FLEXIBLE PROGRAM FOR CONTINUOS TEMPERATURE MONITORING WITH THE USE OF A THERMOCOUPLE

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Abstract: *Program for continuous monitoring of processes and its parameters is presented in this paper. The temperature was observed as it is an important task in preventive maintenance where critical points of the process must always be within the limits of tolerance. This paper shows a program solution created with the LabVIEW software for continuous monitoring of the temperature and maintenance of a reliable process.*
Key words: *Thermocouple, LabVIEW, temperature, maintenance*

1. INTRODUCTION

Temperature conditions for the industrial applications are measured depending on the medium, the temperature measuring range and the device itself. There are different measuring devices that can measure temperature as the thermometer, thermocouple, thermistor, infrared thermometers, etc. The main difference of using a particular device depends on the medium that is measured, then the accuracy of measured data, the equipment cost, measuring range of the device, local standards that are required (Segan & Barisic, 2009). The reasons for the temperature measurement are numerous, because temperature changes cause changes in physical characteristics of materials (change of electrical resistance, dimensions, aggregate state, pressure, radiation intensity, etc.). The measurements of temperatures can be encountered in the construction industry (e.g. measuring the temperature of fresh concrete and the air at the beginning of the installation of concrete and developing control samples for evidence of compressive strength in certain conditions) (Childs et al., 2001), medicine (measuring human body temperature), the food industry (food industries require possession of a device for measuring temperature with a corresponding small diametrically testers designed for measuring temperature of thin and easily available masses to ensure the food is cooked enough). Thermometer for food is used to measure the internal temperature of food to ensure that the safe temperature is achieved and that the harmful bacteria such as salmonella are destroyed (Zell et al., 2009). It is also used to ensure the cooking safety (food safety, 2009). It is used in manufacturing processes such as casting and forming (uneven temperature, as well as sudden cooling can cause errors and poor quality), in electronics and computer sciences (measuring the temperature of individual components), etc. In our presented example temperature is measured for solving problems related for mechanical engineering. Each measuring device is measures according to certain principles; this can be different temperature effects from which the temperature may be indicated. In this paper thermocouple is used to measure electro-magnetic force (EMS or fall of voltage) the voltage generated in a various wires or temperature change. Due to the passage of electricity it comes to a fall of voltage in some strings. This voltage drop depends on temperature differences between the two ends of the connection (Seeback effect). By measuring the drop in voltage it can be connected with the temperature difference. Thermocouple measures the difference between the two connections where one is set as the reference and the other sets the known temperature. In this way the thermocouple can measure the unknown temperature. The movements of voltage should be kept in mind because although the continuous measurement is used that does not mean the data changes at the same time and adapts to the change in temperature. It is therefore necessary to understand the times of temperature response, especially at a very sensitive process. In addition, measurement is the process of determining the measured size whose result is a number that shows how many times the measured unit is larger or smaller than the units of measurement. Costly errors must be discovered before they occur and continuous measurement is a usual procedure of prevention. When gathering necessary data it is important to use a flexible program that allows us to cover the measurement area as well as possible changes in the measurement of the system.

2. THERMOCOUPLE

Thermocouples are the most frequently used of all temperature sensors. They belong to the group of contact temperature sensor for measuring temperature. Their simplicity and reliability enable their application for many industrial applications. Thermocouples original purpose was to measure the high temperature of 500 °C to 1000 °C (Childs et al., 2001). Today their greatest importance is in the measurement of temperature, but the application has been successfully expanded to a low temperature of 1K (-272.15 °C), up to a high of 2400 °C. Because of the good characteristics Thermocouples have many practical applications in measurement and regulation of temperature. General thermocouples advantages, compared to the other thermometer is a simple structure, relatively low cost, ease of installation, as well as good features for dynamic measurements of temperature. Thermocouples are also characterized with some bad features, the low level output signal and a limited lifetime at the higher temperatures. This is why today thermocouples are less used in precise measurements of temperature. Thermocouple represents an electric circuit, which often serves as a sensor of temperature or temperature difference. Thermocouple functioning depends on the potential of two different materials on the combination, which leads to conversion of thermal energy into electrical. For temperature measurement is the thermocouple type K (+ kromel, alumel -) was used (Fig. 1). Type K is used in the temperature range from -270 °C to 1370 °C (Childs et al., 2001).

