnable position in the rocks of the mountains. It was a very great and rich city, being the terminus of one of the great trade routes of the East; and even today its ruined buildings and palaces, carved out of the solid rock, are most imposing and magnificent. But in Ezekiel 35:3-9; Jeremiah 49:16-18, and other places, there were predictions of the ultimated overthrow of Edom. Edom was to be an utter desolation; her trade was to cease, and all her inhabitants were written these prophecies remained in the Scriptures without being fulfilled. Even for some six hundred years after Christ, Edom and Petra remained great and prosperous. But somehow, sometime, a change came. Seemingly no one knows the story. Now the whole land of Edom, as far as the city of Maan, is utterly desolate, with practically no human inhabitants, and very little animal life. It is interesting that only Maan, a town on the east of Edom and the Teman of Scripture, has escaped the desolation. But this is precisely what was predicted in Ezekiel 25:13: "I will make it desolate from Teman."

A similar judgment of perpetual extinction was predicted for the Philistines, another great and warlike people of antiquity. They lived west of the Israelites, on the seacoast, and were almost constantly fighting with them. It was from the Philistines that much of the Jewish trouble with idolatry was derived. Consequently, we have the prophecy in Zephaniah 2:5-6 (ASV): "The word of Jehovah is against you, O Canaan, the land of the Philistines; I will destroy thee, that there shall be no inhabitant. And the sea-coast shall be pastures, with cottages for shepherds and folds for flocks." There are several other similar prophecies against the Philistines, including some directed against specific Philistine cities, as noted before. Eventually, however, the Philistines all vanished and their country was taken over by others. Until its modern inclusion in the state of Israel, the ancient land of the Philistines was thereafter used almost exclusively for grazing and agriculture.

Bethlehem today

The nation of Egypt, on the other hand, was not doomed to extinction, as were Babylonia, Edom, Philistia and others. Egypt was one of the greatest powers of the ancient world, but in passage after passage of Scripture she was threatened with a gradual and permanent decline, but not with extinction. Ezekiel 29:15 says: "It shall be the basest of kingdoms; neither shall it exalt itself any more above the nations: for I will diminish them, that they shall no more rule over the nations". Today that prophecy stands unchallenged. The so-called kingdom still exists; the people of Egypt today are the direct descendants of those who were at one time the greatest people in the world. Yet it is truly the basest of kingdoms and has no more exalted itself above the nations. There are a great many other predictions regarding Egypt, concerning such miscellaneous details as its industries, the weavers, the fisheries, the papyrus plants, the rivers and canals, its rulers, its exploitation by outsiders, the desolation of the country, etc. Every one of these has been fulfilled in a most marvelous way.

We have not the space to discuss more of these predictions here but should mention that such countries as Moab, Ammon,Chaldea, Assyria, Ethiopia and others are the subjects of biblical prophecies, all of which have been fulfilled.

We should consider briefly the Jewish people, however. Their entire history has been foretold in the Bible in a great number of prophecies, most of which have already been fulfilled. In Deuteronomy 28, even before the Israelites had entered the promised land. Moses predicted their future happiness in the land, their sufferings and punishments for disobedience, and finally their great worldwide dispersion. In chapter 30, he promised their eventual return, a prophecy which seemed impossible fifty years ago, but which is now being marvelously fulfilled. Their dispersion was prophesied by many others, including Christ Himself, as well as the terrible persecution that would be theirs in all nations. But it was also revealed that they would not be destroyed or assimilated but their national identity would be retained. Today the nation of Israel has been reestablished in its ancient land, and even the city of Jerusalem again belongs to the Jews.

The book of Daniel contains what are usually regarded as the most marvelous prophecies in the Bible. In chapters, 2, 7, 8 and 11 of this book, the entire history of the world is foretold from the time of Nebuchadnezzar to the end. The careers of Babylonia, Medo-Persia, Greece, Egypt, Syria and Rome are described with such wealth of description and detail that no one acquainted with the facts of history can be uncertain as to the events and nations referred to. This very minuteness of detail is the sole remaining crutch of the critical school which has long contended that the book of Daniel was written after those events had transpired. The rationalism of the critics rules out the miracle of predictive prophecy, so this contention is absolutely necessary for them. Although it must be admitted that they still cling to it as a matter of necessity, it has been almost irrefutably proved that the book is authentic both as to date and author, and thus its marvelous prophecies stand completely vindicated.

One of the most remarkable of all prophecies is in Daniel 9:24-26, known as the prophecy of the seventy weeks. This prophecy was given to Daniel through the angel Gabriel, revealing the future history of his people Israel, including the exact time of the coming of the promised Messiah (Christ). It was given about 540 B.C., while Israel was in captivity in Babylon, with the city of Jerusalem and the great temple of God in ruins. Daniel was told that prophetic time would begin again for Israel when a command was given to rebuild Jerusalem. This command was given by Artaxerxes to Nehemiah in 445 B.C. (Neh. 2:5-8).

From this date, the prophecy indicated that 483 years (i.e., 69 "weeks", literally "sevens", meaning seven-year periods) would elapse until the coming of Messiah as Prince of Israel. Allowing for errors in our present system of chronology (Jesus was actually born about 5 B.C.) and for possible use of a prophetic year of 360 days instead of an actual solar year, it is obvious that this period culminated at about the time of the public ministry of Christ. In fact, Sir Robert Anderson and others have shown that, with certain reasonable assumptions, its fulfillment occurred on *the very day* that Christ for the first time accepted and encouraged His recognition as King of Israel, the day of His so-called "triumphal entry" into Jerusalem, a week before His rejection by His people, He said: "If thou hadst known, even thou, at least in *this thy day*, the things which belong unto thy peace, but now they are hid from thine eyes!" (Luke 9:42).

The prophecy also foretold that after His coming He would be "cut off" and would "have nothing". That is, He would be rejected as King by Israel, and this was of course exactly what happened. Certain other portions of this great prophecy have apparently not yet been fulfilled but are awaiting Christ's return and the full establishment of His kingdom for their final development and realization.

There are many other prophecies relating to the coming of Christ, possibly not as striking as this but just as miraculous. His virgin birth was predicted in Isaiah 7:14. His birthplace in Bethlehem was given in Micah 5:2. Zechariah

9:9-10 describes His public entry into Jerusalem on the foal of an ass. Many details of His teaching and healing ministries are given in various prophecies. His betrayal is described, including even the price of thirty pieces of silver, in Zechariah 11:12-13. The details of the crucifixion are most graphically portrayed in Psalm 22, written by David at a time when offenders were killed by stoning and crucifixion was unheard of, being a distinctively Roman method of punishment. The purpose of His death, as well as several of the details of His trial, suffering on the cross, and His burial are foretold in Isaiah 53. The fact that He died, not for Himself or anything that He had done, but as a substitute for our sins, is most vividly described here. Even the resurrection is indicated in several places in the Old Testament, as well as being foretold several times by Jesus Himself.

There are more than three hundred prophecies in the Old Testament which were fulfilled by Christ at His first coming. In an attempt to determine the scientific significance of these prophetic fulfillments, a California mathematician, Peter Stoner, made an interesting experiment with one of his classes. Each member of the class was assigned a particular Messianic prophecy for study, with the purpose of determining the statistical chance that the particular event could have been predicted without supernatural inspiration. For example, the prophecy in Micah 5:2 says that the Messiah would be born in Bethlehem. There was no more reason for this town to be chosen than any other town in Israel. Therefore its probability of chance fulfillment would be one divided by the number of towns in Israel at the time. In this manner, probabilities of fulfillment were determined for each of fortyeight Messianic prophecies.

Now the laws of mathematical probability show that the probability of several chance occurrences, independent of each other, being accomplished simultaneously is the product of the probabilities of all the individual occurrences. Thus the probability of all these forty-eight prophecies being fulfilled simultaneously in one individual, the promised Messiah and Saviour, was calculated as the product of all the separate probabilities. Professor Stoner found that the resultant probability was one chance out of a number that would be written as one, followed by 181 zeros!

To realize the significance of this tremendous number, visualize a huge ball composed of solidly packed electrons. These are the smallest entities we know anything about; it would take about two and one-half million billion of them to make a line one inch long. The largest thing we know anything about is our physical universe, some four billion light-years in radius (a light-year being the distance light travels in a year, moving at the speed of over 186,000 miles per second). However, our ball of electrons must have a diameter some five hundred quadrillion times as great as the diameter of our universe.

One of these electrons now is marked to distinguish it from all the rest, and then the entire mass stirred and mixed thoroughly. A blindfolded man is then sent into the ball to find the marked electron. *The chance that he would select the right electron on the first trial is roughly equivalent to the chance that these forty-eight prophecies could have been fulfilled without supernatural inspiration.*

All of which amounts to clear mathematical proof that the Scriptures must have been divinely inspired. Most scientific laws have been established on the basis of statistical probabilities far less imposing than the above. And it must be remembered that these represented only forty-eight out of more than three hundred Messianic prophecies, and also that there are still hundreds of other fulfilled prophecies in the Bible. Surely a right-thinking person must conclude that truly the Bible is the very Word of God. Such phenomana as these are found in no other book in all the world!

There is another significant set of prophecies which are excitingly being fulfilled in these days before our very eyes. These prophecies describe conditions in the world shortly before the promised return of the Lord Jesus Christ to this earth "in flaming fire taking vengeance on them that know not God, and that obey not the gospel of our Lord Jesus Christ" (II Thess. 1:8).

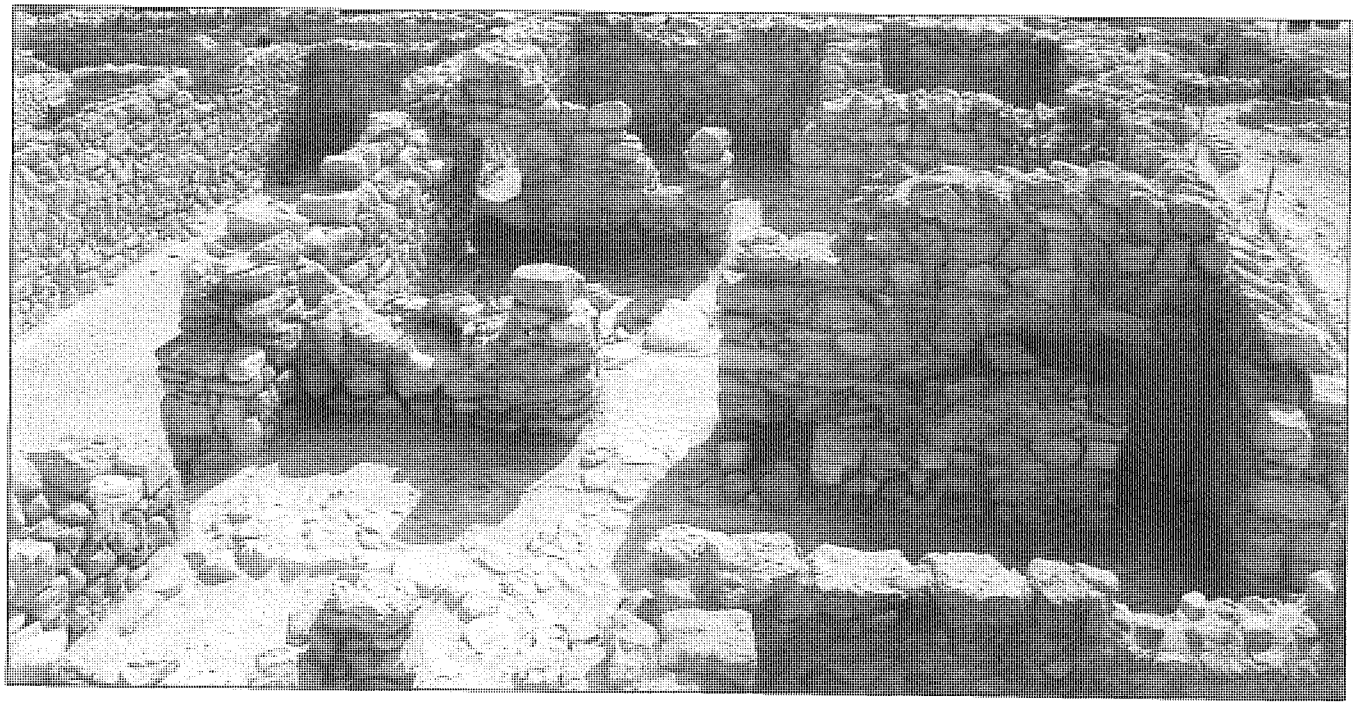
Perhaps the most significant of these "signs of the times" is the restoration of Israel to her own ancient land as a recognized nation among nations. This amazing restoration, with a large number of its details, was promised in many passages of the Bible as an event that would occur in the last days of this age. (See e.g., Isa. 11:10-12; Jer. 23:3-8; 30:3-11; Ezek. 20:34-38; 36:24-35; 37:11-28). Of course, the complete fulfillment of such passages as these awaits a great coming divine judgment on Israel and her national conversion to Christ when He returns to earth to reign (Zech. 12:10-14-11).

The rise of Russia to world prominence and especially its emergence as a Mediterranean power at the head of a confederacy of nations encircling and attempting to destroy restored Israel is clearly indicated in Ezekiel 38. "Gog" in this chapter, the leader of this invasion attempts, is called the "prince of Rosh" (v. 2, ASV), and there are numerous other marks of identification clearly showing that Russia, in the latter days, is the nation referred to. The prophecy has not yet been fulfilled, but events are very rapidly developing in that direction.

Other important prophetic portents of the last days include the following:

Rapid increase of science, communication and travel (Dan. 12:4).
General moral and spiritual deterioration (II Tim. 3:1-17, 12-13).
Doctrinal apostasy of religious leaders (I Tim. 4:1-3, II Peter 2:1-2; II Tim. 4:3-4).
Antisupernaturalism among intellectual leaders (II Peter 3:3-6; II Tim. 3:5).
Conflicts between capitalistic and laboring classes (James 5:1-8).
Widespread materialism and secularism (Luke 17:26-30; 18:8).
Intermittent outbreaks of worldwide wars, famines and diseases (Luke 21:10-11).

