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APPLICATION OF VIRTUAL INSTRUMENTATION IN DETERMINING THE TEMPERATURE FIELDS OF HOT ROLLING CYLINDERS

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Abstract: The paper presents a LabVIEW application to determine the voltage-temperature characteristic of a thermocouple Pt-Rh/Pt. Using virtual instrumentation and LabVIEW graphical programming environment, to determine the temperature field of hot rolling cylinders allows replacement measurement systems consist of conventional devices with simple tools more precise and at a price much lower cost. Understand changes in temperature of hot rolling cylinders is required to study the phenomenon of thermal fatigue in these machine parts. Thus, a signal adapter, a computer and a printer will be able to perform accurate experimental determinations with incomparable precision measuring classics devices.
Keywords: temperature, device, instrument, virtual, characteristics, field

1. INTRODUCTION

Currently, many measurement systems used in various experimental determinations are relatively expensive and limits the possibilities of purchase. But it has an equivalent in the National Instruments company products that can be, on the one hand, data acquisition boards, and on the other, virtual software. Under these conditions, these systems are not absolutely necessary, as it can be implemented virtual LabView graphical programming environment, reducing system cost more endpoints measured quantities, [1]. Using LabVIEW graphical programming environment can achieve complex applications, performance in a simple and elegant while having high flexibility and relatively low cost. In addition to the major advantages, virtual instrumentation also has a wide range of applicability, [8].

In recent years the world has developed an industry in virtual instruments capable of measuring out the various types of sizes:electric, magnetic, mechanical, fluid mechanics, etc.

A virtual instrument is a measuring device that uses software developed and some hardware. Making virtual instrument is represented by writing a program that meets all user requirements. Virtual instrument once made, may be changed and completed as needed, [1].

The main components of a virtual instrument are: front panel, a block diagram and a symbol identification. The front panel is a graphical interface used for data presentation and the introduction of controls which can be heavily customized by the user in a particular application, [8]. In this way you can create simple tools, and real evidence stands that will replace several devices more or less accurate and compatible, [8]. Thus, a signal adapter, a computer and a printer will be able to perform accurate experimental determinations with an incomparable precision measuring of the classical instruments [1]. In the computer, as well as devices for the "real" instruments are buttons on / off, analog or digital dials display, oscilloscope screens, buttons, potentiometers choice of scale measurement and control, trigger buttons, and thermometers, liquid containers, etc. All handles are the same as for conventional devices, but with the mouse.

In this paper we will present an application created using virtual instrumentation and LabVIEW programming environment, designed and built to determinated the thermal field of rolling cylinder mills.

2. POSSIBILITIES TO STUDY THE THERMAL FATIGUE

In industrial operation we use machinery, motors and units working in variable thermal, often cyclical, regimes repeated from time to time, [3],[4],[5],[7]. Some machine parts are subject to variable temperature fields which produce thermal stress variables on the surface and in their surface layer, mainly responsible for the appearance of cracks, [2],[3],[4],[7]. Those are specific thermal fatigue phenomena which develop gradually and occur even under the more favorable operating conditions, depending on the treatment work cycle and material used for these machine parts, [6],[7]. The concept of thermal fatigue is the subject of numerous studies, specific to various fields. Study of thermal fatigue phenomenon has been made on some items such as hot rolling cylinders, pipelines of thermal power industry, gas turbines, nuclear reactories etc.

To study thermal fatigue of the hot rolling cylinders that make up the following objectives must be achieved, [7]:

- ✓ to study the thermal behaviour of rolling cylinders during operation;
- ✓ to determine all variable fields of temperature on the surface and in radial section of the hot rolling cylinders;
- ✓ to perform experimental research on fatigue resistance of samples subjected to different thermal regimes request.

One of the steps in the study is to determine the thermal fatigue from temperature variations in the area of the radial section of the hot rolling cylinders. In [2], [3], [7] is presented in detail both the experimental facility and the principle of this research in two ways:

- ✓ by oscillographying the rolling process;
- ✓ with two analog modules and a program developed in C++.

Both methods use the measuring system made up of a plurality of devices having relatively high costs and, on the other hand, experimental results of the measurements are subject to error, caused by the inaccuracy of the classical measuring devices.

