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A Lab VIEW Based Data Acquisition System for Radial Temperature Distribution

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Abstract

Lab VIEW (Laboratory Virtual Instrument Engineering Workbench) is gaining its popularity as a graphical programming language especially for data acquisition and measurement. This is due to the vast array of data acquisition cards and measurement systems which can be supported by LabVIEW as well as the relative ease by which advanced software can be programmed. One area of application of LabVEW is in the measuring and analyzing of radial temperature distribution. This paper describes a LabVIEW based data acquisition and analysis developed specifically for radial temperature distribution. The temperature is simultaneously measured and displayed.

الخلاصة

إن برنامج اللاب فيو قد كسب شهرته كلغة برمجة تخطيطية وخاصة في مجال تجميع البيانات وفي مجال القياس. وهذا بسبب الانتشار الواسع لبطاقات جمع البيانات والقياس الذي ممكن ان يدعم ببرنامج اللاب فيو والذي هو عبارة عن برمجة متقدمة. واحدة من المجالات التي ممكن ان تستخدم هذا البرنامج هو في مجال قياس وتحليل التوزيع الشعاعي للحرارة في الهواء او في اي مادة اخرى. هذا البحث يتضمن استخدام برنامج اللاب فيو معتمدا على جمع البيانات وتحليلها لدراسة التوزيع الشعاعي للحرارة. يتم قياس درجات الحرارة وعرضها على الشاشة بشكل آني.

1. Introduction

PC-based data acquisition system (DAQS) in measurement and analysis is gaining importance in industry and research organizations because it can be used for teaching, research and product development due to its flexibility in using virtual instrumentation technologies. The main components for DAQS are shown in Figure (1) [1].

LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench) is a graphical programming environment, developed by National Instruments (NI), which is well suited for high level or system level design [2]. This programming approach is based on building blocks called

Virtual Instruments (VIs) and has been widely used for data acquisition instrument control. There are three important components involved in test and measurement applications, namely data acquisition, data analysis and data visualization. LabVIEW features an easy to use graphical programming environment, which covers these vital components [3].

The Lab VIEW full development system features the analysis library. The function in this library is called virtual instruments VIs. These VIs allow us to use classical digital processing algorithms without writing a single line of code. The LabVIEW block diagram approach and the extensive set of analytical VIs simplify the development of analysis applications. These VIs are arranged in subgroups, some of which one digital signal processing and windows. Lab VIEW has the flexibility of a programming language combined with built in tools designed specifically for test, measurement, and control therefore, the use of the integrated LabVIEW environment to interface with real world signals, analyze data for meaningful information is very useful work [4].

Temperature distribution is one of the most important factors determining quality of the grown crystals, the nonuniformity of which is a source of stresses.

To find the exact temperature distribution it is necessary to consider global heat transfer in growth system. Due to the complexity of the problem (melt convection, radiative heat exchange) most numerical simulations have been based on many simplifying assumptions [5].

In this paper, we introduce a LabVIEW based data acquisition system for studying and analyzing the radial temperature distribution. The temperatures have been measured using eight identical thermocouples temperature sensors positioned at equally spaced distance along the radial direction of piece of the clamping.

2. Practical Thermocouple

Thermocouples have become standard in industry as a cost effective method for measuring temperature. Most all practical temperature ranges can be measured using thermocouples; even though, their output full-scale voltage is only millivolts with sensitivities in the microvolts per degree range and their response is non-linear [6].

Standard mathematical power series models have been developed for each type of thermocouple. These power series models use unique sets of coefficients which are different for different temperature segments within a given thermocouple type. Unless otherwise indicated, all standard thermocouple models and tables are referenced to zero degrees Centigrade, 0°C. Equation (1) illustrates the power series model used for all thermocouples except K Type, which is illustrated by equation (3).

$$VTC = \sum_{i=0}^{n} C_i * (T)^i, mV \quad \ldots 1$$

Where T is in degrees centigrade.