The above prophecies and many others are being fulfilled in these present days, and the conditions they describe appear to become more serious with each passing day. Evidently, as both Scripture and current history plainly teach, world conditions will become increasingly perilous and anti-Christian as the return of the Lord draws near. However, there is one other prophecy of the latter times that is entirely different in character, namely, that the gospel will be preached as a witness to all nations before the end comes (Acts 1:8-11; Matt. 24:14; II Peter 3:9-15). Although there are some lands where the gospel has not yet really been preached, there has been a tremendous extension of evangelical Christian missions in recent generations. The Bible has been translated, at least in part, into more than 1,120 tongues to date. A number of mission boards are concentrating particularly on reaching hitherto unevangelized areas and tribes. Modern inventions such as the radio, TV, satellite and airplane are contributing significantly to world evangelization, which seems well within the possibility of accomplishment in this generation. By doing all within our personal power to aid in the cause of world missions, it seems that we can thus hasten "the coming of the day of God" (II Peter 3:12).



Archaelogical discoveries verify the books in the Bible

Thus, as the world deteriorates and ripens for judgment, the gospel of Christ is nevertheless being taken to the ends of the earth. And all of these things both add to the tremendous evidences of the truth of Scripture and of the Christian faith, and also prove that the coming of the Lord Jesus must be very near!

For any reader who does not yet know the joy and assurance of personal salvation, may the author urge him with all his heart to receive the Lord Jesus by faith as Son of God and personal Saviour, committing his life and soul fully to Him. "For God so loved the world, that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life" (John 33:16).

"Behold, now is the accepted time; behold, now is the day of salvation" (II Cor. 6:2).

HIGHER TECHNICAL INSTITUTE QUALITY IN GENERAL AND A MOVE TOWARDS TQM PHILOSOPHY IN TEACHING

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1. GENERAL INTRODUCTION

One service industry of paramount importance in the public sectors of nations is that of education. It is the quality of education that shapes the long-term prosperity and well being of both nations and their people. The vast resources that governments allocate to this sector of the economy make it imperative for those who manage education to ensure that education is effectively imparted in schools, colleges and universities. Given the crucial role of education in an increasingly competitive global environment, administrators and educators are constantly looking for ways to make educational establishments more effective. We teach to educate people, and where people are involved, fundamental managerial concepts such as commitment, motivation, participation, and leadership play an important role in determining the effectiveness of processes used to shape and influence them.

2. INTRODUCTION OF THE ORGANISATION

The Higher Technical Institute (HTI) was established in 1968 initially as a 5-year joint project of the UNDP, UNESCO and ILO and the Government of Cyprus. In 1973 it became the sole responsibility of the Government of Cyprus and operates in Nicosia the capital of Cyprus under the Ministry of Labour and Social Insurance. Its main purpose is to train high level Technician (Incorporated) Engineers in order to satisfy the needs of a developing industry. The language of instruction is English. All full time courses are of three years duration and, the diploma awarded is that of the Technician Engineer in the appropriate field. (Qualification somewhat higher than UK's HND). The fields of training covered are:

- Civil Engineering
- Electrical Engineering
- Mechanical Engineering
- Marine Engineering
- Computer studies

Currently around 700 students are studying at HTI in all specialisations. Around 5% of the students are foreigners from commonwealth and other countries of the region.

Main characteristics of the HTI courses are the practical approach, the systematic work in laboratories, the hands on experience and skills in the workshop environment, and the industrial training in the actual industrial working environment.

The admission requirements to the HTI are a Lyceum or Technical School leaving certificate (after 6 years of secondary education) and success in entrance examinations. For foreigners the requirements for entry are GCE English Language and GCE A level in Mathematics or Physics.

Between 40% and 50% of the HTI graduates pursue further studies abroad by being admitted to honours degree courses notably in the United Kingdom and the United States. HTI graduates have been given transfer students status by numerous accredited Universities of the UK, USA, Canada and other countries. For the award of Bachelors degree a 2 years of further study is usually required.

In recognition of the rapid technological changes HTI has, during the last years, given particular attention to the hosting of short courses and seminars in the area of its activities. These courses are attended by professionals from local industry and abroad. Such courses include engineering, microelectronics technology, safety, management, quality, energy management, computers, solar energy, computer aided design and manufacturing, antiseismic structural design and others. In recent years over 2400 participants have attended such courses both from Cyprus and abroad, with HTI becoming a centre of considerable and fruitful activity in updating and continuing education. It is estimated that approximately 600 professionals attend such courses every year.

The HTI had a limited activity over the past years in applied research, due to the fact that very limited resources were allocated on the budgets for research work every year.

The Institute is governed by a Board of Governors with tripartite composition. Industry (employers and trade unions), Professional Associations (relevant to fields of study) and Government. The Board of Governors have a semi-autonomous status under the Ministry of Labour and Social Insurance, and mainly deals with policy matters.

More or less the same composition is reflected in the committees which keep the Institutes syllabi and curricula under constant review in order to ensure that the level and content satisfy the needs of industry and the economy. There is one committee for every specialisation.

The day to day running of the HTI is the responsibility of the Management Team which is formed by the Director, the Heads of Departments (4) and the Workshop Superintendent. The HTI is employing about 80 members of academic staff and 20 members of other administrative and clerical staff.

Each Department is having its own Academic Council that deals with academic matters, and a Disciplinary Board that deals with disciplinary matters. In addition a Central Academic Board is in operation.

3. THE HIGHER TECHNICAL INSTITUTE AND THE NEED FOR QUALITY

The Higher Technical Institute since its operation in 1968 and until 1989 was the highest academic Institution in Cyprus. In 1989 the University of Cyprus was established and had its first students enrolling in 1992. Since then the situation changed dramatically and although the University is not having a school of engineering yet, is operation affected the quality of HTI students intake, and its operation in general.

The desire of Cypriots to get University qualification gives first choices in higher education entrance examinations, any specialisation of the University and then HTI specialisations. Of course this is not the rule but it covers the majority of higher education entrance examination applications.

In addition a great number of HTI graduates pursue further studies abroad in order to obtain a University degree. The very first graduates were automatically employed just after graduation and proved to be of high academic caliber and professionalism. However their professional carrier was frustrated due to the control by legislation of the profession demanding University degree for independent professional activity. Efforts to give professional rights to HTI graduates are still in progress after nearly 30 years of operation of HTI but there are difficulties because of the strong opposition of professional bodies and the oversupply of University degree holders. This problem forced gradually HTI graduates to go for further studies. At the beginning around 20% to 30% of the graduates were pursuing further studies but now these numbers increased to 50% with even a higher upward trend.

The only major changes in the HTI structure and courses since its establishment was an increase of the students intake from 90 per year to 180 in 1980, the introduction of the Marine Engineering course in 1980 and the Computer studies course in 1986. The latter two courses have an intake of 30 students each.

Cyprus is aiming to join Europe soon. HTI programs have to be re-evaluated and adjusted to match with the new trend in PanEuropean Education system allowing students mobility and graduates employability in any EU country.

Technology is changing fast. Twenty years ago computers were the tools of very big organisations. Nowadays personal computers are everywhere, at home or even at the smallest size of business. The replacement or purchase of new modern machinery and equipment is a pressing need. The training development and updating of the human resource of organisations is even more demanding. Attractive infrastructure able to provide the quality and magnitude of facilities for a challenging dynamic educational environment is needed in order to maintain the organisation in business. Such infrastructure shall not be limited to the essentials for the running of the courses but must be extended to cover student recreation sports and social life as well.

From all reasons given above it is more than obvious that there is an urgent need for HTI to reconsider its plans of operation and to update its mission statement. Quality work and effort for continuous improvement is the key phrase for the success.

Until recently no special attention was given to quality as such, although the traditional academic control in maintaining the standards is in operation. Recently there is an increasing interest in the various departments for Total Quality Management (TQM). Some members of the staff attended seminars and courses on TQM but yet there is no formal decision for the move of HTI towards TQM.

HTI is considered to be a government department with all the bureaucracy associated with it. HTI is operating as an academic institution by certain internal arrangements that were approved by the Board of Governors but are not legally binding, creating a lot of conflict and inconvenience in the smooth running of the institute.

Some points that affect the quality of work, and motivation of people are given below.

Staff recruitment and promotions are carried out by the Public Service Commission, which has the responsibility for recruitment of staff for any government department. This commission recruits, messengers, clerks, accountants, department directors and at the same time HTI academic staff. The staff appraisal is of the same style as for any other government employee. The same form is used for the appraisal of HTI academic staff as well as for a clerk in a Ministry.

The annual leave of staff is exactly the same as for any other government employee although some internal arrangements were made in order to ensure proper functioning of the HTI. These arrangements are not legally binding.

Staff promotion prospects are very limited and nearly 50-60% of the staff are at the top of their salary scale. Most of them are having 15 or more years of service until their retirement, with professional prospects and incentives next to nil.

Most of the HTI staff is highly qualified academically and professionally but the system itself is not harnessing this highly intellectual capacity of staff. Efforts were made under the existing system for offering consultancy services to industry and organisations but the bureaucratic system of government do not allow for expansion in this area. In addition research work undertaken by HTI do not reflect the intellectual capacity of its staff.

Additionally the bureaucratic procedures of government departments is causing a lot of problems in the smooth operation of HTI. Budgeting has to go through the Ministry of Labour & Social Insurance, Ministry of Finance, Planning Bureau, Council of Ministers and House of Representatives. Extensions and maintenance of buildings has to go through the Government Public Works Department. Anything that has to do with electrical and mechanical services has to go through the Government Electromechanical Services Department. All supplies have to go through the Government Central Stores. All computers supplies and associated infrastructure have to go through the Government Computer Services Department.

A very good example here that shows all the bureaucracy associated is that the latest model was specified for the purchase of 40 PC's for two new laboratories. By the time that they were approved and purchased they were outdated.

All correspondence with other Government Departments has to go through the Director General of the Ministry of Labour and Social Insurance.

Hopefully with the new legislation which is under consideration, HTI will be changed to an autonomous academic institution. It is the right time for management and staff to commit themselves to Total Quality approach in all processes either operational, administrative or academic. Together with the new legislation to be embarked soon the TQM principles can be introduced.

Such principles must include:
- Management's commitment (leadership)
- Focus on the customer (internal and external) and the employee
- Focus on facts (measurements)
- Continuous improvements (Kaisen)
- Everybody's participation

The new system has to cater for the provision of all the mechanisms to be created that are required for the introduction and implementation of the TQM philosophy such as for instance Quality Council, Process Quality Teams and Quality Action Teams.

The Quality Council must be drawn from all levels in the organisation. Members could be the Director, a Head of Department, a Senior Lecturer, a Lecturer (preferably one of those teaching the subject of TQM), an Instructor, a Laboratory Assistant and a member of the administrative staff. The responsibilities of the Quality Council may

include the following:
- Updating the mission statement
- Identifying the critical success factors
- Providing overall strategic directions on TQM philosophy for the HTI
- Establishing plans for TQM implementation
- Setting up process Quality Teams and Quality Action Teams to make improvements
- Reviewing progress and plans for quality improvement
- Revising plans for the development of TQM and process improvement

The Quality Council to meet regularly and in general it will be the executive body to review quality strategy, implementation, progress and improvement.

The Process Quality Teams will be set up to manage critical process improvements. Various such teams will be established and their number will be according to the processes to be identified. The participation in these teams must be wide and their responsibilities will include:
- Breaking down and describing the assigned critical processes
- Prioritizing and selecting processes for improvement
- Setting up Quality Action Teams
- Reviewing and supporting Quality Action Teams activity.

The Quality Action Teams to be set up to define and improve a particular process assigned to them. The team membership will be again wide and must represent all those involved in the assigned process. The responsibilities of these teams will include:
- Drawing a flowchart of the process to identify its customers and suppliers
- Identifying measurement points
- Measuring and comparing results with requirements
- Improving the process and documenting it.

In general all members of the staff must be involved in the TQM application in one way or another.

However whatever the developments are with the new legislation and re-organisation of HTI teaching will still be teaching. It is for this reason that the following suggestion is put forward for the Introduction of TQM Philosophy in teaching at HTI now.

4. DEFINITION OF TQM IN TEACHING

The driving force behind total quality management is a relentless daily hunt for opportunities to improve quality and productivity. The concept of total quality improvement means getting every person in a company to evaluate continually and aggressively how every job, every system, and every product can be improved. TQM is based on the participation of all members of an organisation in improving processes, products, services, and the culture in which they work. Finally, TQM is a way of doing business that must be instigated by top management and flow as a way of life throughout the organisation, to focus on the customer and to strive to improve the product, performance etc. continually, to ensure competitive advantage.

Key elements of the TQM philosophy as contained in the above definitions are:
- a relentless hunt for ways to improve quality;
- involvement of all employees;
- managerial leadership;
- corporate culture; and
- customer focus

These apply just as much to the teaching context as they do to business. The difference lies only in that in the teaching context, "lecturer" substitutes for "manager", the "students and lecturer" for "employees", "class culture" for "corporate culture", and the "student" for "customer".

5. BUILDING BLOCKS OF THE TQM ORIENTED TEACHING APPROACH

The following elements of TQM teaching approach are given as a set of guidelines for implementation. It presents some specific practices of the lecturer in using this approach. Further using student feedback obtained through

course evaluations and other inputs from students, a simultaneous attempt is made to illustrate the effectiveness of a TQM oriented approach to teaching. Kansas State University used the standard forms shown in Appendix 1 in order to receive feedback from students on a survey on the results of the application of TQM in teaching approach. The same forms or modified ones may be used to give feedback in our case.

5.1 Communicate your Teaching Philosophy

The course syllabus is used as a vehicle to communicate to students the lecturers TQM-oriented teaching philosophy the very first day of class. In going beyond the more typical "course objective", a "teaching objective" is also included on the syllabus of every course. A clearly stated teaching objective serves as a first step in creating a climate conducive to learning, involvement, and commitment on the part of students as well as the lecturer.