3. EXPERIMENTAL DETERMINATION

Determining changes in temperature research aimed at the fields of knowledge of temperature on the surface in a radial section of cylinder, during operation. In this regard, research has been conducted in an experimental rolling mill with cylinder diameter of 220 mm, which is in the laboratory of Industrial Mechanical Equipment, in the Faculty of Engineering of Hunedoara, fig. 1. Experimental determinations based on thermoelectric effect in thermocouples. The basis for measurements is selection of the thermocouples.

Although the maximum number of rotations of the cylinders experimental mill is relatively small, n_{max} = 120÷ 140rot/min to highlight the changes in temperature on the surface and in the superficial layer of the cylinder to complete their rotation was necessary to carried out with thermocouple having a minimum thermal inertia response and indicating the minimum temperature tolerance, fig.1, [2],[3],[7]. The thermocouples were selected are Pt-Rh/Pt that have a small tolerance in the temperature of 600^{0}C. This choice was favored by the opportunity to purchase thermocouples, [2], [7].

The bolt 1 with thermocouples 3 are mounted in the cylinder 2, and the rolling thermocouple wires passing through the axis of the hole made in the discs 5 of the thermotensione colector which provides transfer the thermotensione of the slip rings 7 to carbon brushes 6. The relationship between cylinder 2 and termotensiune collector is achieved through rigid coupling 8, [7].

The termotensione collector assembly, the bolt with thermocouples implanted in the hot rolling cylinder and the link to adapter signals shown in fig. 2.

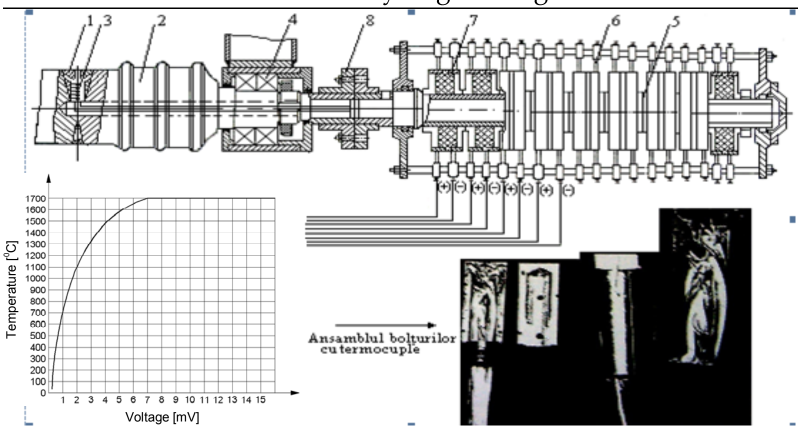

Fig.1. Bolt assembly with thermocouples implanted in the cylinders and the diagram inertia response of the thermocouples Pt-Rh/Pt, [7]

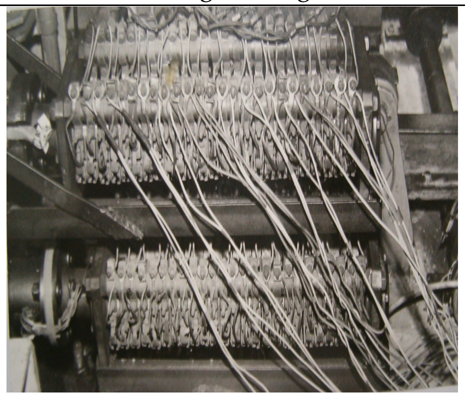

Fig.2. Links from collectors termotensiune sent to the adapter signals, [7]

Links to the termotensiune collector signals are sent to an adapter and from there, signals are taken from a computer. Virtual instrument block diagram of a data acquiring process for determining the variations in temperature of hot rolling cylinders is shown in fig. 3. In fig.4 presents the connection to a data acquisition system.

