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Real-Time Thermal Expansion Measurement System and the Data Acquisition and Control Application Software - User Interface

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Abstract- ***In order to operate the designed thermal expansion measurement system, a user interface is constructed by using Borland Delphi. This paper presents how the user interface is constructed and why it is necessary.***

I. INTRODUCTION

PC-based data acquisition and control systems are widely used in industrial and laboratory applications. . A data acquisition and control hardware generally performs one or several of the following functions: analog input, analog output, digital input, digital output and counter/timer functions. After selecting a suitable hardware, the software which is driving force behind any data acquisition and control system becomes very important. Programming the data acquisition and control system can be accomplished in the following three ways: hardware-level programming, driver-level programming and package-level programming[1].

In this work, a data acquisition and control application software is designed to computerize the system completely shown in Fig. 1 by using driver-level programming[2]. In this programming type, the designers simply call high-level functions from libraries provided by the card manufacturer. These functions encapsulate complete tasks, such as A/D conversion, into a single call.

In designed thermal expansion measurement system, an ADVANTECH PCL-812PG Labcard is used. All Advantech DA&C series PC-Labcards come with standardized drivers to simplify designer's programming. The manufacturer driver supports a wide range of popular programming languages, including Borland Delphi, Borland C/CC++, Microsoft C/CC++, Turbo C/CC++, Turbo Pascal, Microsoft QuickBasic[3]. A high-level programming language Borland Delphi is used in constructing the software in this work.

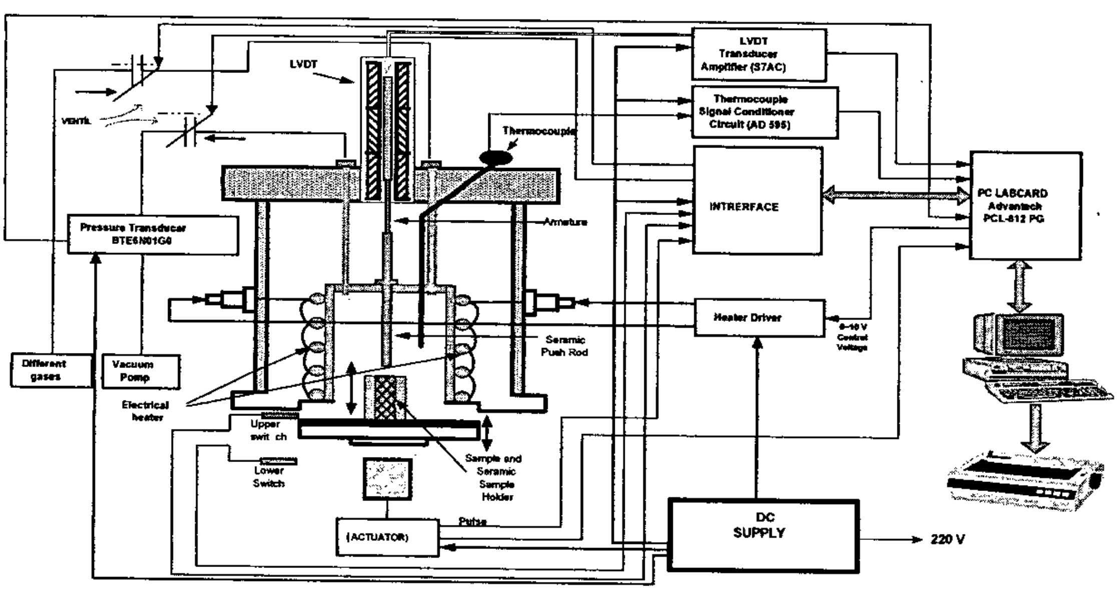

Fig. 1. Schematic of the measurement system[2]

II. DATA ACQUISITION AND CONTROL APPLICATION SOFTWARE

ADVANTECH PCL-812PG Labcard is used to acquire data from system and also to send data from computer to the system in both direction. That labcard has 5 connectors and all of them are used in this work. These connectors are as follows: Analog Input (AI), Analog output (AO), Digital Input (DI), Digital Output (DO) and Counter CTR)[4].