It sets the stage by defining the respective roles of the student and the lecturer. Moreover, the concepts of team work (the lecturer is a member of the team as well), participation, and the desire to make a real difference through the teaching objective.

5.2 Influence Students by "Setting a Good Example"

If those who teach business expect their students to "manage by example" in their future role as professionals and managers then they, as their lecturers, must "teach by example". The most fundamental, yet significant, building block of the proposed TQM-oriented approach to teaching is the concept of "influencing by example". As such, a strong and constant undercurrent of "teaching by example" is maintained in whatever the lecturer does.

The "example" that a lecturer sets is bound to exert a significant influence on the students' actions and performance. Moreover, the kind of "example" that a lecturer sets essentially determines his personal power and, consequently, the ability to influence students through educational leadership in ways that would not be possible through the use of position power alone.

To exert a greater influence through good example, lecturers must truly believe in and themselves practice that what they expect their students to do. Unfortunately, often lecturers do not themselves practice what they preach. Lecturers must feel passionately about the issues they address and the stakes that are involved. As Deeming suggests, we must feel just as passionately about quality as we do about religion in order to make the implementation of quality efforts, a success.

5.3 Shape a Climate for Excellence and Get the Students to "Stretch" their Goals

It is important for lecturers and students to realize that often their individual potential remains unrealized simply because of the constraints they impose on themselves. An essential component of the TQM philosophy is the drive for continuous improvement, with no limits placed on what one can accomplish. The more goals are stretched, the greater is the likelihood of attaining higher performance through involvement, participation, commitment, and effort. In keeping with these students are invariably asked to "stretch" their goals.

Just as the students, the lecturer must also stretch his objectives.

Getting the students to take pride in higher performance constitutes not only a prerequisite, but also serves as a catalyst in getting them to stretch their goals.

In a frank manner, the lecturer explains to the students why it is so important for them to develop good habits, the benefits they can derive from these, and the pride they can take in the impression that high quality work conveys in life. In turn, the lecturer recognises that the students now expect the same from him and, as such, he must deliver in terms of the quality of his own work, be it related to the content of class lectures, handouts, transparencies etc. are prepared, the effort he puts in when grading, or the attention he gives students.

Of importance in getting the students to stretch their goals is the shaping and providing of a culture for excellence. If students are expected to excel, then the lecturer must set a positive example for them and a standard to match. The lecturer must be well prepared, have a strong interest in teaching be enthusiastic about what he teaches and wants the student to learn, put in the best effort, be knowledgeable, pay attention to detail, have students participate and, most of all, show respect for the students so as to motivate and involve them. Of all the attributes that can possible foster quality, what Peters is most obsessed with is respect for people. In teaching, it is respect for students!

5.4 Motivate Students Through Fairness, Feedback, Encouragement, Commitment and values

Feedback plays an important role in individual behavior and performance. Be it positive or negative, it is inherently affective. It plays a crucial role in the fostering of goals any TQM-driven effort might aim to achieve, be it in business or in education.

Similarly, fairness and encouragement serve as powerful motivators in any such context. The level to which the lecturer is perceived as being fair by the students can exert a strong influence on their level of motivation involvement and effort.

In order to motivate students, it is important for the lecturer to communicate with them at an individual level. While lectures may not always be able to remember every student by name, they can easily refer to their students by name when communicating with them through comments they write in the process of grading their assignments and exams. The Lecturer addresses every student by name on any written feedback he provides. A student's sincere effort and commitment is recognised, and this recognition communicated to the student by the lecturer through written comments such as "excellent work and effort etc. To get those students who might not perform up to expectation to improve continually, the lecturer provides feedback such as "a good attempt but you can do much better" etc. For students who show significant improvement on a following exam, the lecturer's comments might read "well done...do keep up the effort" etc. Feedback can be used to open the channels of communication further, establish a closer bond with students, and to motivate them.

A strong undercurrent of ethical values, team work and commitment is maintained throughout the courses taught and in whatever the lecturer does and expects from his students. The students' sense of commitment is reinforced not only by the lecturer's setting an example, but also by his sharing with students numerous business-related examples from which lessons can be drawn.

5.5 Be Sensitive to the Many Other Aspects of TQM Philosophy

There is so much more that lecturers can do and accomplish by drawing from the broader TQM philosophy and applying it to teaching. Total quality initiatives require a total effort, a can do attitude and, most of all, total involvement. Empowerment, teamwork, reward systems that encourage continuous improvement efforts while eliminating fear of failure, effective and pen communication, and the sharing of common goals are just some of the attributes the TQM philosophy encompasses.

6. CONCLUSIONS/RECOMMENDATIONS:

It is of great importance that the new legislation governing the operation of the HTI is approved the earliest possible. HTI must turn to an autonomous educational establishment offering Incorporated Engineer courses that must be oriented towards application and at the same time be compatible with similar courses offered in Europe and Worldwide. Alternatively HTI may form the core of the school of Engineering of the University of Cyprus offering both Incorporated Engineer courses as well as University degree courses.

The infrastructure of HTI must be upgraded accordingly. Laboratories and workshops must be reorganised to cope with the new situation. Computer networking must be extended to cover all computer laboratories, offices and computer facilities must be upgraded. The existing library must turn to a modern learning resource center.

An on campus students accommodation must be created with all its associated infrastructure including recreation and sports facilities in order to encourage students life and activity both academic and social. The working hours of the Institute to be extended to cover all day and night. (Presently the Institute is working as a government department from 7.30 in the morning to 2 o'clock in the afternoon. In the afternoon minor activities take place such as very limited lectures on cultural elective subjects and sports).

Staff must be trained and developed to meet the new challenges. Schemes covering staff exchange with similar educational establishments in Europe must be enhanced. Research work must be encouraged and financed, and used as a means for motivating the staff. In addition a consultancy unit must be created that may offer services to Industry. A big proportion of the income of such a unit must be used as a reward incentive for the staff participating. The presently challenging potential that exists for the involvement of Cyprus in European Union research activity to be considered seriously.

The TQM philosophy must be adopted from the very first moment that the new legislation is approved. This TQM philosophy to be widely applied and cover every single activity and process to be developed. All staff must be accordingly trained and informed of the benefits of the TQM philosophy approach for everybody, staff, students and the competitive advantage for the institution itself.
The teaching philosophy a lecturer adopts and the example that he sets has a profound influence to students. This teaching philosophy must be very well communicated to students at the beginning of the course.

Commitment, honesty, openness and high ethics are essential prerequisites to adopting the TQM philosophy in teaching. Respect for students is quite important.

Lecturers must continuously improve and more effectively, educate, train, and influence students. Lecturers must be open to ideas and constantly evaluate the processes they use. Feedback is quite important and must be used for continuous improvement. Feedback on lecturers attributes is quite important and the recommendations given in Appendix 1 may be used or the Institute it self may develop its own system for such a feedback. At the same time feedback to students by the lecturers is crucial and is part of the motivation process that may be used.

The increasing role of educational establishments in the training and retraining of the human resource makes it more demanding than ever for better performance and effectiveness. Adopting TQM philosophy the way to success and continuous improvement is open.

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STUDENTS RATING OF THE LECTURER ON INSTRUCTIONAL ATTRIBUTES
(Source: Kansas State University)

ITEM	STUDENT RATING
His enthusiasm, energy and interest in the subject	
Practice of mutual respect	
The way the instructor interacted with the students	
Encouraging class participation	
His knowledge of the sujbect	
Not only wanting the student to learn but also willing to learn himself	
His effort in attempting to teach effectively	
Challenging the students to be creative think productively and expand their conceptual horizons	
The quality of work as reflected by content/presentation of material on the syllabus, tests, assignments etc	
Paying attention to detail (on the syllabus, course content, assignments, examinations, policies, evaluation, etc.)	
His involvement with the personal attention given to the students	
Willingness to help students and making himself available for help	
Really caring that the students actually learn	
Being frank, open and up-front about things	
His teaching in a way that students may actually be able to echance competitiveness	

Any other comments: .....

.....

.....

NOTE

Scale: very bad example = -3; very good example = +3

STUDENTS RATING OF THE LECTURER ON TEACHING ATTRIBUTES RELATED TO MOTIVATION FAIRNESS, FEEDBACK, ETHICAL VALUES AND COMMITMENT

(Source: Kansas State University)

ITEM	STUDENT RATING
Fairness in the treatment of students	
Fairness in grading and evaluating performance	
The feedback provided (the type/nature of feedback, e.g. whether encouraging or discouraging and its usefulness	
Encouraging and supporting your effort in any way so as to improve your learning and performance continuously in this class	
The values he communicated and displayed	
Ethical values and the practice of such values	
His commitment to the teaching profession	
His commitment to shaping students into better and more committed managers	
His practicing what he preaches	
Teaching the subject and material as is best for the student rather than what suits him best	
Promoting a sincere commitment to the organization for which one works	
Any other comments:	.....
.....	.....
.....	.....

NOTE

Scale: very bad example = -3; very good example = +3

STUDENTS RATING OF THE LECTURER ON SOME OTHER TQM RELATED INSTRUCTIONAL ATTRIBUTES

(Source: Kansas State University)

ITEM	STUDENT RATING
Challenging the students to be creative and not be bogged down by traditionally held views and perceived constraints	
Promoting a "can do" attitude by encouraging and assuring the students that even objectives and goals that may seem "stretched" and "out of reach" can in fact be attained	
Encouraging student involvement in ways that help improve learning and performance	
Encouraging the student to except more of themselves in terms of what they can do and how they can make a difference as managers	
Putting "the ball in the students' court" in that through sincere effort the students are actually able to shape their learning and determine their performance	
Rewarding the student in proportion to effort	
Stating and abiding by the statement that it takes work (both on the part of the teacher and the student - a two way street) to facilitate learning	
Using various means to facilitate effective communication between the teacher and the student so that the expectations on both sides are clearly understood	
Rewarding sincere effort over and above merely right answers	
Not establishing and believing in numerical quotas for grades (grading) in such a manner or adjusting the distribution etc.) but rather, encouraging improved performance of all	
Any other comments:	.....
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NOTE

Scale: very bad example = -3; very good example = +3

AN OVERVIEW OF SOLAR WATER HEATING IN CYPRUS - PRESENT SITUATION AND PROSPECTS

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ABSTRACT

This paper is concerned with the present situation and prospects of solar water heating in Cyprus. It aims to review the progress achieved in this application and suggests measures and incentives for further improvements and developments. Solar water heating in Cyprus began in 1956 while local production started four years later. Today the estimated park of solar collectors in working order is 560,000 m^2, which corresponds to approximately 0.86 m^2 per inhabitant and a contribution to the national energy demand of about 6%. The payback period for solar water heating systems is about 3-4 years when the comparison is made with electricity and 7-9 years when the comparison is made with diesel oil.

1. INTRODUCTION

The almost full reliance of Cyprus on imported oil in meeting its energy demand and the abundance of solar radiation together with a good technological base and the popular acceptance of solar energy systems created favorable conditions for the exploitation and utilisation of solar energy. Today, the contribution of solar energy to meeting the primary energy needs of the island is estimated to about 6%. Furthermore, it contributes to the reduction in the atmospheric pollution that is estimated to approximately 250,000 tons of CO_2 per year (European Commission, 1996).

The purpose of this presentation is to describe the present situation of solar water heating in Cyprus and to elaborate on the future prospects, including measures to be taken for improving the situation.

2. HISTORICAL NOTES

A visit of the Cypriot manufacturer Kypros Psimolophitis (late chairman of Metalco Group of Companies) at the factory of MIROMIT-OLYMPIA in Israel, manufacturers of solar water heaters, in 1956, marked the beginning of solar water heating in Cyprus (Psimolophitis, 1996). Following the above visit, Mr Psimolophitis imported four thermosyphon solar water heating units, complete with all accessories except the cold water tanks. The first one was installed on his house in Nicosia and the rest on the houses of friends and associates.

Following an agreement made by the two parties, the Israeli company agreed to supply Mr Psimolophitis the absorber plates and other accessories for the collectors and the storage tanks which were then assembled locally, until 1960 that all components were constructed and assembled in Cyprus, based on the imported design with minor modifications and improvements.

In 1961, Mr Psimolophitis participated to the 1st Trade Fair in Nicosia, where he installed a working model of thermosyphon solar water heater. Among the visitors were the President and the vice-president of the newly established Republic of Cyprus, who according to Mr Psimolophitis, tested the unit and were convinced with surprise that the running water was hot.

As a result of the promotion campaign made by Mr Psimolophitis, the number of orders had increased and further improvements were implemented.

3. THE PRESENT SITUATION

In Cyprus, solar energy is almost exclusively used for the production of sanitary hot water, mainly in households. According to the Ministry of Commerce Industry and Tourism (1995), the utilisation of solar energy in Cyprus for hot water generation in 1994 was as follows:

Residences	91%
Hotel Apartments	80%
Hotels	44%

The system used in residential applications is the traditional thermosyphon solar water heater that comprises two flat plate solar collectors of 3 m^2 of surface and a hot water storage tank of 180 liters capacity. The solar collectors are of the flat plate type, made of copper absorber and copper tubes (risers) and header. The risers are bonded to the absorber plate using various techniques that result in poor to very good thermal contact. Roll bonding is not used. In most of the cases, the risers fit in corrugations made on the absorber plate, while in few cases soldering is used to improve the contact.

The unit is equipped with an auxiliary electric element of 3 kW that boosts the system in case of reduced solar radiation. In buildings which are equipped with oil fired central heating systems, the boiler is used as auxiliary to feed a hot water heat exchanger fitted in the hot water storage tank of the unit. The payback period for a typical thermosyphon solar water heater under the socio-economic and weather conditions of Cyprus varies from 3 to 4 years when the comparison is with electricity (Michaelides, 1991). The payback period changes to 7-9 years when the comparison is made with diesel oil (Sema-Metra *et al.*1985, Michaelides 1991).