Fig. 1. Thermocouple of type K

Kromel the wire that has a yellow insulation and is made from nickel alloys (Ni) and chromium (Cr) and alumel has red insulation and is made from nickel alloys (Ni) and aluminum (Al).

2.1 Thermoelectric potential

When the ends of the guide are at different temperatures $T_2 > T_1$ between them heat flow is created from the warm toward the cold end (Fig. 3.1). Heat transfer is closely linked with the movement of free electrons. Their concentration and the associated potential is unevenly distributed along the guides, so there electric current appears.

$$I_e = -K_e \frac{dU}{dx} . \tag{1}$$

At the same time the currents occurs due to the temperature gradient:

$$I_T = -K_T \frac{dT}{dx}. \tag{2}$$

Coefficients K_e and K_T indicate proportionality of the currents I_e and I_T with a potential gradient of the temperature.
Minus sign refers to a negative growth of the potential and temperature with the positive increment of distance along the guide. Because this is not a closed electric circuit, the total current through the guide is equal to zero, i.e. $I_e + I_T = 0$, where

$$dU = -\left(\frac{K_T}{-K_e}\right) dT. \tag{3}$$

Voltage that occurs as a result of the temperature difference T_2-T_1 between the ends of the observed guide is called the thermoelectric voltage and its value is gained with the integration of equation

$$U_{T_2} - U_{T_1} = \int_{T_1}^{T_2} K dT. \tag{4}$$

Coefficient $K = -(K_T / K_e)$ depends on the properties of the material from which the guide is created and the given temperature. For small temperature changes it can be considered that:

$$U_{T_2} - U_{T_1} = K(T_2 - T_1). \tag{5}$$

2.2 Transmitters

Data collection begins with the need to measure something. Physical phenomena that is measured may be room temperature, the intensity of light source, the pressure inside the chamber, force applied to an object, etc. Efficient Data Acquisition system (DAQ) can measure all of these different phenomena. The converter is a device that transforms a phenomenon into its corresponding measurable electrical signal, such as voltage or current. The possibility of a DAQ system to measure different phenomena depends on the converter to convert physical phenomena to measurable signals from the DAQ hardware. In our example specific converter SCXI-1112 was used for thermocouples. (Fig. 2.).

Fig. 2. Thermocouple of type K

3. EXPERIMENTAL WORK

Twelve measurements were done and the comparison of measured temperature between thermocouple and mercury thermometer (Table 1).

Table 1. Temperature measurement comparison.

Number	Temperature Thermocouple T_1 [°C]	Mercury Thermometer T_2 [°C]	Mistake of Thermocouple T_2-T_1 [°C]	Mean of the Thermocouple mistake [°C]
1	34.9	34.83	-0.07	0,084
2	36.3	36.21	-0.09	
3	36.6	36.41	-0.19	
4	37.4	37.22	-0.18	
5	38.3	38.21	-0.09	
6	38.2	38.11	-0.09	
7	38.3	38.23	-0.07	
8	38.8	38.67	-0.13	
9	39	38.94	-0.06	
10	39.5	39.33	-0.17	
11	40.3	40.21	-0.09	
12	41.1	41.32	0.22	

3.1 Response time of the thermocouple

To calculate response times of thermocouple it is necessary to measure the temperature higher than the temperature of the environment and then measure the response times or the time it takes to get back on thermocouple temperature. The temperature of the environment in this case was 19 °C. We have eight measurements whose values can be seen in Table 2.

Table 2. Temperature response time.

Number	Temperature Thermocouple T_1 [°C]	Response time [s]
1	22	6
2	24	9
3	25	11
4	29	22
5	42	29
6	52	30
7	82	39
8	92	40

By diagram in Fig. 3 the time response curve shows that the temperature is not linear. With the increase of temperature increases and response times, this was to assume.