These equations with their different sets of coefficients are difficult to use in directly determining actual temperatures when only a measured thermocouple voltage [VTC] is known. Therefore, inverse models have been developed to determine temperatures from measured thermocouple voltages. Equation 2 represents this inverse model.

$$T = \sum_{i=0}^{n} D_i * (VTC)^i, {}^oC \quad \ldots 2$$

Where VTC is in millivolts.

It is noteworthy to mention here that K Type thermocouples require a slightly different power series model. Equation 3 represents the standard mathematical power series model for Type K thermocouples.

$$VTC = \sum_{i=0}^{n} C_i * (T)^i + A_0 * e^{A1*(T-A_2)^2}, mV \quad \ldots 3$$

The exponential term $A_0 * e^{A1*(T-A_2)^2}$ in equation (3) is added to account for special effects.

Standard thermocouple look-up tables and models are referenced to zero °C; whereas, field measurement topologies are made with the thermocouple connected to a connector that is not at zero °C; consequently, the actual measured voltage must be adjusted so that it appears as referenced to zero °C.

Modern signal conditioning modules have electronically resolved this situation and, in addition, have linearized the thermocouple voltages. These conditioning modules provide the end-user with a linear output signal, scaled to either volts per °C (°F) or amps per °C (°F). The concept of electronically referencing thermocouple measurements to zero °C is shown in Figure (2). This technique is known as cold junction compensation or CJC [7,8,9].

3. National Instrument PCI 6024E Data Acquisition Board

The 6024E data acquisition board features 16 channels of analog input, two channels of analog output, a 68-pin connector and eight lines of digital I/O. This board is used to acquire analog inputs from the thermocouples modules. DAQ hardware acts as the interface between the computer and the outside world. It primarily functions as a device that digitizes incoming analog signals so that the computer can interpret them. Other data acquisition functionality includes analog Input/Output, Digital Input/Output, Counter/Timers and Multifunction (combination of analog, digital, and counter operations on a single device). Software transforms the PC and the DAQ hardware into a complete data acquisition, analysis, and presentation tool. Without software to control or drive the hardware, the DAQ device will not work properly. Driver software is the layer of software for easily communicating with the hardware. It forms the middle layer between the application software and the hardware. The application software that was used in this paper is the LabVIEW programming. The maximum sampling rate of the board is 200KS/s and voltage range is $\pm 5V$. [10,11].

4. Experimental Setup

For studying and analyzing the radial distribution of the temperature, a cylindrical piece from aluminum was designed for clamping the thermocouples. This piece with a diameter of 9 cm and comprises of eight holes each one with a diameter of 3 mm. The holes were positioned at equally spaced distance along the radial direction of the cylindrical piece. Distance of 1 cm between each hole and another was made as shown in Figure (3). A strip of plastic was put along the radial direction for clamping the thermocouples inside the holes as shown in Figure (4). Figure (5) shows the piece and the eight thermocouples connected to the data acquisition system cylindrical piece. The heater element was used as a heat source. The heater was supplied at the center of the piece as shown in Figure (6).

This project is computer based system for measuring the temperature. The connection between the computer and the experimental system was made using the National Instruments PCI 6024E data acquisition card for measuring the temperature from thermocouples temperature sensors. National Instruments PCI 6024E data acquisition card can only receive voltage less than 10V. The thermocouple sensor is connected to the 5678 module, which is designed for thermocouple requirements, and this module will output a voltage that can be read by the data acquisition card.

5. Software Design and Results

A LabVIEW program was created to measure the distribution of the temperature in air from eight thermocouples.

IT was built using National Instrument 8.2.1 software. A VI program was designed to read and display the temperature simultaneously. Because of the nonlinearity of the thermocouple a linearization was made inside the program in order to get a voltage linearly proportional with the temperature.