Hotels and hotel apartments are usually equipped with active solar systems, which employ pump, heat exchanger and oil-fired boiler as back-up source of energy. Two different studies conducted in Cyprus showed that central solar hot water systems for hotels and hotel apartments are technically and economically feasible. Sema-Metra *et al.* (1985), found a payback period of 7 years for a solar hot water system intended for a 4-star hotel in Cyprus. Another study conducted by Michaelides *et al.* (1996) showed that the payback period corresponding to optimum design criteria for hotel applications in Cyprus is about 7 to 8 years when compared to diesel oil.

Compared to other countries in the Mediterranean region and the European Union, Cyprus holds a very good position in the exploitation of solar energy, as shown in fig. 1, plotted from information taken from a study conducted by the European Union (European Commission, 1996). According to that study, the estimated park of solar collectors in working order is 560,000 m^2, which corresponds to approximately 0.86 m^2 per inhabitant as compared to 0.56 and 0.2 for Israel and Greece respectively. In terms of solar water heaters, for every five people in the island there is a solar water heater, which is a world record. Cyprus holds the first place as far as installed solar collector area per capita is concerned.

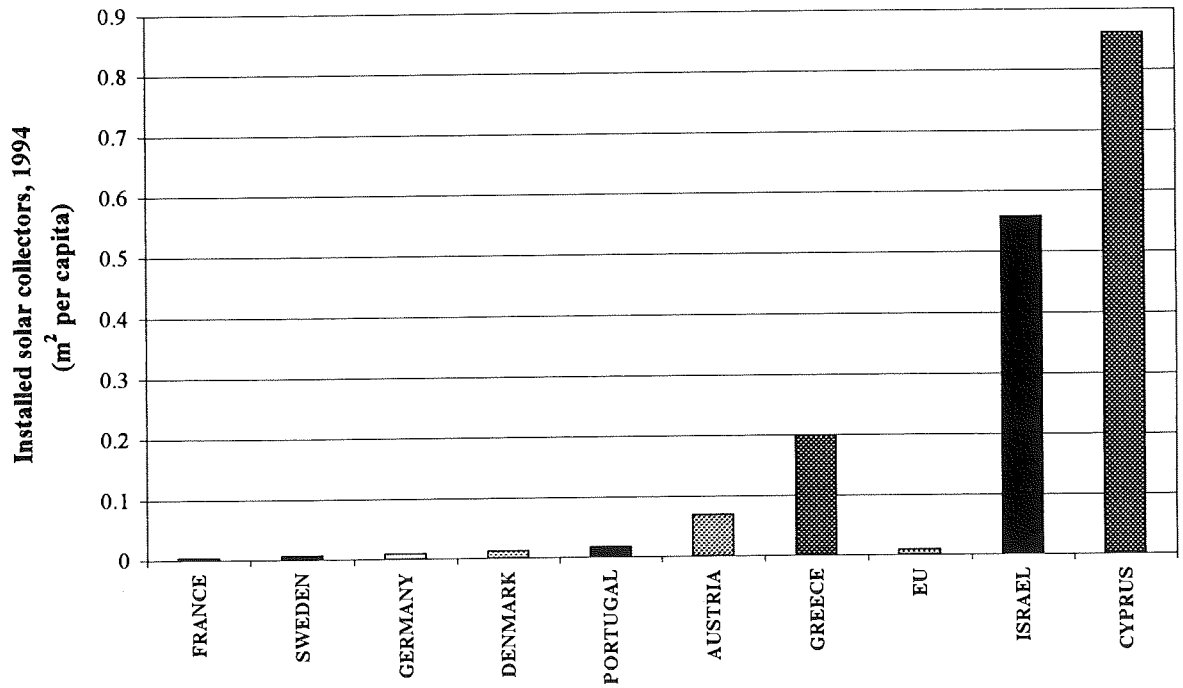

Fig. 1. Installed solar collector area per capita, 1994

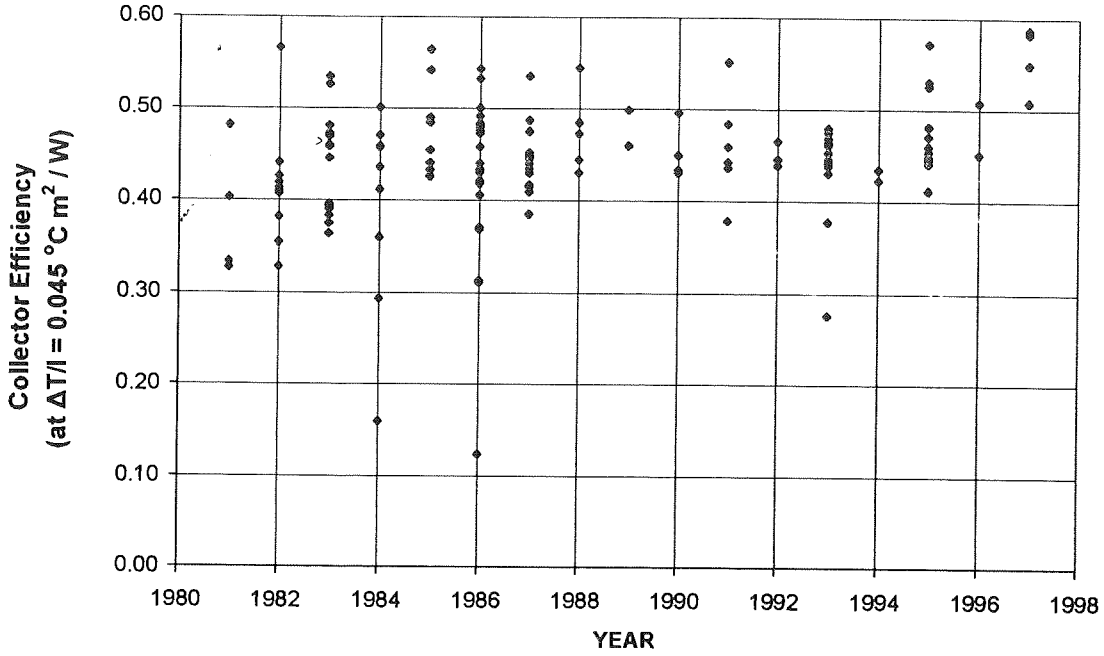

Fig. 2. Efficiency of solar collectors in Cyprus, 1981-1997

With regard to the quality of construction and the thermal performance of the solar collectors manufactured in Cyprus, an improvement has been observed during the last 5 to 10 years. This can be seen in the graph of fig. 2, which illustrates the instantaneous efficiency of 152 flat plate solar collectors for $\Delta T/ I=0.045\ ^{0}C\ m^2/W$, taken from tests conducted at the Applied Energy Centre of the Ministry of Commerce Industry and Tourism during the period of 1981-1997. It must be noted that the results concern those collectors which have been taken to the above Centre for testing by different manufacturers. It can be seen from the graph that in general the efficiency of collectors tested the last 3 years, which in fact represent new or improved designs, is slightly higher than that of previous years which is an indication of the need for further development and improvement.

4. PROSPECTS AND MEASURES FOR FURTHER IMPROVEMENTS

4.1. Thermosyphon Solar Water Heating Systems

There are a lot of improvements that could be made by the Cypriot manufacturers of thermosyphon solar water heaters; they concern both, the collector itself and the storage tank as well as the system configuration. Following are some suggestions:

a) Optimum collector slope. It has been found that the optimum collector slope for a hot water supply system, which is in fact a year-round application, is 35 degrees from horizontal (Michaelides, 1993). A survey in the Cyprus market showed that almost all manufacturers use a slope different than the above.
b) Vertical distance between collector and storage tank. It is generally accepted that the optimum distance between the top header of the solar collector and the cold leg fitting on the storage tank is about 30 cm (Kreider *et al.,* 1977). The situation is not exactly like that in Cypriot solar water heaters.
c) Auxiliary source of energy. The traditional Cypriot solar water heaters are equipped with an electric heater of 3 kW, located at the lower part of the storage tank. From simulation studies conducted at the Higher Technical Institute (Michaelides *et al.,* 1997), it was found that the annual solar fraction of a solar water heater is much higher if the auxiliary heater is located outside the storage tank, in line to the taps (see fig. 3).
d) Need to study the extent of the problem of reverse water flow during the night.
e) The Government should immediately proceed to the testing of solar water heating units and issue performance certificates to the manufacturers. This will indirectly force the manufacturers to proceed to serious modifications and improvements on their products. A test fee to be agreed with the manufacturers' Association should be charged for each test. An appropriate test fee should also be agreed for the testing of solar collectors.
f) Solar collectors. It is about time for the manufacturers to make a jump to new technologies, in order to improve both quality of workmanship and thermal performance of the collector by improving on the absorber optical characteristics and the heat transfer characteristics between the absorber and the tubes.

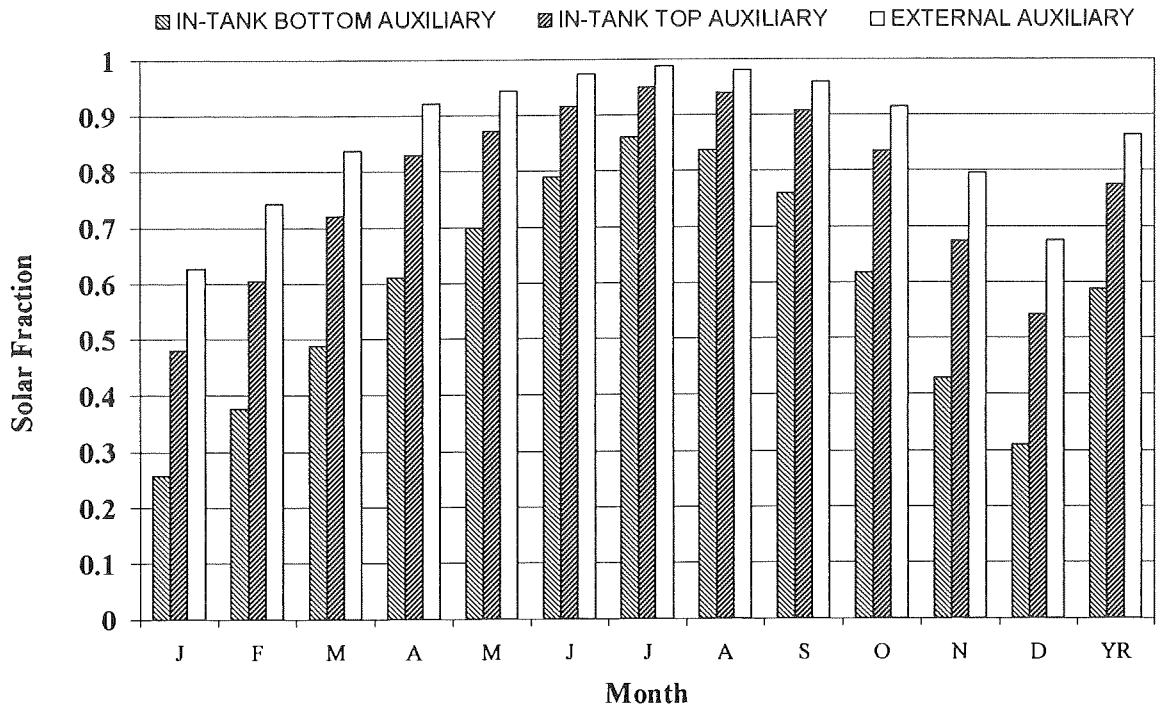

Fig. 3. Effect of auxiliary position on the system solar fraction

4.2. Central large-scale applications

The low percentage of applications in hotels is a good reason for a survey within the hotel industry that will investigate the reasons for which the utilisation of solar energy in this field of application is not as high as in the case of residences. For the success of such a survey, it would be very helpful if the Association of hotel owners could be actively involved in the process.

The survey should be firstly extended to all those hotels and hotel apartments which are equipped with solar systems, and secondly on a selective basis, to hotels and hotel apartments which are not equipped with solar systems. If some of the systems installed do not operate satisfactorily and as a result of this their contribution to the building energy balance is not cost effective, the survey should be extended to identify the reasons which resulted to that situation. Some of the reasons are perhaps known. These are for example, bad design, inappropriate system selection, wrong controls and strategies employed, unsatisfactory maintenance, etc. The survey will investigate the extent of the problem and will help the parties concerned to find out what remedial measures should be taken.

To this effect, monitoring of the operation of some of the systems should be made to evaluate the thermal performance of the systems and investigate their actual contribution to the hot water thermal load. Most of the existing installations use a conventional energy back-up system, usually an oil-fired boiler. In case of a failure or malfunction in the solar system, the back-up boiler is put into operation so that the production and supply of hot water is not interrupted. The problem however is that the user does not have any indication of the actual contribution of the solar system unless an appropriate monitoring system is available. Such a system will not only evaluate the performance but will also help in fault finding and system servicing and maintenance.

Tele-monitoring should also be employed for a number of existing systems. According to a study conducted by the European Commission (1998), tele-monitoring is commercially feasible for all collective installations, as the cost represents only 5% of the total installation costs. A tele-monitoring system will make it possible for the interested parties (hotel owner and technical consultant) to check the results at any moment. The above technique could initially be employed in selected hotels, 2-3 in each of the tourist areas of Cyprus.

The survey should also be extended on a selective basis, to hotels and hotel apartments which are not equipped with solar systems to find out the reasons for which solar energy applications have not been preferred.

In parallel to the above measures, effort should be made by all concerned actors (government, engineering consultants and hotel owners) for the promotion of appropriate design systems including all necessary controls which will guarantee an efficient and cost effective operation. A good incentive for example could be the subsidization of the design fees. Most of the existing installations are not properly sized and in many cases the controls are not set correctly or the sensors are not located to the appropriate position.

4.3. Other measures and incentives

Solar water heating should be extended to other applications, such as Industrial (breweries, leather industries, etc.), public buildings (hospitals and clinics, etc.) and Greenhouses.