A multi-page user interface is designed to observe the thermal expansion measurement system on a PC monitor. These pages are as follows: Settings Page, Temperature Monitoring Page, Vacuum Monitoring Page and Expansion Monitoring Page. Multipage application is performed by using TPageControl object's Active Page properties. If Tabsheet is equal to 1, then Settings Page is active. If Tabsheet is equal to 2, Temperature Monitoring page is active and so on. A view of the user interface is shown in Fig. 2. That method is useful for operation classification.

Designed software provides the following operations:

- Fuzzy Logic Controller (Inner furnace temperature)
- On-Off Controller (Inner furnace Vacuum rate)
- Data acquisition (Analog Input, Analog output, Digital Input, Digital Output, Counter/Timer)
- Data logging
- Real-time Data display
- Up-down movement of the furnace bottom plate
- Start/Stop function of the Vacuum Pomp
- Monitoring of the FLC's active rule display
- Choosing the appropriate sample type and entering of the inital length
- Calculation and drawing of the theoretical linear expansion curve according to the selected metal sample type and entered initial length,
- Comparison of the theoretical and experimantal expansion values by a X-Y graph

First of all, the user must select the SETTINGS page shown in Fig. 3 by pressing desired page-name on top of the screen in order to select the PCL812-PG Labcard. After that, program can be started by pressing the RUN button.