A facility of choosing different types of thermocouples was attached with the program and also it is possible to choose different temperature units. The main program is composed of eight sub VIs each one represents the program that performs the function that produces alinear relationship of the thermocouple sensor. Figures (7) and (8) show the front panel and the block diagram of the designed program using LabVIEW. Figure (9) shows the graph of the temperature distribution that was measured using eight thermocouples. It is clear that the temperature almost the same around the center of the piece that is mean that the temperature distribution is almost identical around the center. Figures (10) and (11) show the temperature for each side of the piece around the center (4-right and 4-left) thermocouples. This program has the capability of saving in a file on request at the end of the measurement.

6. Conclusion

The results of this experiment explain that the temperature is almost equally distributed around the center of the piece of the clamping. The use of virtual instrument is cost effective and suitable for lab experiments and exposing students to virtual instruments and PC based measurements.

7. References

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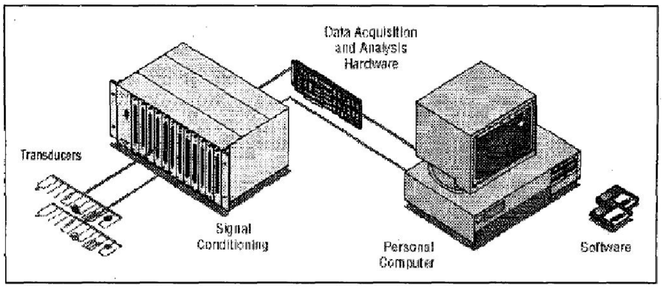

Figure (1): PC-Based Data Acquisition System.

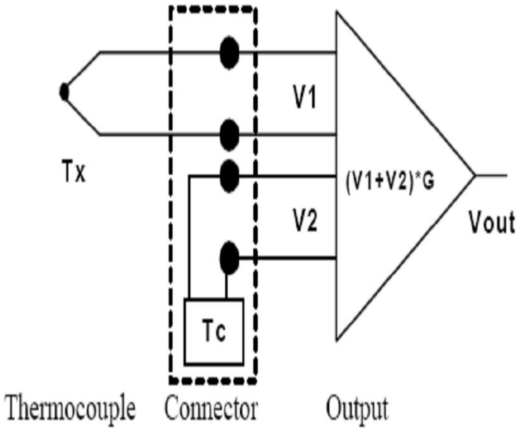

Figure (2): Cold Junction Compensation Concept.

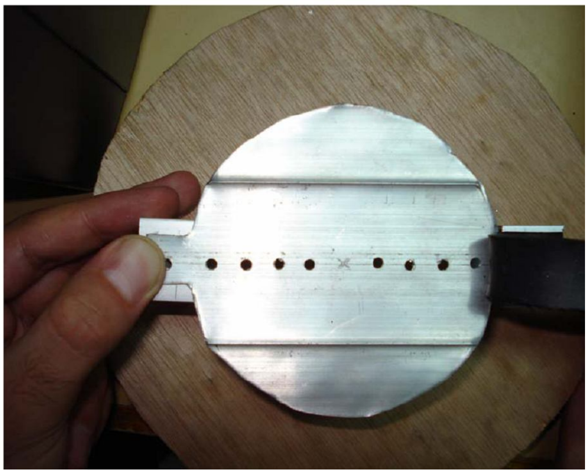

Figure (3): Cylindrical Piece For Clamping.

Figure (4): Cylindrical Piece With strip of plastic For Clamping.

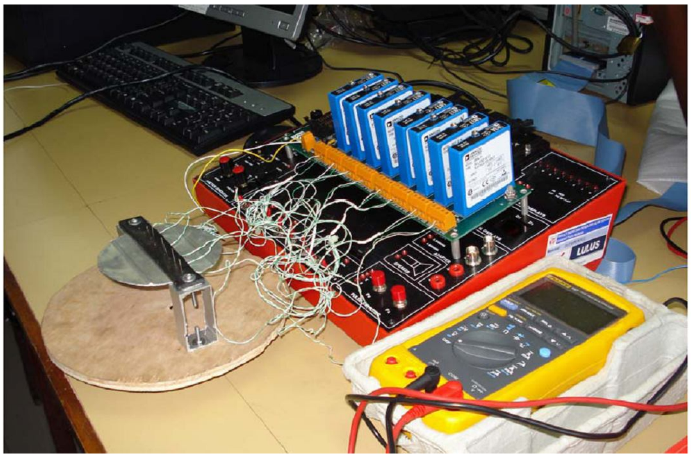

Figure (5): Eight Thermocouples connected to DAQS.

