

HIGHER TECHNICAL INSTITUTE
MECHANICAL ENGINEERING DEPARTMENT

DIPLOMA PROJECT

COMPUTER CONTROLLED TEMPERATURE
OF A FURNACE

by
PANAYIOTIS KAMENOS

JULY 1997

**COMPUTER CONTROLLED TEMPERATURE
OF A FURNACE**

by

Panayiotis Kamenos

Project Report

Submitted to

the Department of Mechanical Engineering

of the Higher Technical Institute

Nicosia Cyprus

in partial fulfillment of the requirements

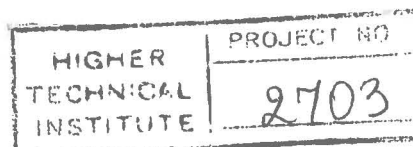
for the diploma of

TECHNICIAN ENGINEER

in

MECHANICAL ENGINEERING

July 1997



ABSTRACT

The objectives of this project are to, investigate and report on the methods of computer controlled temperature, propose a method for the control of temperature using a PC and a suitable data acquisition card, present all necessary detailed calculations for the design and the required program for the control of the furnace, present selection procedures and detailed specifications for all items that are not to be designed, and present detailed layout drawings and a cost image.

ACKNOWLEDGMENTS

I would like to thank my supervisor, Mr. Costas Neocleous, lecturer in Mechanical Engineering, at H.T.I., for his valuable assistance and guidance offered to me in carrying out the presented diploma project.

I wish also to thank Mr. Nicos Angastiniotis, also lecturer in H.T.I. for his help offered to me by providing me with references and information about this project.

Also my thanks to Mr. Constantinos Dalmiras, Chief Engineer of Lanitis Bros Ltd., for helping me carrying on with this project and providing me with a wide variety of useful information.

Finally, I would like to thank my father for his patience and help given to me on this project. To the rest of my family and especially my brother Marios, for their support.

TABLE OF CONTENTS

| | |
|---|-----------|
| INTRODUCTION | 1 |
| CHAPTER 1 | 2 |
| CONTROLLING/MONITORING VARIOUS REAL WORLD DEVICES | 2 |
| 1.1 INTERFACING FOR DATA ACQUISITION | 2 |
| 1.1.1 The problem | 2 |
| 1.1.2 A/D converters | 3 |
| 1.2 TEMPERATURE MEASUREMENT | 6 |
| 1.2.1 Temperature-measuring instruments | 6 |
| 1.2.2 Temperature indicators | 7 |
| 1.2.3 Calibration and application | 8 |
| 1.3 THERMOCOUPLE | 8 |
| 1.4 ANALOG TO DIGITAL CONVERSION (A/D OR ADC) | 14 |
| 1.5 SIGNAL AVERAGING AND LOCK-IN DETECTION | 16 |
| 1.6 MOTOR CONTROL | 17 |
| 1.7 DATA SMOOTHING | 21 |
| CHAPTER 2 | 22 |
| TEMPERATURE CONTROLLERS | 22 |
| 2.1 STANDARD PRECAUTIONS TO BE TAKEN WHEN USING TEMPERATURE CONTROLLERS | 22 |
| 2.2 CONTROL LOOP | 23 |
| 2.3 TYPE OF CONTROL | 23 |
| 2.3.1 ON/OFF Control | 24 |
| 2.3.2 PID Control | 24 |
| 2.4 GLOSSARY OF TERMS | 25 |
| 2.4.1 Proportional Band | 25 |
| 2.4.2 Integral Time | 25 |
| 2.4.3 Derivative | 26 |
| 2.5 CUTBACK | 26 |
| 2.6 1048 SELF TUNE PID TEMPERATURE CONTROLLER | 26 |
| 2.6.1. Precautions and relay contact protection | 26 |
| 2.6.2. Mounting | 28 |
| 2.6.3. Input sensor wiring | 28 |
| 2.6.4. 2 and 3 wire PT100 RTB | 28 |
| 2.6.5. 2 and 3 wire PT100 RTB connections | 29 |
| 2.6.6. Thermocouples | 29 |
| 2.6.7 1048 programming instructions | 30 |
| 2.6.8. Degrees C/F, output action and 1st ramp inhibit | 31 |
| 2.6.9. Alarm & set point 2 (sp2) | 31 |
| 2.6.10. Scale range | 32 |
| 2.6.11. Set point value | 33 |
| 2.6.12. Alarm/SP2 value | 33 |
| 2.6.13. Autotune | 34 |
| 2.6.14. PID Values | 34 |
| 2.6.15. Approach control | 34 |
| 2.6.16. Cycle time | 35 |
| 2.6.17. Security lock | 35 |

| | |
|---|-----------|
| CHAPTER 3 | 38 |
| DATA SMOOTHING | 38 |
| 3.1 INTRODUCTION..... | 38 |
| 3.2 ANALYTIC SOLUTION AND RECURSION RELATION..... | 38 |
| 3.3 FILTER PARAMETERS..... | 42 |
| 3.4 EQUIVALENT FILTERS..... | 45 |
| CHAPTER 4 | 50 |
| 4.1 EXPERIMENTAL SETUP..... | 50 |
| REFERENCES | 51 |



The principle of an OMF-GA system is...

The system is implemented for the... of the... parameters...

The experimental setup consists of... powders with varying... and...

The data acquisition and analysis are performed using... software...

The AD converter and the... are connected to the... ENGINE...

The output of the system is... which is... collected...

INTRODUCTION

All studies were conducted in conjunction with an OMEGA split furnace. A schematic of the apparatus is shown in the figure below.

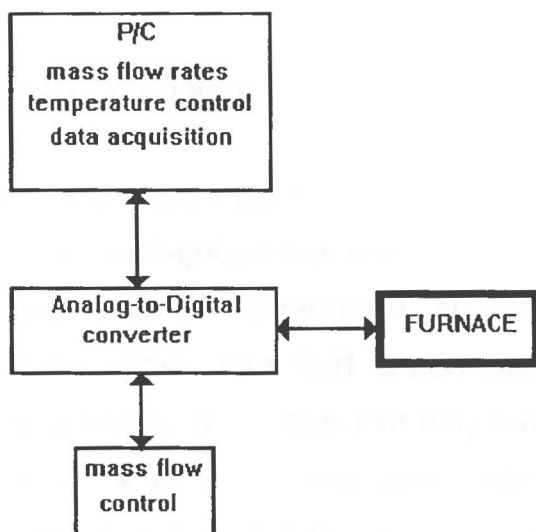


Figure 1 Schematic of the apparatus of an OMEGA split furnace.

Real-time control was implemented for the heating elements, mass flow controllers and TGA. The principal parameters controlling thermochemical processing of the precursor powders were heating rate, temperature, time and gas flow rate. The data acquisition and parameter control was enabled by an IBM-PC and a software package in communication with an Analog-to-Digital (A/D) converter. Both the A/D converter and data acquisition software package were purchased from OMEGA ENGINEERING. The input data (PID parameters for temperature and flow control) was integrated in a closed-loop control cycle and the sample weight was collected at a minimum two second interval, stored in a data file and tabulated or displayed as a function of temperature and time.