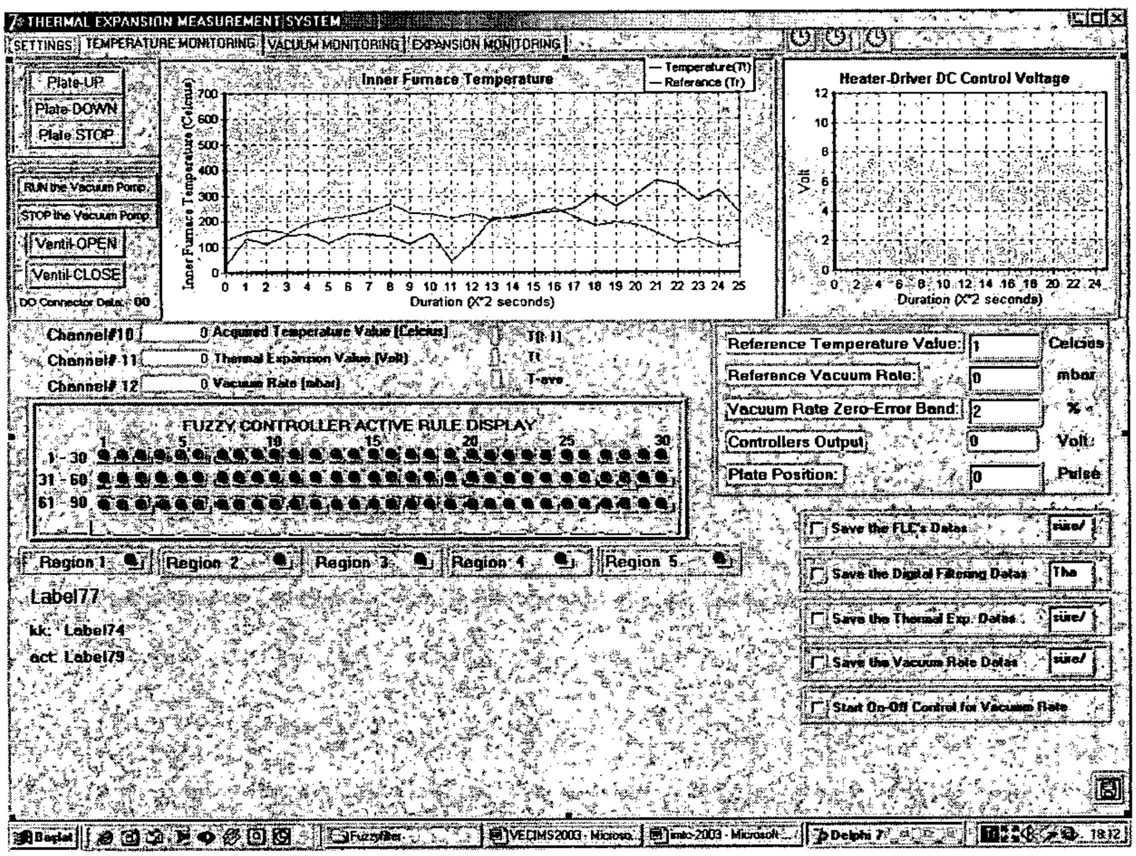

Fig. 2. Temperature Monitoring Page

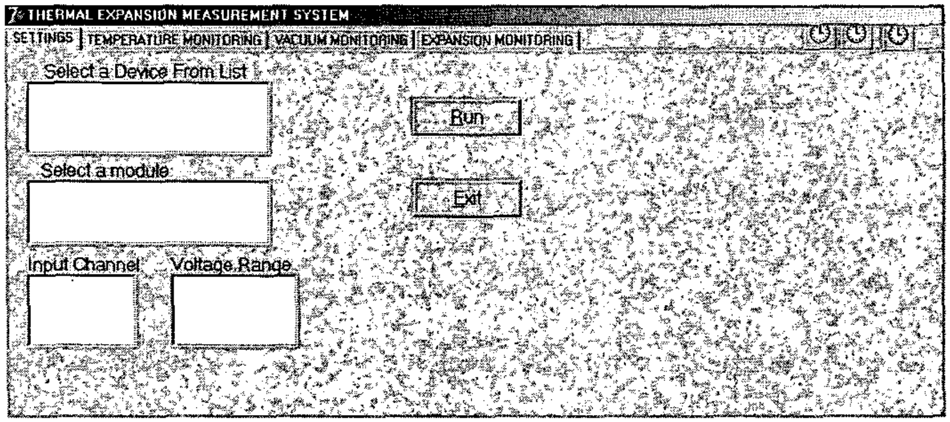

Fig. 3. Settings Page

II.1Temperature Monitoring Page

After running the program, the user must enter the reference temperature, reference vacuum rate and vacuum-rate zero-error band values in the related Editbox (on teh middle -left) shown in Fig. 2 by using keyboard. In addition if the user want to save the data on a file during the operation, related Checkboxes shown on the left bottom corner in Fig. 2 must be checked by clicking

Temperature monitoring page has lots of different and important operations explained as follows:

II.1.1 Analog Input There are 3 analog input variables acquired from the system:

- Inner furnace temperature
- Thermal expansion of the metal samples
- Inner vacuum rate

Analog input is defined by two parameters according to the manufacturer driver: AI channel number ***(lpAIVoltageIn.chan=10)*** and AI value ***(lpAIVoltageIn.voltage).*** Channel # 10 is reserved to inner furnace temperature which is measured via a K-type thermocouple, Channel # 11 is reserved to thermal expansion value which is measured via a displacement transducer (a LIN156 coded LVDT) and Channel # 12 is reserved to Vacuum rate which is measured via a pressure transducer (a BTE6N01G0 coded) on the Labcard and software as shown in Fig. 1 and 2.

AI data can be read on the textboxes as shown in Fig. 2. While inner furnace temperature can be observed on x-y graph on this page, thermal expansion and vacuum rate data can be observed on the related pages.

II.1.2 Analog Output Advantech PCL812-PG has two D/A channels (AO) on Connector 2 (CN2)[4]. In this work DA #1 is used to drive the heater. FLC's output is converted to a DC voltage and then applied to the heater circuit control input. The DC voltage can be observed on the right-up corner x-y graph as shown in Fig.2.

II.1.3 Digital Input Up-down movement of the furnace bottom plate is limited by reed sensor inside the actuator. However a second protection element is used on the system. When the plate is closed (plate thouches the switch), upper limit switch's position changes to 1 and then the actuator is stopped automatically. Then, Upper Limit and Lower Limit switches' positions are DI variables.

II.1.4 Digital Output CN3 is DO connector[4]. In this work DO connector is set shown in Table 1. This connector is reserved to plate movement (up-down), position changing of 2 ventils (Open-Close) and also operation of the vacuum pump (Start/Stop).