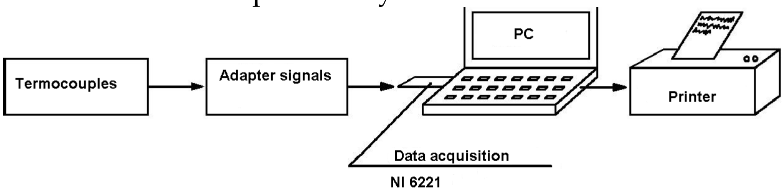

Fig.3, Block diagram of the virtual instrument used to determine the temperature fields of hot rolling cylinders in order to study the phenomenon of thermal fatigue [8]

Fig.4 The connection to a data acquisition system

Thermocouple signals taken by collector termotensiune are introduced into an adapter that serves as a signal amplifier. Following their reconditioning this adapter signals, they are sent to a data acquisition board, type NI 6221 which is not integrated into the computer. This is a driver that is installed on the hard disk. During the experiments, the computer creates a database, where the measured quantities recorded with the data being able to carry out the operations of any kind. Results or data stored in the computer can be printed in the form of measurement sheets, with the printer.

4. DESCRIPTION OF THE APLICATION

The application developed in LabVIEW, determine the temperature-voltage characteristic for a Pt-Rh/Pt thermocouple. Application front panel contains controls: buttons, color controls and indicator elements: xy chart and indicator image, fig.4.

The application uses a table of data on temperature-voltage variation. The data in this table are introduced in the application in the form of a matrix. To calculate the parameters sumaU, suma u2, suma uT and sumaT, it used repetitive structure „For" as a „Shift register" with 31 iterations, one for each line of the table.

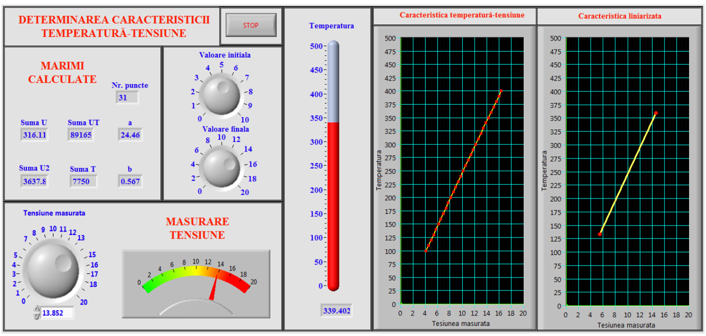

Fig. 4 The front panel of the application

The input stages of the voltage-temperature table is as follows:

- ✓ initialize an matrix with 31 elements 0.;
- ✓ replacement of element by turn, following ascending index with the 31 values in the table.

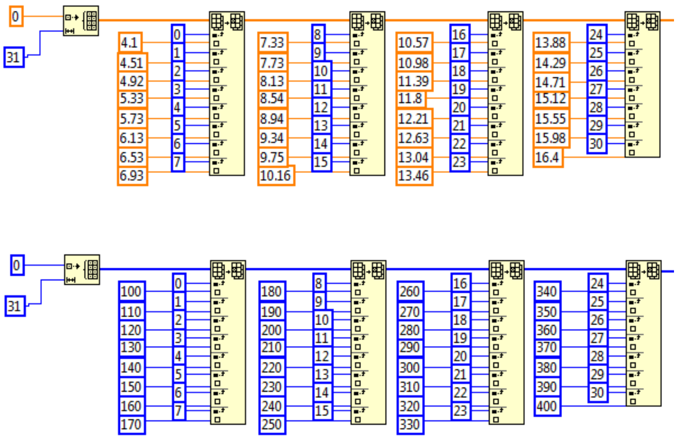

Fig. 5 Loading algorithm for data tables, above voltage [V], down-temperature [° C])

Figure 5 is shown loading algorithm for data tables. It is noted that the first matrix includes the voltage and temperature values of the second matrix. Inserted into the „Shift register" structure functions generates parameters sumaU, suma t suma u2, suma uT and suma T, fig.6. It is thus inserted, one by one, all values of the table, the index „Array functions" that extract the input matrices, desired items. All functions described above are inserted into a repetitive structure „While" performing a single iteration.