Furthermore, for the promotion and further exploitation of solar water heating, the following measures and incentives could be implemented:

a) Establishment of an Energy Research Fund to be supported by the Government.
b) Promotion of mandatory certification of solar collectors and solar water heating systems.
c) Organisation of short training courses and seminars intended for different groups of people, like for example, architects, consulting engineers, manufacturers, and consumers.
d) Promotion of exports of solar water heaters. Currently, exports are occasional and are estimated to about 200 units (600 m2 of collector) per year, as compared to imports, which are estimated to about 700 units per year (European Commission, 1996).
e) Subsidisation of design fees to prospective users of large-scale solar water heating systems (hotels, hotel apartments, commercial or industrial applications).

CONCLUSIONS

Cyprus holds a very good position in the world in the use of solar energy for water heating which is a cost-effective application in the island. There is however space for improvements and developments which concern both the system components and the system design, installation and operation.

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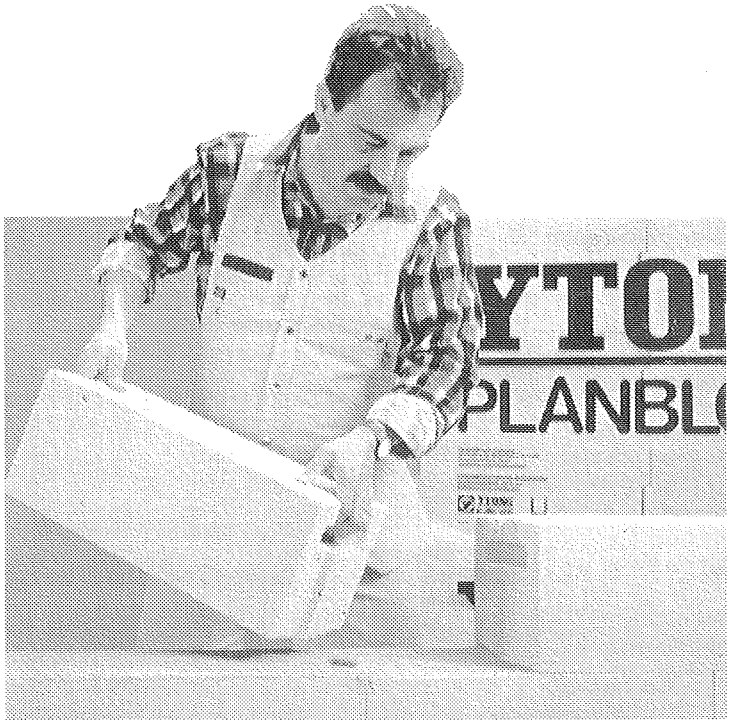
YTONG®

ΕΛΑΦΡΥ-ΜΟΝΩΤΙΚΟ-ΑΝΘΕΚΤΙΚΟ-ΕΥΧΡΗΣΤΟ

ΕΤΣΙ ΔΟΜΕΙΤΑΙ Ο ΚΟΣΜΟΣ ΣΗΜΕΡΑ



ΔΩΣΤΕ ΣΤΟ ΣΠΙΤΙ ΣΑΣ ΑΝΑΣΑ

• Χτίστε με **YTONG**. Τα δομικά υλικά που παράγονται από φυσικές πρώτες ύλες. Ετσι εξασφαλίζουν τη φυσική αναπνοή της τοιχοποιΐας και σε σας τις ιδανικότερες συνθήκες υγιεινής. Κανένα άλλο σύστημα δόμησης δεν σας δίνει τόσες εγγυήσεις μοναδικής ποιότητας.

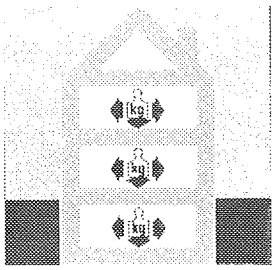
ΖΗΣΤΕ ΣΤΗΝ ΙΔΑΝΙΚΗ ΘΕΡΜΟΚΡΑΣΙΑ

• Χτίστε με **YTONG**. Οι θερμομονωτικές ιδιότητες των **YTONG** σας εξασφαλίζουν ζέστη το χειμώνα και δροσιά το καλοκαίρι δημιουργώντας το πιο ευχάριστο κλίμα δωματίου, με τη μεγαλύτερη εξοικονόμηση ενέργειας. Και όλα αυτά χωρίς τη χρησιμοποίηση πρόσθετων χημικών μονωτικών υλικών στην κατασκευή.
Επιπλέον τα **YTONG** σας παρέχουν τη μέγιστη πυρασφάλεια και εκτός αυτού ηχομονώνουν το χώρο σας.

ΠΡΟΣΤΑΤΕΨΤΕ ΤΟ ΣΠΙΤΙ ΣΑΣ ΑΛΛΑ ΚΑΙ ΤΟΝ ΠΡΟΫΠΟΛΟΓΙΣΜΟ ΣΑΣ

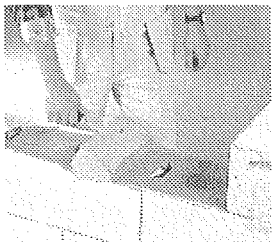
• Χτίστε με **YTONG**. Τα πιο ελαφρά και ελαστικά δομικά υλικά με την υψηλότερη αντισεισμικότητα. Χάρη στο μικρό τους βάρος μειώνουν δραστικά το φορτίο της οικοδομής και αυξάνουν θεαματικά την αντισεισμική της αντοχή.
Και κάτι πολύ σημαντικό: Ο μοναδικός τρόπος δόμησης και η ευκολία χτισίματος **YTONG** σας παρέχουν σημαντική εξοικονόμηση χώρου και μείωση στο μισό του κόστους επιχρίσματος.
Αν χτίζετε σήμερα, χτίστε γερά, σωστά, ολοκληρωμένα και με οικονομία χωρίς συμβιβασμούς στην ποιότητα.
Χτίστε με **YTONG**. Γιατί έτσι δομείται ο κόσμος σήμερα.

➢ΣΥΝΕΠΕΙΑ ➢ΤΑΧΥΤΗΤΑ ➢ΕΜΠΙΣΤΟΣΥΝΗ

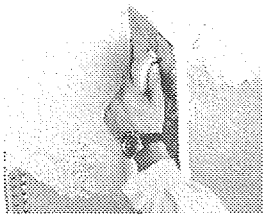


Κτίζοντας με **YTONG** μειώνετε 4 φορές τα φορτία της οικοδομής, τον οπλισμό και το κόστος του φέροντος οργανισμού.

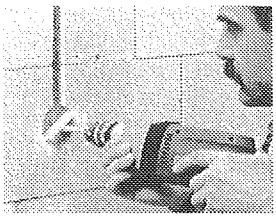
Τα **YTONG** κόβονται τόσο εύκολα, όσο και το ξύλο και επεξεργάζονται σε οποιοδήποτε σχήμα.



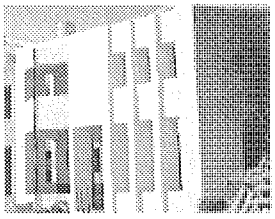
Δεν είναι απαραίτητη η χρήση της κοινής λάσπης. Με τη χρήση του κονιάματος (κόλλα) της **YTONG** μειώνεται ο αρμός σε 1-2 mm και η εργασία του κτίστη στο ελάχιστο. Τα αρσεινκά/θηλυκά κάνουν το κτίσιμο παιχνίδι.



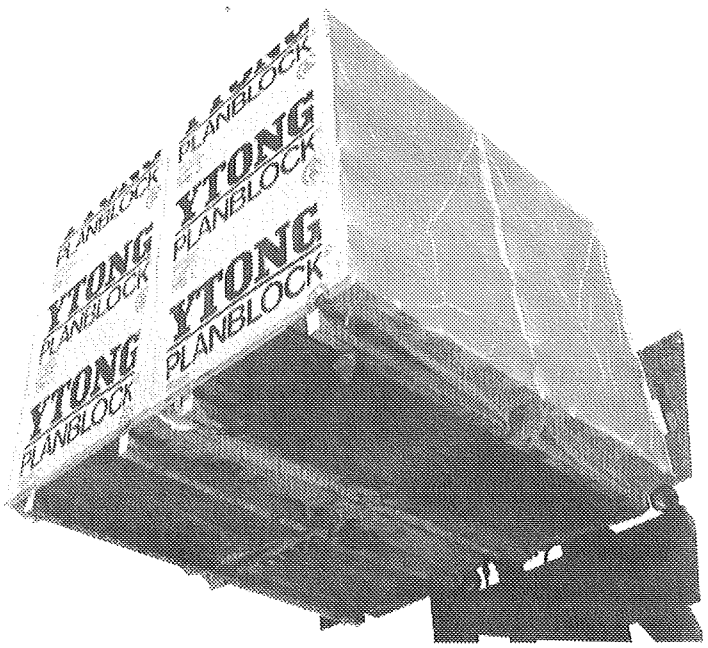
Το σοβάτισμα είναι πολύ απλό, λόγω της ένιαίας επιφάνειας που σχηματίζεται. Δεν είνοι απαραίτητος ο διπλός σοβάς. Αρκεί ακόμα και ένα σπατουλάρισμα. Τα **YTONG** επιδέχονται βαφές και ταπετσαρίες κάθε είδους και ποιότητας.



Οι ηλεκτρικές και υδραυλικές εγκαταστάσεις σε σπίτια που κτίστηκαν με **YTONG** γίνονται με απλά εργαλεία χωρίς ακαθαρσίες και καταστροφές στο κτίριο.



Κτίζοντας με **YTONG** ένα σπίτι 100 τ.μ. κερδίζεται ωφέλιμη επιφάνεια 10 τ.μ. γιατί μειώνεται το πάχος των τοίχων.



ΕΠΙΦΑΝΙΟΥ
ΦΑΝΟΣ Ν. ΕΠΙΦΑΝΙΟΥ ΛΤΔ

Λευκωσία: Τηλ. 438991, 436121.
Λεμεσός: Τηλ. 564984, 387613
Λάρνακα: Τηλ. 631661/2
Πάφος: Τηλ. 245318

SOLAR AND LOW ENERGY COOLING TECHNOLOGIES A REVIEW

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ABSTRACT

This paper examines the subject of solar cooling and low energy cooling technologies. A brief review of various cooling systems is presented including solar sorption cooling, solar-mechanical systems, solar related air conditioning, and low energy cooling technologies. The relative efficiencies and applications of the various technologies are presented. These technologies can be utilised to reduce the use of HCFCs, which harm the environment.

1. SOLAR COOLING SYSTEMS

Cyprus is called the "Sun Island" because sun shines for about 300 days per year. This means that solar energy is in abundance in the island. During the summer time mean monthly temperatures for Nicosia, at 14.00 hours in July, are 35.4°C (Kalogirou, 1991) with the temperature sometimes reaching 42°C. For this reason, solar cooling of buildings seems the most attractive. This is an application in which the demand for cooling energy closely matches the availability of solar energy, not only to the seasonal but also to the daily variation.

Solar cooling systems are mainly classified in three categories, namely solar sorption cooling, solar-mechanical systems and solar-related systems (Swartman, 1979).

1.1 Solar Sorption Cooling

The binding of one substance to the other is called sorption. Sorbents are materials that have an ability to attract and hold other gases or liquids. This characteristic makes them very useful in chemical separation processes. Desiccants are sorbents that have a particular affinity for water. The process of attracting and holding moisture is described as either absorption or adsorption, depending on whether the desiccant undergoes a chemical change as it takes on moisture. Absorption changes the desiccant as for example the table salt, which changes from a solid to a liquid as it absorbs moisture. Adsorption, on the other hand, does not change the desiccant except by the addition of the weight of water vapour, similar in some ways to a sponge soaking up water (ASHRAE, 1989).

Absorption systems are similar to vapour-compression air conditioning systems but differ in the pressurisation stage. In general, an evaporating refrigerant is absorbed by an absorbent on the low-pressure side. Combinations include lithium bromide-water (LiBr-H2O) where water vapour is the refrigerant and ammonia-water (NH3-H2O) systems where ammonia is the refrigerant.

The pressurisation is achieved by dissolving the refrigerant in the absorbent in the absorber section (Fig. 1). Subsequently, the solution is pumped to a high pressure with an ordinary liquid pump. The addition of heat in the generator is used to separate the low-boiling refrigerant from the solution. In this way the refrigerant vapour is compressed without the need of large amount of mechanical energy that the vapour-compression air conditioning systems demand.

The remainder of the system consists of a condenser, expansion valve and evaporator, which function in a similar way as in a vapour-compression air conditioning system.

The NH_3-H_2O system is more complicated than the LiBr-H_2O since it needs a rectifying column that assures that no water vapour enters the evaporator where it could freeze. The NH_3-H_2O system requires generator temperatures in the range of 125°C to 170°C with air-cooled absorber and condenser and 95°C to 120°C when water-cooling is used. These temperatures cannot be obtained with flat-plate collectors. The coefficient of performance (COP), which is defined as the ratio of the cooling effect to the heat input is between 0.6 to 0.7. The LiBr-H_2O system operates at a generator temperature in the range of 70°C to 95°C with water used as a coolant in the absorber and condenser and has COP higher than the NH_3-H_2O systems. This COP is between 0.6 and 0.8 (Duffie and

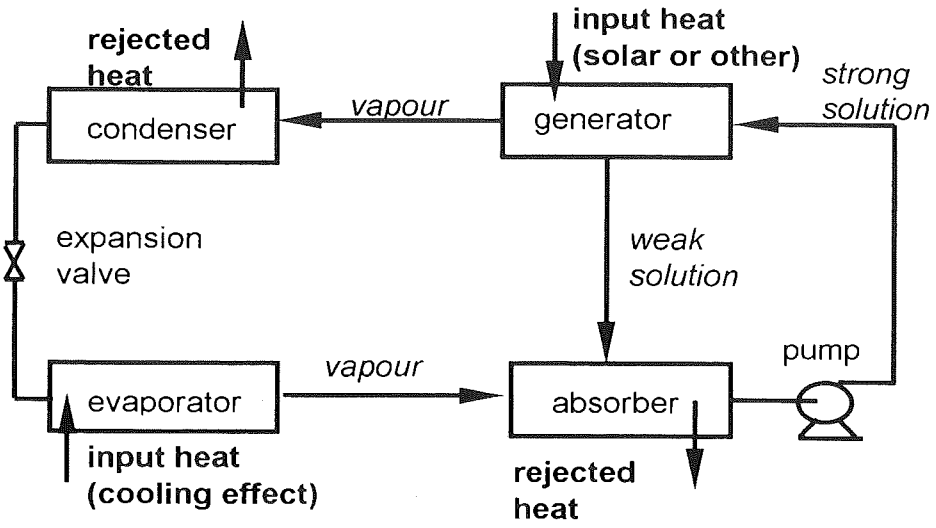

Fig. 1. Basic principle of the Absorption Air Conditioning System.