By pressing left-up corner buttons on TEMPERATURE MONITORING page shown in Fig. 2, the desired operation is processed. For example, if the user press the RUN button

Table-1. DO Connector Setup

Bit 7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
P8	**P7**	**P6**	**P5**	**P4**	**P3**	**P2**	**P1**
NC	Vacuum Pomp	NC	Ventil 1	Ventil 2	Furnace Bottom-Plate Movement		Clock
128	**64**	**32**	**16**	**8**	**4**	**2**	**1**

for vacuum pomp, then **IpDioWritePort.state** variable has a value of 64 and then desired operation is get.

II.1.5 FLC Active Rule Display In this work, inner furnace temperature is controlled by Fuzzy Logic. FLC has 90 rules and each rule is represented by a lamp on the panel shown in Fig. 2. If any rule is active (DOF-degree of fullfillment not equal to zero) then the lamp's colour of related rule is red. On the other hand, if the rule is not active (DOF-degree fo fullfillment equals to zero), then the lamp's colour is green. Each lamp is an Image object on the user interface. In addition, when the program is running, if the user reach and wait on a lamp image by mouse, the action of the related rule can be displayed on the screen inside a yellow box. Above mentioned functions are performed by using Visible and ShowHint properties of Image object in Borland Delphi[5].

II.2 Vacuum Monitoring Page

Inner vacuum rate is controlled by On-Off controller. Entered reference vacuum rate and change on inner vacuum rate can be observed on this page by using an x-y graph as shown in Fig.4.

II.3 Thermal Expansion Monitoring Page

After running the program, if thermal expansion measurement experiment will be done (sample exists position), the user must select the suitable metal type under the SAMPLE named Combobox object shown in Fig. 5. After defining metal type, Label88.caption will be displayed as the thermal expansion coefficient of the related metal automatically. Secondly, the user must enter the initial length of the sample. After that, the user must decide the temperature rising rate (Low or High). In this work, three different temperature controlling types can be utilized by using 3 different action group without changing the available FLC rule base. These different temperature controlling types are as follows:

#1 No sample, Temperature rising rate is HIGH and nonlinear

#2 Sample exists, Temperature rising rate is HIGH and nonlinear

#3 Sample exists, Temperature rising rate is LOW and linear.

Low/High selection is a user-defined variable by pressing the RadioGroup object shown on the page in Fig. 5. On the other hand, sample exist or not exist selection is software-defined variable by controlling the Channel #11 analog input data.

In Low rate selection, duration is longer than the Higher one. In this situation, inner furnace temperature rising rate islinear having a slope of 10K°/min.

After settings, theoretical and experimental thermal expansion curves can be observed and compared simultaneously. Theoretical curve is calculated by using Eq.1

$$\Delta l = (T_2 - T_1) * l_o * \alpha \qquad (1)$$

Here, T_2 is the last inner furnace temperature value in Celcius and T_1 is the initial temperature value. These values are acquired from the system in real time. Lo is the sample's initial length that is entered by user at the beginning. α is coefficient of thermal expansion for selected sample type by user. When the user select a sample from the Combobox, then related CTE value can be seen on the textbox in Fig.5 and then Δl value can be calculated theoretically.

III. CONCLUSION

In this work, a data acquisition and control application software is designed to computerize the system completely shown in Fig. 1 by using driver-level programming. A user interface is designed similar to high-cost professional thermal analysis equipment's interface. Then it is used to operate the system by using ADVANTECH PCL-812PG.