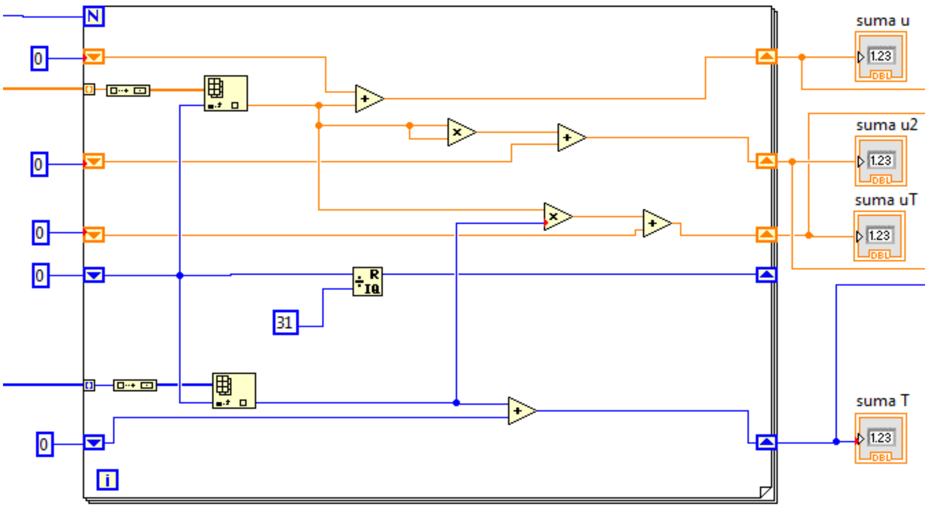

Fig. 6 "Shift register" structure for calculating parameters suma U, suma u2, suma uT & summative Suma T

Calculation of linear regression parameters is performed using a "Formula Node" function calculation are specified input parameters, output parameters and their relationship,fig.7. Generating such "a" and "b" parameters are displayed on the front panel as a numerical indicator.

Referring to fig. 7 it can be seen that the voltage can be adjusted from the front panel within 0 - 20V, measured temperature is displayed on the front panel with a numerical. With a button, located on the front panel, you can adjust the voltage within 0-20V. Following data table displays the temperature values on the indicator.

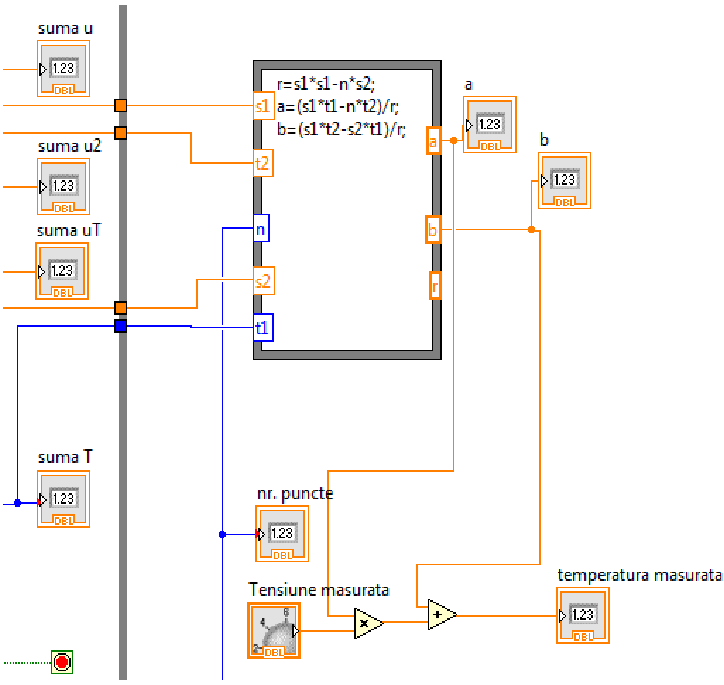

Fig. 7 Calculation of linear regression parameters

Temperature-voltage characteristic can be viewed through two screens.

On the left screen is drawn using the 31 feature points, and the second characteristic flattened between a starting point and an end point. The graph on the left is determined by the algorithm shown in fig. 8.

The algorithm for generating the linearized characteristic is determined by placing the two values of the program start and end point coordinates using the button located on the front panel. The algorithm is shown in fig.9.