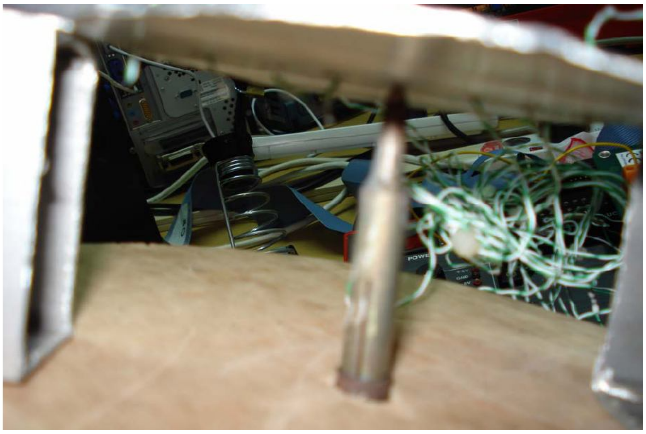

Figure (6): Heating Element supplied to the center of the piece.

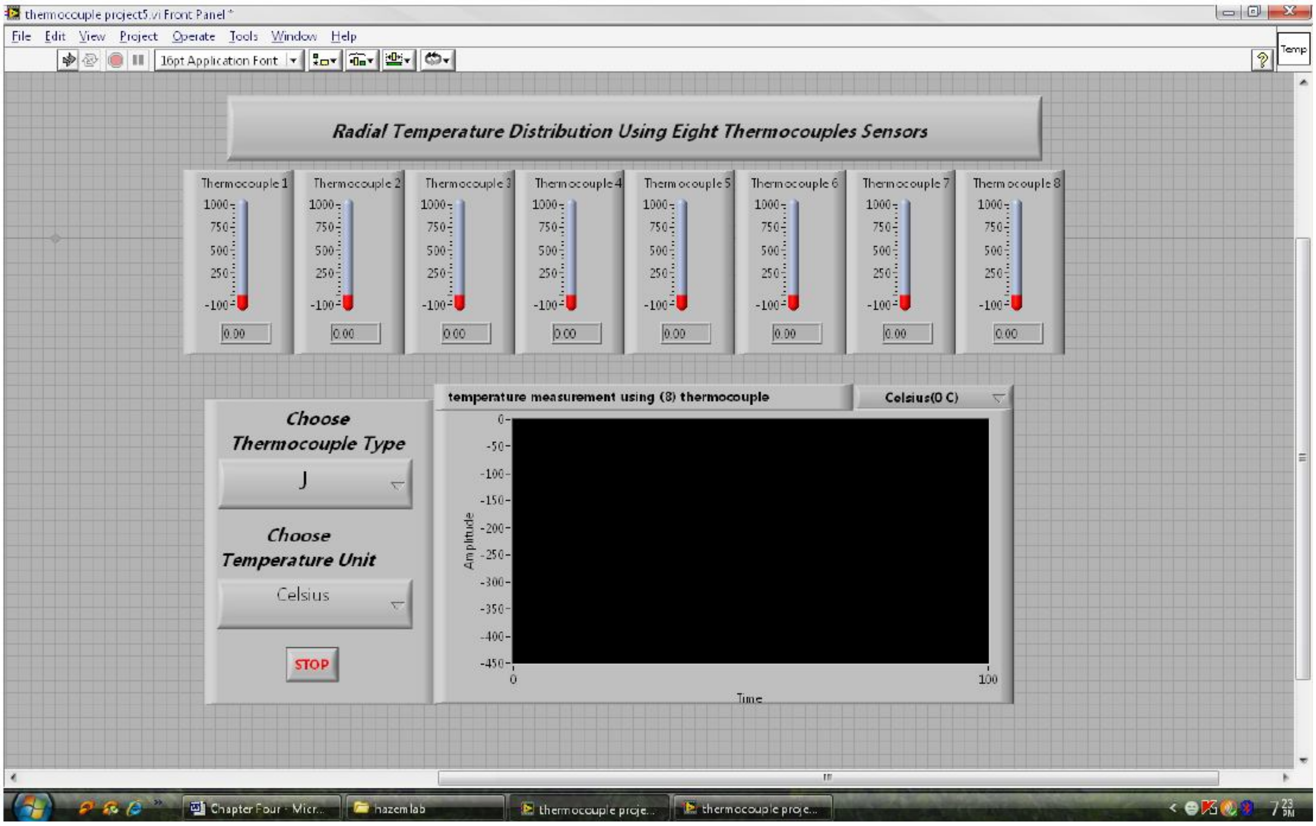