Beckman, 1991). A disadvantage of the LiBr-H_2O systems is that their evaporator cannot operate at temperatures much below 5°C since the refrigerant is water vapour.

Adsorption cooling is the other group of sorption air conditioners that utilises an agent (the adsorbent) to adsorb the moisture from the air (or dry any other gas or liquid) and then uses the evaporative cooling effect to produce cooling. Solar energy can be used for regenerating the drying agent. Solid adsorbent classes include silica gels, zeolites, synthetic zeolites, activated aluminas, carbons and synthetic polymers (ASHRAE, 1989). Liquid adsorbent can be triethylene glycol solutions of lithium chloride and lithium bromide solutions.

Many cycles have been proposed for adsorption cooling. The principle of operation of a typical system is indicated in Fig. 2. The process followed at the points from 1 to 9 of Fig. 2, is traced on the psychrometric chart of Fig. 3. Ambient air is heated and dried by a dehumidifier from point 1 to 2, regeneratively cooled by exhaust air from 2 to 3, evaporatively cooled from 3 to 4 and introduced into the building. Exhaust air from the building is evaporatively cooled from 5 to 6, heated to 7 by the energy removed from the supply air in the regenerator, heated by solar or other source to 8 and then passed through the dehumidifier where it regenerates the desiccant.

The selection of the adsorbing agent depends on the size of the moisture load and the application.

Rotary solid desiccant systems are the most common for continuous removal of moisture from the air. The desiccant wheel rotates through two separate air streams. In the first stream the process air is dehumidified by adsorption, which does not change the physical characteristics of the desiccant, while in the second stream the reactivation or regeneration air, which is first heated, dries the desiccant. A schematic of a possible solar-powered adsorption system is illustrated in Fig. 4 (Swartman,1979).

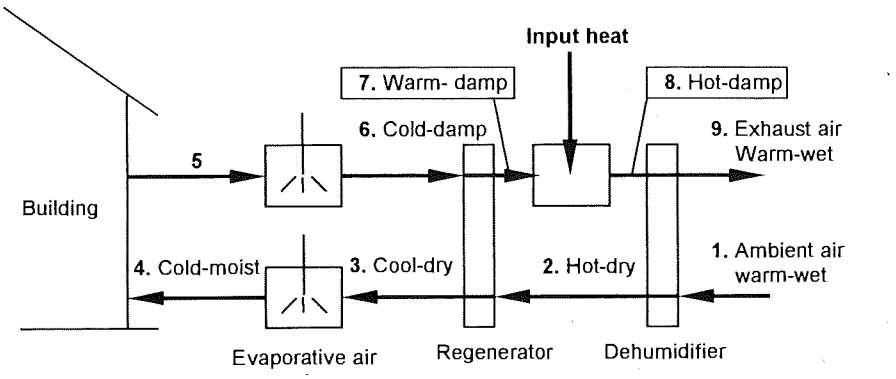

Fig. 2. Schematic of a solar adsorption system.

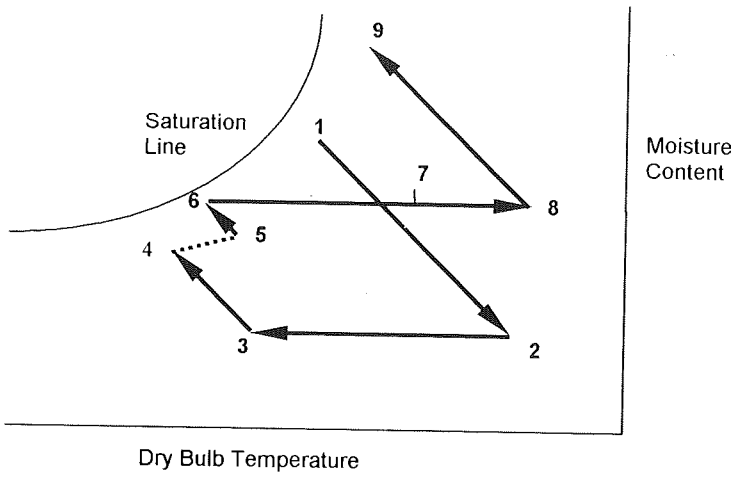

Fig. 3. Psychrometric diagram of a solar adsorption process.

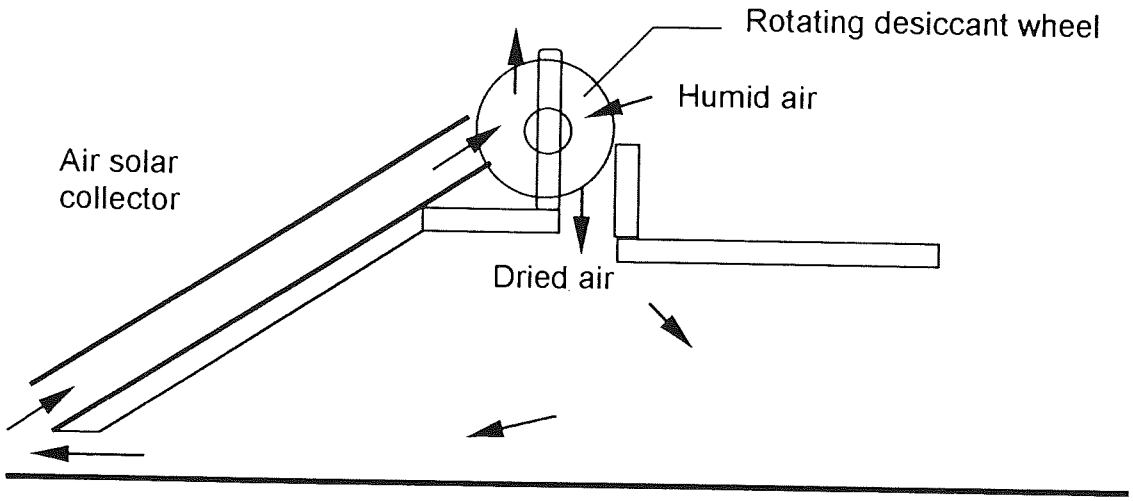

Fig. 4. Solar adsorption cooling system. Redrawn from Swartman (1979).

When the drying agent is a liquid like triethylene glycol, the agent is sprayed into an absorber where it picks up moisture from the building air. Then it is pumped through a sensible heat exchanger to a stripping column where it is sprayed into a stream of solar heated air. The high temperature air removes water from the glycol, which then returns to the heat exchanger and the absorber. Heat exchangers are provided to recover sensible heat, maximise the temperature in the stripper and minimise the temperature in the absorber. This type of cycle is marketed commercially and used in hospitals and large installations (Duffie and Beckman, 1991).

The energy performance of these systems depends on the system configuration, geometries of dehumidifiers, properties of adsorbent agent, etc., but generally the COP of this technology is around 1.

1.2 Solar-Mechanical Systems

These systems utilise a solar-powered prime mover to drive a conventional air-conditioning system. This can be done by converting solar energy into electricity by means of photovoltaic devices and then utilise an electric motor to drive a vapour compressor. The photovoltaic panels have a low efficiency (about 10%) which results in low overall efficiencies of the system.

The solar-powered prime mover can also be a Rankine engine. In a typical system, energy from the collector is stored, then transferred to a heat exchanger and finally energy is used to drive the heat engine. The heat engine drives a vapour compressor, which produces a cooling effect at the evaporator. As shown in Fig. 5, the efficiency

of the solar collector decreases as the operating temperature increases, whereas the efficiency of the heat engine of the system, increases as the operating temperature increases. The two efficiencies combine at a point giving an optimum operating temperature for steady state operation. The combined system has overall efficiencies of about 17-23%.

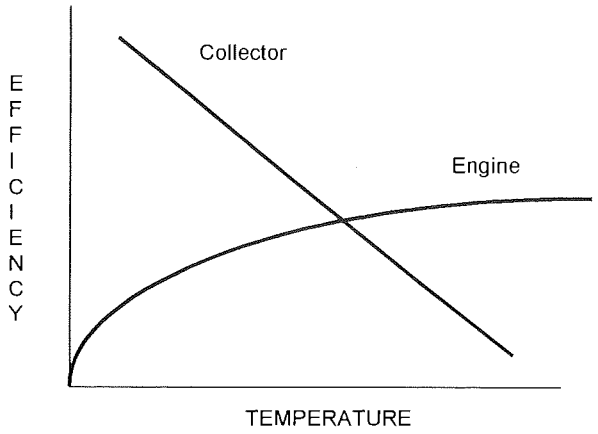

Fig. 5. Collector and Power cycle efficiencies as a function of operating temperature.

Due to the diurnal cycle, the cooling load varies and also the storage tank temperature changes through the day. Therefore, the designing of such a system presents appreciable difficulties. When a Rankine heat engine is coupled with a constant speed air conditioner, the output of the engine seldom matches the input required by the air conditioner. Therefore, auxiliary energy must be supplied when the engine output is less than that required or otherwise, excess energy may be used to produce electricity for other purposes (Swartman,1979).

1.3 Solar Related Air Conditioning

Some components of systems installed for the purpose of heating a building can also be used to cool it but without the direct use of solar energy. Examples of these systems can be:

(a) Heat pumps

A heat pump is a device that pumps heat from a low temperature to a higher temperature, appearing to violate the laws of thermodynamics. Heat pumps are usually vapour compression refrigeration machines where, the evaporator can take heat into the system at low temperature and the condenser can reject heat from the system at high temperature. In the heating mode a heat pump delivers thermal energy from the condenser for space heating and can be combined with solar heating. In the cooling mode the evaporator extracts heat from the air to be conditioned and rejects heat from the condenser to the atmosphere with the solar energy not contributing to the energy for cooling.

(b) Sky radiation

This method utilises solar equipment already installed, to dissipate energy into the night sky, by radiation. This method if used with flat plate collectors, demands collector properties opposite to those needed for efficient collection (Swartman, 1979). Hence, a compromise is necessary. Also these systems can be used where the night sky temperatures are low, i.e., where atmospheric moisture and dust content are low and also where the night-time wind speeds are low (Duffie and Beckman, 1991). Other systems can combine a separate collector, radiator and storage capabilities in the basin of water on a horizontal roof of a building. During summer the solar collector area on the roof is covered by movable insulation and the radiator area is in operation. During winter the insulation covers the radiator allowing the collector area to operate.

(c) Rock bed regenerator

Rock beds (or pebble beds) storage units of solar air heating systems can be night-cooled during summer to store "cold" for use the following day. This can be accomplished by passing outside air during the night when the temperatures and humidities are low, through an optional evaporative cooler, through the pebble bed and to the exhaust. During the day the room air can be cooled by passing it through the pebble bed.

(d) Alternative cooling technologies or passive systems

Passive cooling is based on the transfer of heat by natural means from a building to environmental sinks like clear skies, the atmosphere, the ground and water. The transfer of heat can be by radiation, naturally occurring wind, air flow due to temperature differences, conduction to the ground or conduction and convection to bodies of water. The options depend on the climate type.

When using passive cooling systems, co-operation with the architect for providing good insulation to the building, double roofs, shading devices and generally minimising the cooling loads, is essential.

Ventilation of building interiors is also effective in cooling. To maximise natural ventilation, windows and doors can be placed in such positions so as to take advantage of prevailing winds, appropriate vents can be placed in attics and roof spaces to induce thermal circulation of air, etc.

The ground temperature below the surface normally does not vary much and is low enough. Earth tempering, i.e. the use of the ground as a heat sink can be a means of removal of energy from a building interior.

Finally, other methods of cooling load reduction including hybrid methods, operated with mechanical energy and by passive means, can also be used.

2. LOW ENERGY COOLING TECHNOLOGIES

Low energy cooling technologies are regarded as alternative cooling technologies and they can offer reductions in energy consumption, peak electrical demand and energy cost, when they are properly designed and implemented. The most common of these technologies are described briefly in the following section.

2.1 Night Cooling

In this system, night cool air is used to remove heat from the interior of a building. The outdoor air can enter into the building naturally, mechanically or with both methods. During natural ventilation (Fig. 6), air enters into the building through intentional openings left to utilise either the indoor/outdoor temperature differences (stack effect) or the wind pressures.

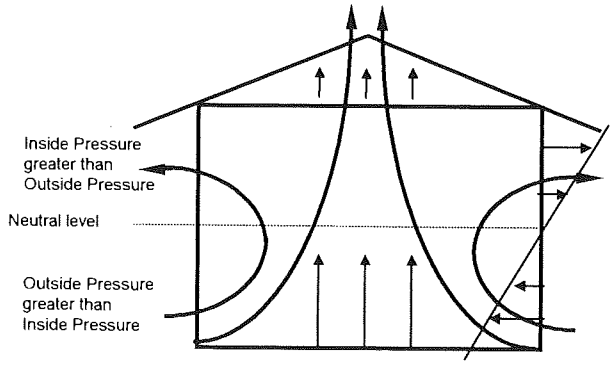

Fig. 6. Air circulation due to stack effect. Arrows indicate pressure differences (ASHRAE, 1989).

Figure 7, indicates how the prevailing wind is utilised in a traditional Iraqi house, to take advantage of the night cool air and provide a cooler environment during the day. In mechanical ventilation a fan and a duct system can be used to force air into the building.

Natural night cooling is an unreliable method for air quality, quantity and controllability. Its effect depends largely on the magnitude of heat gains and ventilation rates and results on unreliable indoor humidity control.