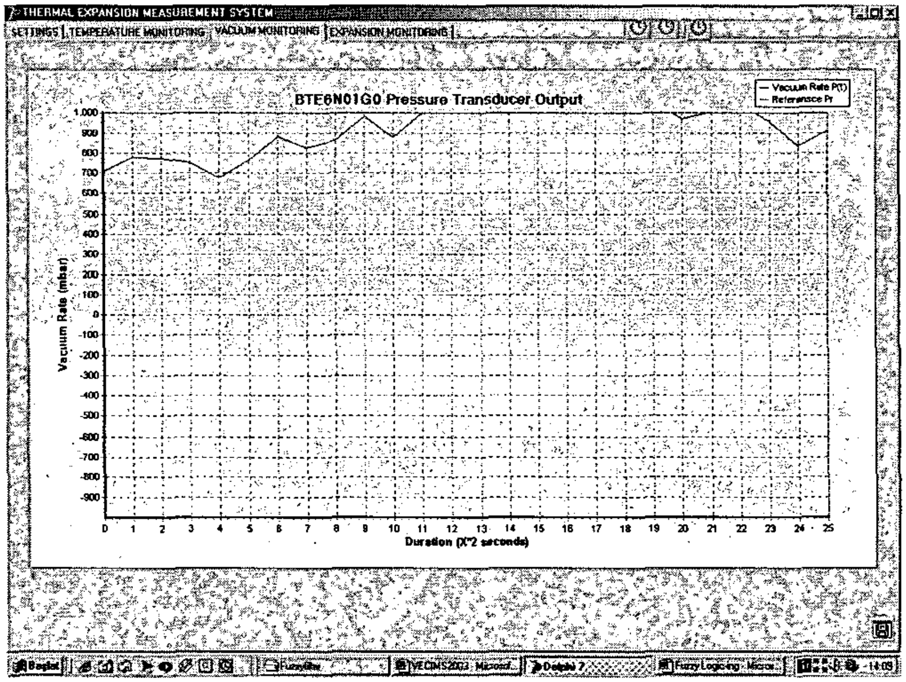

Fig. 4. Vacuum Monitoring page

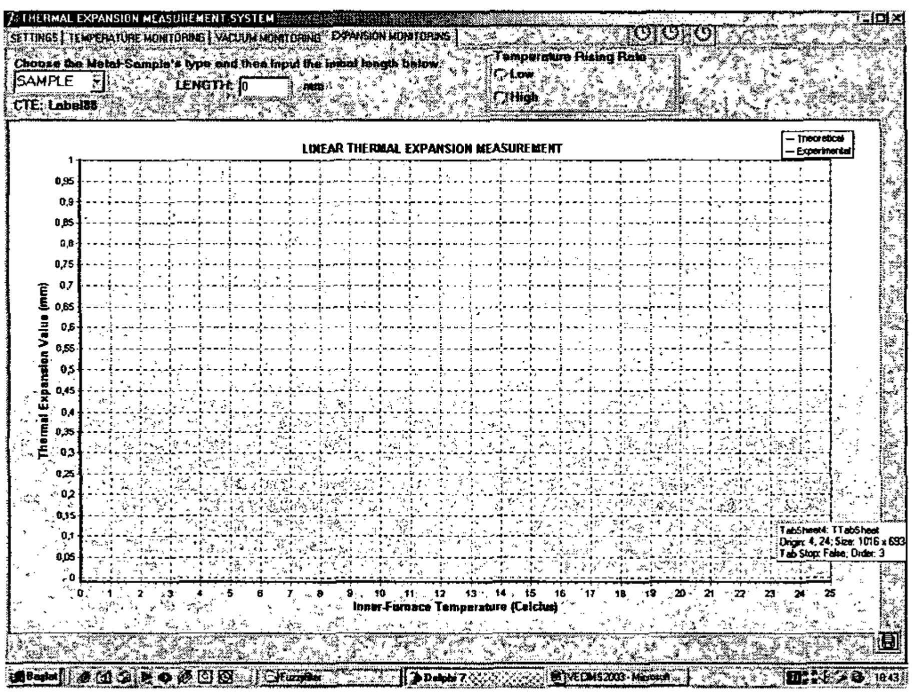

Fig. 5. Thermal Expansin Monitoring Page

REFERENCES

[1] Total Solutions for PC-Based Industrial Automation, Solution Guide Volume.61, ADVANTECH Co.

[2] Korkmaz, H., "Designing And Realizing of a Temperature and Vacuum Rate Controllable Furnace", PhD Thesis, Istanbul, 2002

[3] Advantech Driver CD

[4] Advantech PCL812-PG Data Acquisition Labcard User's Manual

[5] Marco Cantu, Mastering Delphi 4, ISBN 975-316-200-6