Figure (7): Front Panel of the system.

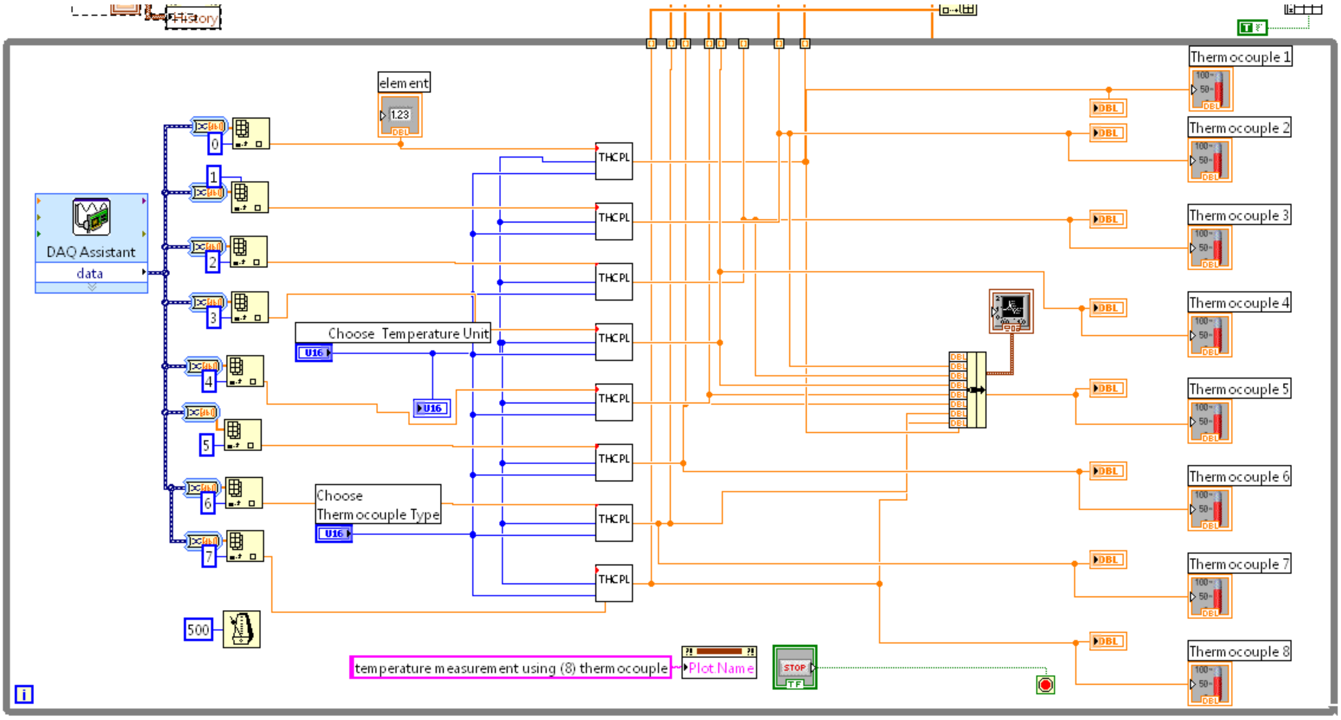

Figure (8a): Block Diagram of LabVIEW Main Program.