Night cooling with mechanical ventilation is much more controllable and is especially suited for unoccupied buildings during the night, where relatively high air flows can be used to maximise the cooling effect.

The building mass is of great importance when night cooling is used, since a large mass will absorb greater amounts of heat load during the day. Also the interior surfaces of the building need to be exposed as much as pos-

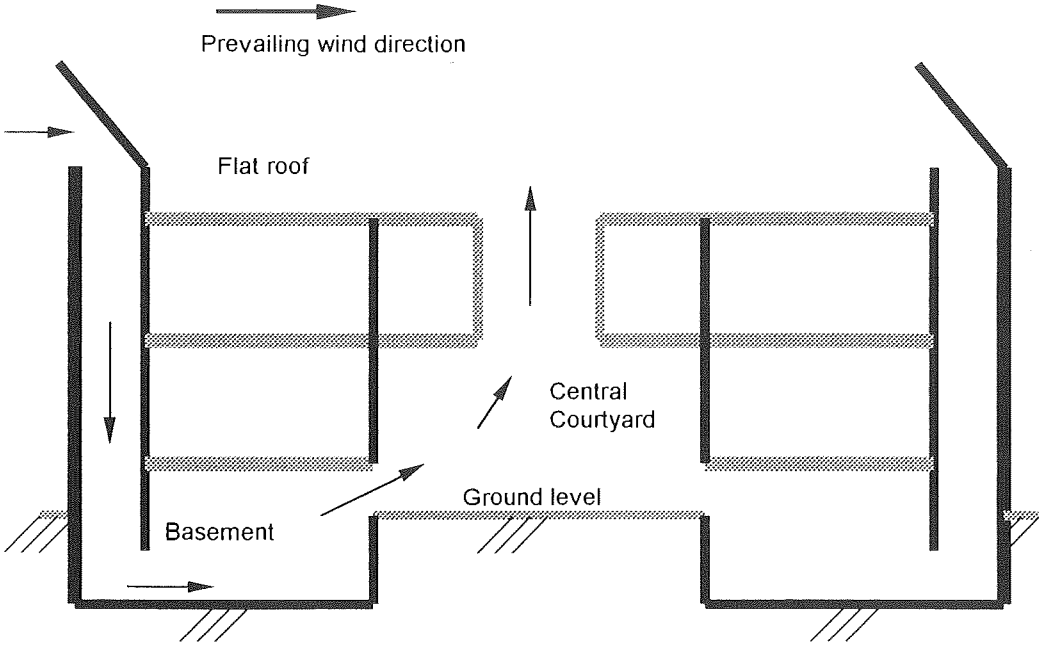

Fig. 7. Schematic view of a traditional Iraqi dwelling, utilising the wind flow.

sible to the air flow and lightweight materials such as carpets and false ceilings, should be replaced by installing thermally-heavy dry coatings. In some cases, better results can be obtained when the air flow is directed through a false floor or through a cavity within the building.

2.2 Slab Cooling

This technique utilises the thermal capacity of the building structure to store a large amount of energy leading to a small variation of the structure's temperature. In this way, day-time heat gains are absorbed by the structure and stored until they can be purged with night cooling. At the moment, most Fabric Energy Storage systems (FES) utilise floor and ceiling slabs. The basic principle of FES is to bring air or water into contact with the slabs in the building envelope as indicated in Fig. 8. The FES systems provide flexibility to work with other technologies like natural and mechanical cooling, evaporative cooling etc.

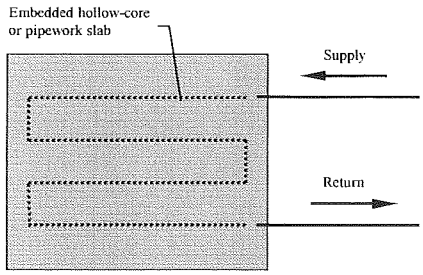

Fig. 8. Basic principle of Fabric Energy Storage system (FES) which utilise floor or ceiling slabs.

Air slab cooling techniques include (Winwood et al., 1997):

(a) The FES slab (Trade name Termodeck). This is a prefabricated rectangular concrete block with typical dimensions of 4m length by 1.2m width by 0.3m depth. The interconnection of the hollow core slabs establish the air paths, through which cooled or heated air is discharged via ceiling diffusers to the indoor spaces.

(b) The plenum-and-slab system, which provides air through hollow core floor slabs, interconnected between a number of large air plenums. Operating experience indicated that this system is only suitable for floor slabs at the ground floor.

(c) The generic slab, which creates parallel air in and out paths to improve heat transfer. This advantage is, however offset by relatively low levels of turbulence.

(d) The double wall slab, which contains two independent air paths around a central corrugated concrete core shaped to generate a high degree of turbulence for heat transfer purposes.

(e) The hollow-core screed, which produces cross air paths between a layer of hollow-core screed and a solid concrete slab. The advantage of this system is that it can be retrofitted into an existing building and consists of square grids of semicircles, 37.5 mm in radius, covered with 75 mm thick screed. The narrow air channel design of this method may present difficulties in maintenance.

In general the above methods provide low capital and operating cost but their potential depends on the level of overnight ambient air temperature and provide sensible cooling only.

In the case that water is used to cool the slab, the pipework can be in a layer of screed of about 75 mm thick or a layer of solid concrete slab exposed to the conditioned space. The circulating water can be cooled by a heat exchanger, a chiller or any other apparatus but water leakage of the embedded piping and replacement of the embedded pipework due to corrosion and erosion problems are the serious drawbacks of the method.

2.3 Chilled Ceilings

In this approach surfaces within the ceiling are cooled by chilled water circulation for the removal of heat gains, leaving ventilation and humidity control to the air-distribution system.

An essential feature of these systems is that the entering chilled water temperature should be above the room dew-point by at least 1.5°C to allow for control tolerance, in order to avoid condensation from forming on the cooling surfaces. Typically, chilled ceiling systems have a flow water temperature of 14-15°C and a temperature increase across the exchange device of 2-3°C (Martin and Oughton, 1995).

The cooling surfaces may take any number of forms and are classified into radiant panels, convective panels and chilled beams.

In the case of radiant and convective panels, the cooling surface covers large areas of the ceiling. The radiant panels depend mainly on radiation heat transfer between their surface and the conditioned space, and can be of a metal or concrete slap type. The radiant panels can be embedded within the false ceiling or be accommodated in shallow ceiling voids (Fig. 9).

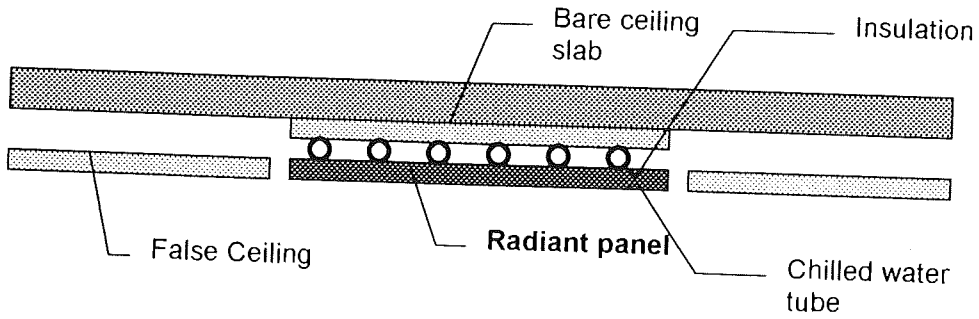

Fig. 9. Radiant panel embedded within the false ceiling.

Convective panels can be finned pipe coils, which are located within the void above the false ceiling. In this case the false ceiling is perforated or slotted with at least 20% free area, to the room space. Warm air rising into the ceiling void is cooled by the coil and then falls down in the room due to its higher density.

Chilled beams work in a similar manner to convective panels. Is this case, the finned coils are located into a unit, which can also supply ventilation air (Fig. 10).

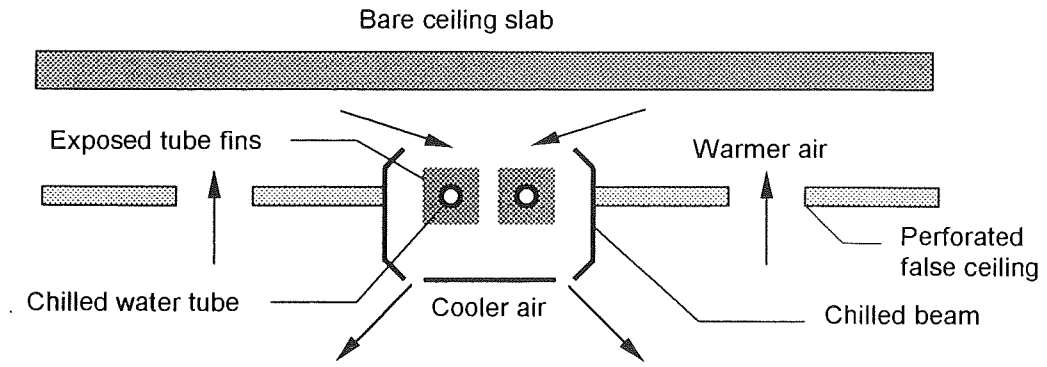

Fig. 10 Chilled beam.

2.4 Evaporative Air Coolers

Evaporative air cooling is achieved by evaporating water at ambient temperature into the air stream. With this method the air dry-bulb temperature is reduced along a line of constant wet-bulb temperature, resulting in an increase of the latent heat and air moisture content. Evaporating cooling can be achieved through direct air cooling, indirect air cooling, a multistage combination of both and can also be combined with mechanical refrigeration systems and desiccant technologies.

In direct evaporative cooling systems, the water in an evaporative pad or from a fine water spray, evaporates directly into a supply of air stream, producing both cooling and humidification (Fig. 11). The maximum reduction in dry-bulb temperature is the difference between the entering air dry and wet bulb temperatures. When the air is saturated the air is cooled to the wet-bulb temperature and the process is 100% effective. System effectiveness is the depression of the dry-bulb temperature of the air leaving the apparatus divided by the difference between the dry and wet-bulb temperatures of the air. Evaporative cooling systems may be 85 to 90% effective. The direct evaporative cooling when used together with mechanical refrigeration can reduce the operating costs by about 25 to 40% (ASHRAE, 1995).

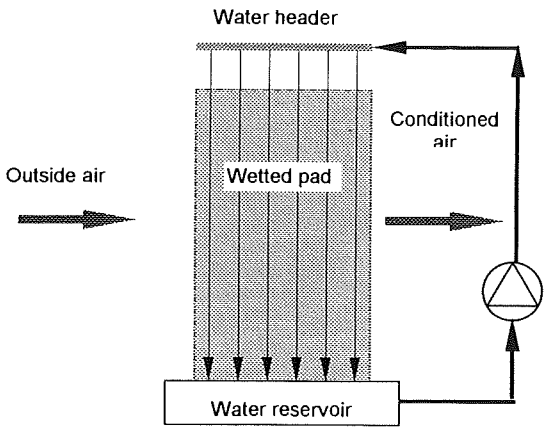

Fig. 11. Direct Evaporative Cooling Diagram

Indirect evaporative air cooling evaporates water into a secondary air stream through the channels of a heat exchanger. The heat exchanger cools air flowing in a primary stream. This results in sensible cooling only. Except in extreme dry climates, most indirect systems require several stages to further cool the primary air entering the conditioned spaces.

Indirect evaporative cooling can precede a direct evaporative stage and can reduce in this way the entering dry and wet bulb temperatures before the air enters the direct evaporative cooling unit. Indirect evaporative cooling systems may save about 60 to 75% of the total cost of operating a mechanical refrigeration system to produce the same cooling effect (ASHRAE, 1995).

3. SYSTEMS EVALUATION

Table 1, summarises the advantages and disadvantages of the cooling methods described above as well as their performance and main uses.

Table 1. Main advantages and disadvantages of cooling techniques

Cooling Method	Advantages and disadvantages
Solar Sorption Cooling : Lithium bromide-water ($LiBr-H_2O$)	• Generator temperature must be 70°C to 95°C with water cooling in absorber and condenser • COP 0.6 to 0.8 • Evaporator cannot operate at temperatures below 5°C
Ammonia-water (NH_3-H_2O) systems	• A rectifying column must be present • Generator temperatures must be 125°C to 170°C with air-cooled absorber and condenser and 95°C to 120°C when water cooling is used • COP 0.6 to 0.7
Desiccant cooling	• Independent control of humidity and temperature • Removal of certain airborne contaminants • Ability to use energy sources such as waste heat, solar power and natural gas • COP around 1 • Payback time between 3 and 5 years
Solar-Mechanical Systems	• Efficiency of photovoltaic panels is very low about 10% • The solar-powered prime mover combined with a Rankine engine has low efficiency about 17 to 23%. Very expensive system viable for very large applications • Difficulty to ensure that only vapour enters the turbine since the boiler temperature changes during the day • Not steady output power

4. CONCLUSIONS

The objective of this work was to present the various cooling technologies. Due to the abundance of solar energy and the high ambient temperatures available in Cyprus a direct solar cooling system will meet a large amount of the daily load. Low energy technologies such as wall and slab cooling can be employed to minimise the dialy cooling load requirements by utilising the high variation of day and night temperatures. The low energy cooling technologies can also be used in the intermediate seasons of autumn and spring to either absorb completely the cooling load or reduce it drastically, depending on the requirements. The adoption of these technologies however, presents a considerence challenge to both, building services engineers and architects. Additionally, advance modelling and control techniques for environmental control in buildings are required.

Table 1. Main advantages and disadvantages of cooling techniques (cont.)