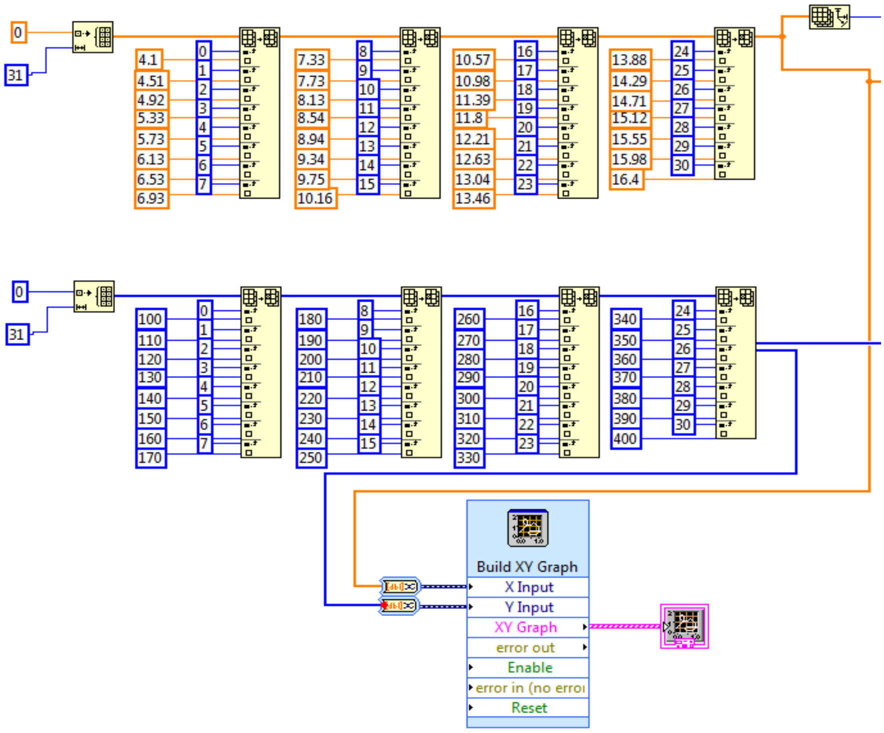

Fig. 8 Algorithm for generating feature linearized by thirty one points

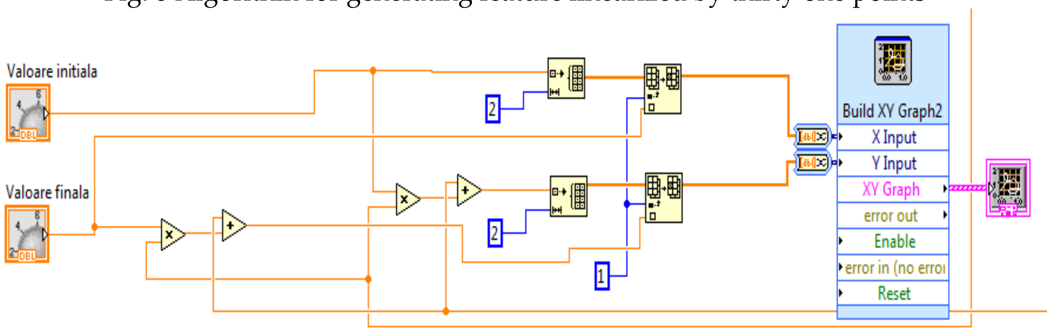

Fig. 9 Algorithm for generating feature linearized by two points

With the virtual instrument previously created we can trace voltage-temperature characteristic of a Pt-Rh/Pt thermocouple implanted in the radial surface of hot rolling cylinders to experience measurements.

5. CONCLUSIONS

The various features that LabVIEW graphical programming environment makes available allowing the development of applications with varying degrees of complexity and different levels of user access.

Using LabVIEW graphical programming environment, providing analysis and determination of voltage-temperature characteristic, is particularly useful in laboratory applications. Completed applications allow changing input parameters with specific controls, choice of method for measuring and determining feature Pt-Rh/Pt thermocouples for determining temperature variations. An important characteristic of a virtual instrument is the ability to integrate data acquisition devices and software procedures for the establishment of virtual systems analysis and control.

Relatively simple way of development based on LabView modules means that as a whole created is particularly strong in terms of calculations, easy to use graphical interface and easy thanks configured.

If these features add much lower price than the classic test, it can be concluded that the virtual instrumentation represent an adequate solution for the implementation of automated office measurement of temperature variations of the type in question.

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