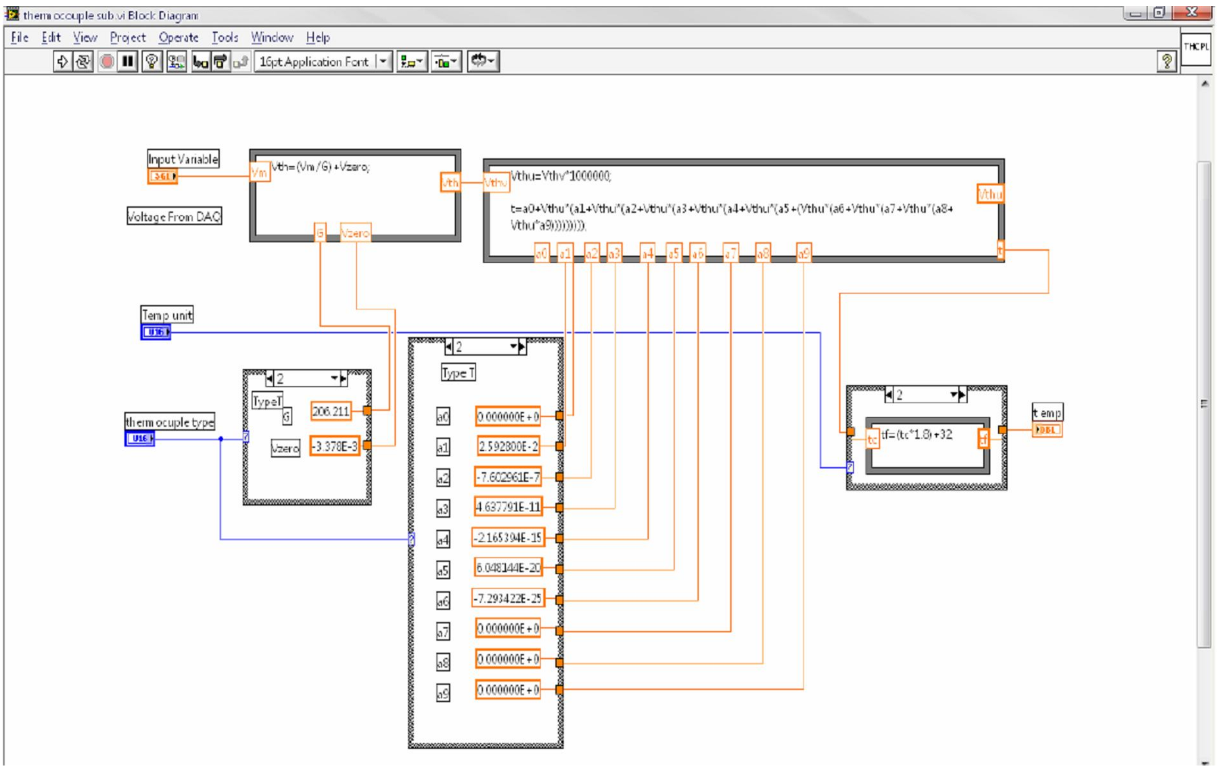

Figure (8b): Block Diagram of LabVIEW SubVI Program.