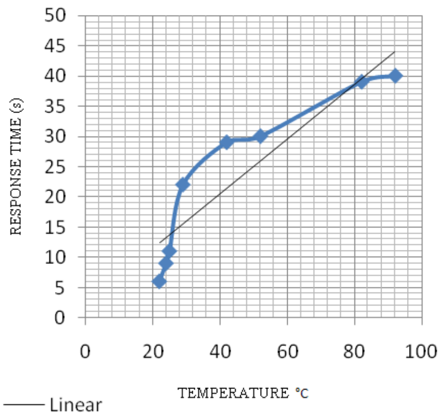

Fig. 3. Temperature response time is not linear

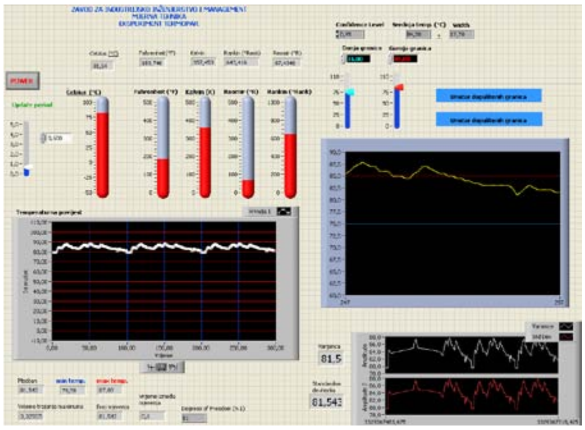

Fig. 4. Front panel of developed programme

Fig. 4 shows a LabVIEW program that gathers data and gives diagram of the process behaviour. The thermocouple was heated in a fluid and the acquired data was analyzed.

4. PROGRAMING

4.1 Front panel

The front panel (Fig. 4) contains controls and indicators and serves as the main access to the process parameters that can be manipulated. LabVIEW has a very rich menu of one and other and it allows an engineer to adjust the parameters of the system in a way that suits him best. Apart from the measurement information the electronic components that are managed by the process can also be manipulated.

4.2 Block diagram

Figures 5 and 6 show the whole of the program block diagram, a G graphical program of LabVIEW was used for its creation.

5. CONCLUSION

Important information for the process is recorded and a view of determining the quality of the process has been shown. Software LabVIEW 8.20 of National Instruments Company was used for programming. The temperature was measured and the important parameters that influence the measurement were discussed in the work. The response times of measurement were tested and comparison of mercury thermometer and thermocouple found little deviation of thermocouple 0.084 °C. With it a robust and independent but flexible program application for process monitoring was made. Future research and trends depend on the needs of industry and currently there are great demands for optimum process monitoring and maintenance of high quality products. Other research should lead to a combination of different parameters within the program, in this way the program could show all of its programming flexibility in the acquisition of data, depending on the measured objects. There should also be implemented testing of different materials to create thermocouple that knows the ideal relations in a measurement category and thus better track specially selected measuring ranges.

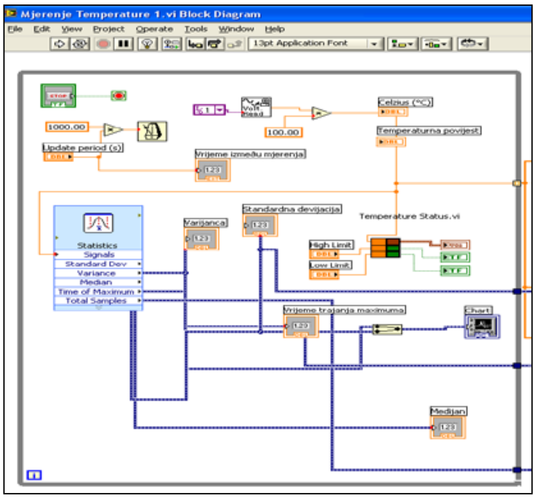

Fig. 5. Block diagram of the loop, left side

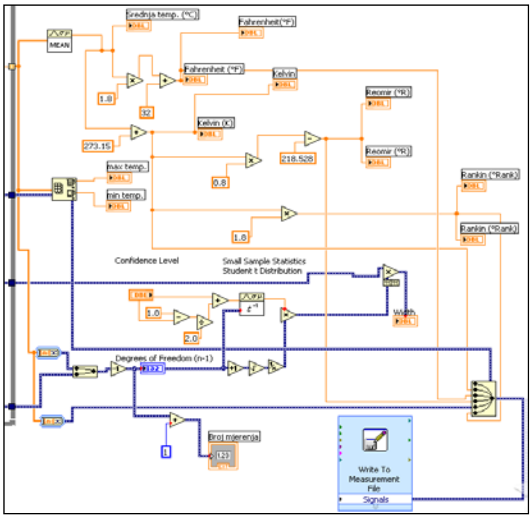

Fig. 6. Blok diagram outside the loop, right side

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