Cooling Method	Advantages and disadvantages
Heat pumps	• COP (useful effect/work done), between 2 to 5 • Heat pumps increase the effectiveness of electricity by a factor of 2 to 3 over electric heating • Heat pumps can combine with solar energy
Natural night cooling	• Unreliable air quality • Unreliable air quantity • Inefficient control of humidity and temperature • Effective for building mass in excess of 800 kg/m^2 • Provides sensible cooling only • Used in residential applications • Cool, Dry to semi-humid climates • Night air temperature 12-15°C
Mechanical night cooling	• Good controllability of air flow and distribution • Extra fun energy consumption • Noise present, depending on air velocities • Additional space needed for extra flow to existing buildings (false floors or cavities in buildings) • Effective for building mass in excess of 800 kg/m^2 • Provides sensible cooling only • Used in commercial buildings
Slab Cooling	• Reduction of mechanical cooling • Utilisation of off-peak electricity • No need for suspended ceilings • High levels of human comfort • Slow thermal response to indoor load variations • Higher maintenance cost due to leakages • Provides sensible cooling only

Table 1. Main advantages and disadvantages of cooling techniques (cont.)

Cooling Method	Advantages and disadvantages
Chilled ceilings	• Reduction of refrigeration capacity • Low energy consumption • Good acoustics and indoor air quality • Low maintenance cost • Reduction in the space required for pure air ductwork in the ceiling void • Risk of condensation • High capital cost, at least 50% higher compared to conventional air-conditioning systems • Possibility of water leakage in the ceiling installation • Active cooling surface needed is 30 to 70 % of the total ceiling area
Direct evaporative Air Coolers	• Provides relief or comfort cooling depending on weather conditions and types of building • Once-through airflow principle normally employed • Used in residential applications • Used in arid and semi-arid climates and relatively dry environments
Indirect evaporative Air Coolers	• Provides sensible cooling only • Provides relief or comfort cooling depending on weather conditions and types of building • Used in commercial buildings • Used in arid and semi-arid climates and relatively dry environments

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HTI Calendar of Activities for Academic Year 1997 - 1998

Prepared by:
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D. Charalambidou-Solomi, BA (Hons), MA, MA (Ed), Lecturer, HTI.

SEPTEMBER

● Two hundred and fourty (240) new students were enrolled on the regular courses of HTI: 61 for Electrical Engineering, 61 for Civil Engineering, 59 for Mechanical Engineering, 27 for Marine Engineering and 32 for Computer Studies.

● Dr. Chr. Chrysostomou, Lecturer, attended a course on "New Ways of Teaching: The electronic classroom" at the University of Cornell, USA, between 1 - 30 September.

● Dr. A Stassis, Lecturer, attended a short course on "Robotics: Modal Analysis" at the Katholieke University, Leuven, Belgium between 17 - 19 September.

● The Department of Mechanical Engineering organised a 22 hours short course on "Statistical Process Control" for all Mechanical Engineering students between September and October. The course was presented by Mr Ioannis Angeli.

● The Department of Civil Engineering in collaboration with the Industrial Training Authority and the Joint Group of Civil and Mechanical Engineers, organised a course on "Quantity Surveying Principles and Building Contracts" between September - December.

OCTOBER

● Dr. I. Michaelides, Senior Lecturer, Dr. P. Eleftheriou, Lecturer, and Dr. S. Kaloyirou, participated in a meeting on "Sea Water Desalination Using Renewable Energy Sources" in Portugal between 2 - 4 October.

● Mr. A. Loizides, Lecturer in Marine Engineering and Mr M. Shammas, Instructor in Mechanical/Marine Engineering, visited the Marine Training Service of the Ministry of Navigation in Greece and the Naval Academy between 14 - 17 October.

● The Higher Technical Institute in co-operation with the Institution of Electronics and Electrical Incorporated Engineers Cyprus Development Group organised a short course of 21 hours duration between 20 - 22 October on "Strategic Purchasing and Supply Chain Management".

● Mr. P. Tramountanellis, Lecturer, attended a short course on "Marine Steam Power Plants", United Kingdom, between 27 - 30 October.

● Ms Chrystalla Antoniou, Senior Instructor, visited the University of Glamorgan, S. Wales, between 31 October - 7 November within the framework of Staff Exchange Programme between HTI and other Universities / Institutions abroad.

NOVEMBER

● Within the framework of the HTI staff exchange scheme Dr. Andreas Stathopoulos, Senior Lecturer, and Mr. P. Masouras, Lecturer, visited Salford University between 2 - 8 November.

● The First Mid-Semester Examinations were held between 3 - 7 November.

● Dr. H. Stavrides, Head of the Civil Engineering Department and Mr. I. Economides, Lecturer, visited the University of Glamorgan and the City University respectively, between 3 - 7 November within the program of staff exchanges between HTI and Universities and Polytechnics abroad.

● Mr. G. Iordanou, Head of the Mechanical Engineering Department and Mr. V. Mesaritis, Lecturer, visited the Brunel University between 3 - 7 November within the program of staff exchanges between HTI and Universities and Polytechnics abroad.

● Dr. A. Stassis, Lecturer of the Mechanical Engineering Department, participated in the 2nd International Seminar on Information Technology Application (ITA 1997), held between 6 - 7 November in Cyprus. Dr. A. Stassis presented a paper entitled "Electromagnetic and Structural Finite Element Analysis for improved Electrical Machine Designs".

● The HTI UNESCO Day was celebrated on Wednesday 12 November. Students and Staff

visited the Holy Cross Monastery in the village of Omodos. The visit ended with lunch in a nearby restaurant.

● Within the framework of the National-Technical Co-operation between Cyprus and Greece, the Senior Lecturer Dr. D. Serghides, organised and participated in the program of the visiting Greek participants which included meetings, discussion and seminars given to architects and Town Planners between 14 - 16 November. Dr. D. Serghides is the scientific co-ordinator for the program: "Bioclimatic Design for Housing".

● Mr Ioannis Angeli was awarded a PhD from the University of Glamorgan. The title of his research was "Principal factors affecting senior management culture change for Total Quality Metamorphosis".

● Mr. C. Theopemptou, Lecturer of the Electrical Engineering Department, participated in a meeting for the European Program EURODESK which took place in Luxemburg between 19 - 21 November.

● The Mechanical Engineering Department in collaboration with the Cyprus Engineers Association and the Industrial Training Authority organised a 28-hr course on "Total Quality Management: Making Quality Happen" between 24 - 28 November. The course was presented by Dr. Ioannis Angeli.

● The Department of Electrical Engineering in collaboration with IEE Cyprus Centre and the Industrial Training Authority organised two short courses on: "Windows NT Server" (25-28/11/97) and "Supporting Windows 95" (16-19/12/97). The courses were aimed at personnel working in industry. The first course was presented by a local Microsoft approved instructor and the second course was developed by Merlin Training, London, and was presented by their authorised instructor. The duration of each course was 25 hours and included theoretical and practical sessions.

● Mr. D. Lazarides, Director of HTI, visited the City University between 24 - 28 November, within the program of Staff Exchanges between HTI and Universities and Polytechnics abroad.

● Messrs, S. Spyrou and C. Marouchos participated in staff exchanges with the University of City, UK (17 - 19/11/97) and the University of Budapest (1 - 4/12/97) respectively.

DECEMBER

● Dr. D. Serghides, Senior Lecturer, attended a short training course on "Technical Instrumentation and Techniques for Monitoring Energy Use in Buildings" between December 1 - 5. The course took place at the University of California School of Architecture at Berkeley and in the Pacific Energy Center in San Fransisco, California.

● Within the framework of the HTI Staff Development Scheme Mr. P. Masouras, Lecturer, attended a course in the U.K. on "JAVA & VISUAL C++ PROGRAMMING". The course was organised by Learning Tree International between 2 - 12 December.

● Dr. Andreas Tamanas, Lecturer, participated in the First Pancyprian Seminar on "Mathematical Education" which was organised by the Cyprus Pedagogical Institute and the Cyprus Mathematical Society between 5 - 7 December in Paphos.

● Messrs E. Michael and C. Theopemptou attended short updating courses on "IEE Wiring Regulations" and "Computer Interfacing" respectively. The first course took place in UK during 26 - 28/11/97 and the second in USA during 7 -18/12/97.

● In co-operation with the Cyprus Architects Association, the Association of Civil Engineering & Architects and the International Solar Energy Society (ISES - Cyprus) Dr. D. Serghides, Senior Lecturer, organised and lectured a training programme on "Daylighting in Building and Energy Efficiency".

JANUARY

● The First Semester Examinations were held between 21 January and 3 February.

FEBRUARY

● The Department of Mechanical Engineering Organised a 9-hr short course on "Overview of ISO 9000" for all HTI students between 10 - 12 February. The course was presented by Dr. Ioannis Angeli.

● The Department of Mechanical Engineering organised for a second time a 24-hr short course

on "Statistical Process Control" for all HTI students between 23 February - 17 March. The course was presented by Dr. Ioannis Angeli.

MARCH

- HTI students resorted to lockout and abstained from lectures and second Mid-Semester Examinations between 19 March - 21 April demanding professional recognition for HTI gra-duates and academic status for HTI.

APRIL

- The Cyprus Professional Engineers Association in collaboration with the Higher Technical Institute organised a 28-hour programme on "Total Quality Management: Making Quality Happen" between 6 - 9 April. The instructor was Dr I. Angeli and the programme was subsidised by the Cyprus Industrial Training Authority.

- The Cyprus Computer Society in co-operation with the Higher Technical Institute organised a course on "Internetworking: Bridges, Routers & Switches" between 7 - 10 April. The course was delivered by consultants of the Learning Tree International Ltd (UK) and was partially subsidised by the Cyprus Industrial Training Authority.

MAY

- The Cyprus Computer Society in co-operation with the Higher Technical Institute organised a course on "Implementing the Year 2000 Conversion" between 5 - 7 May. The course was partially subsidised by the Cyprus Industrial Training Authority and was delivered by consultants of the Learning Tree International Ltd (UK).

- The Cyprus Professional Engineers Association in collaboration with the Higher Technical Institute organised a course on "IEE Wiring Regulations: 16th Edition" between 5 - 21 May. The programme was subsidised by the Cyprus Industrial Training Authority.

- The Cyprus Computer Society in co-operation with the Higher Technical Institute organised a course on "Data Network Design and Optimisation" between 12 - 15 May. The course was delivered by consultants of the Learning Tree International Ltd (UK) and was partially subsidised by the Cyprus Industrial Authority.

- The Department of Electrical Engineering in collaboration with IEE Cyprus Centre and the Cyprus Industrial Training Authority organised a short course on "Supporting Windows 95" between 26 - 29 May. The course was developed and presented by staff of Merlin Training Ltd (UK).

- The HTI Social Formal Dinner was held on Thursday, 28 May at the Popular Bank Sporting Club, Latsia. The third year students dined with HTI staff and guests from the private and government sectors.

JUNE

- The Department of Electrical Engineering in collaborations with IEE Cyprus Centre and the Industrial Training Authority organised a 25-hour course on "Windows NT Server" between 2 - 5 June. The course was presented by a local Microsoft approved instructor.

- Dr. Ioannis Angeli, participated in the First Panhellenic conference on Quality in Nicosia between 12 - 13 June and presented a paper on "Performance indicators with the implementation of Quality Systems Standards in Cyprus".

- Dr Sotiris Kalogirou presented a paper on "Renewable Energs and Desalination - A European Project" at the "SunDay '98 - Seminar on Desalination and Water Reuse" which was held at the Philoxenia Hotel by the International Solar Energy Society and the Water Development Department of the Ministry of Agriculture, Natural Resourses and Environ-ment.

- The Mid-Semester and Second Semester Examinations were jointly held between 22 June - 7 July.

- The Cyprus Computer Society in collaboration with the Higher Technical Institute organised a programme on "Windows NT 4 Server & Workstation" between 29 June - 3 July. The programme was partially subsidised by the Cyprus Industrial Training Authority and delivered by Learning Tree International Instructors.

JULY

- The 1998 Graduation Ceremony was held on 10 July at the International Conference Centre in Nicosia.

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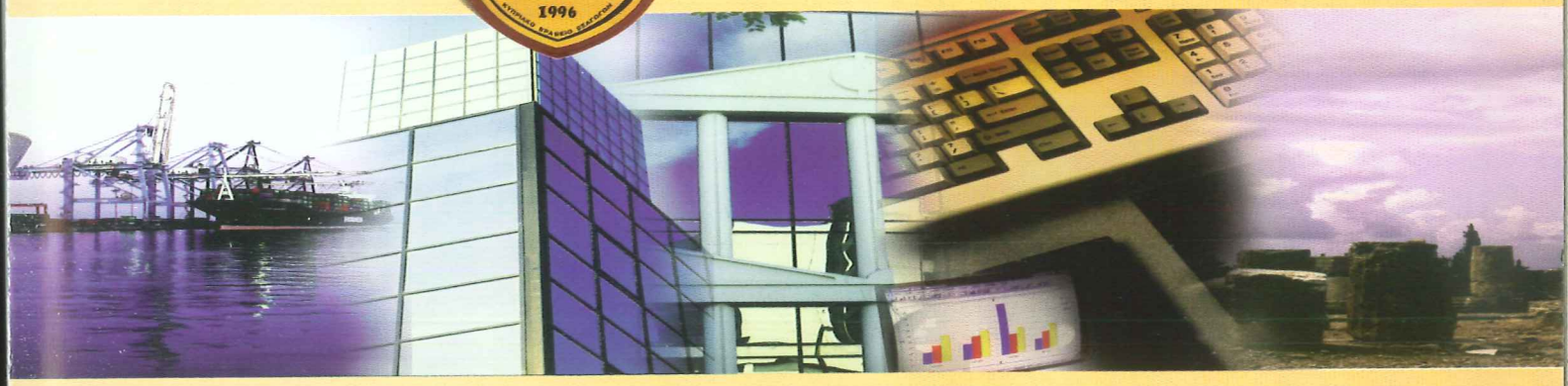

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ΔΙΚΟ ΣΑΣ ΣΠΙΤΙ

από το όνειρο... στην πραγματικότητα

Η ΕΤΑΙΡΕΙΑ ΠΟΥ ΠΡΟΣΦΕΡΕΙ ΣΤΑ ΜΕΛΗ ΤΗΣ ΟΥΣΙΑΣΤΙΚΗ ΕΞΥΠΗΡΕΤΗΣΗ

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