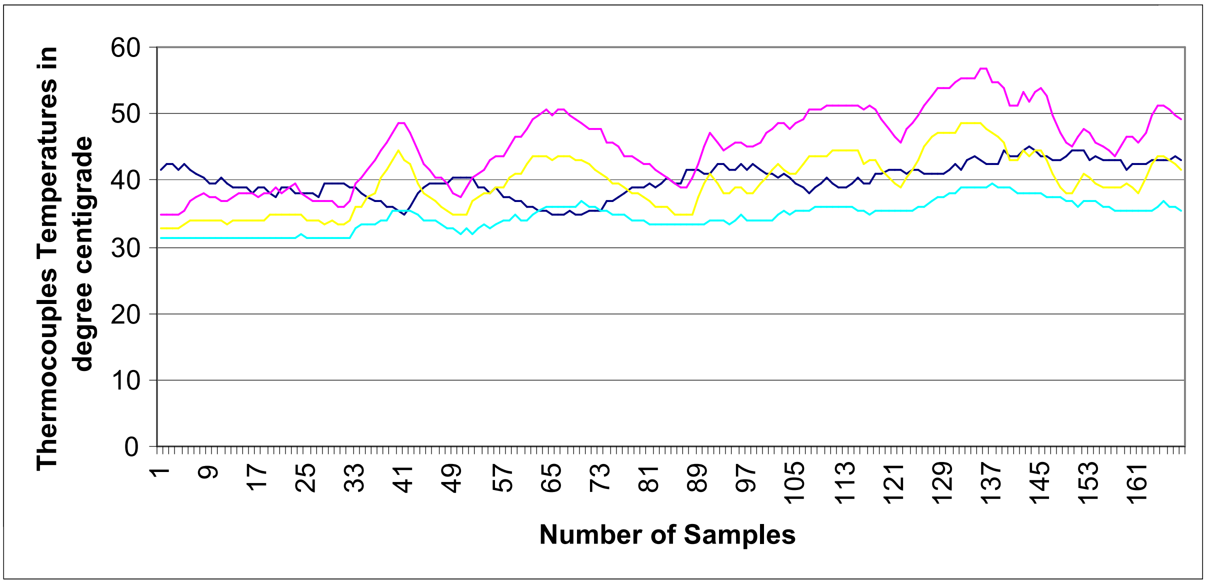

Figure (9): Eight thermocouples Temperatures.

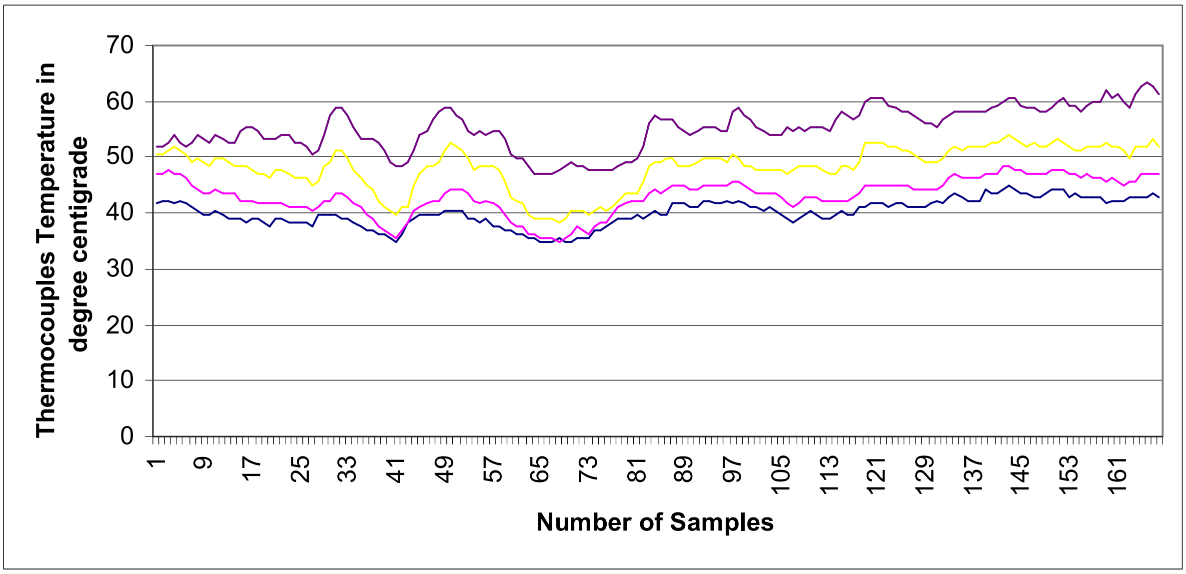

Figure (10): Four-Left side thermocouples Temperatures.