MEASURING AND RECORDING OF TEMPERATURE ON PEDAGOGICAL MODEL OF HOT-BLAST STOVES

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Abstract

Hot-blast stove is apparatus for preheating air blown into a blast furnace, an important step in raising the efficiency of iron processing. Physical model of 4 hot-blast stoves is created on a small scale. This model is used by students to understand its function and the possibility to test automation tools for its commissioning. Presented article deals with measuring of temperature using PLC on the model.

Keywords: Hot-blast stove, PLC, temperature

1. INTRODUCTION

Hot-blast stove, apparatus for preheating air blown into a blast furnace, an important step in raising the efficiency of iron processing. The stove is a vertical cylindrical steel shell lined with firebrick and with the interior separated into two chambers: a combustion chamber, in which gases from the blast furnace and from other fuel sources such as the coking plant are burned, and a regenerative chamber filled with a checkerwork of refractory brick heated by the burned gas. [1] Physical model of 4 hot-blast stoves is created on a small scale. The stoves are heated by heat guns. Each stove has integrated three PT100 temperature senzors. The main task is to design and realize temperature measurement in that model by means of PLC.

2. EQUIPMENT

List of used hardware and software.

2.1. CompactLogix™ L32E

CompactLogix™ L32E is a CPU of modular Allen-Bradley PLC. This controller is ideal for small to mid-size control applications that don't require motion or safety functionality and offers integrated serial, EtherNet/IP™, or ControlNet™ channels; and modular DeviceNet™ communications. [2]

2.2. 1756-IF6I analog input module

Table 1 Possible input ranges for 1756-IF6I module [3]

Cat. No.	Inputs/Outputs	Range	Resolution
1756-IF6I	6 individually isolated inputs	±10.5V 0...10.5V 0...5.25V 0...21 mA	16 bits 10.5V: 343 mV/bit 0...10.5V: 171 mV/bit 0...5.25V: 86 mV/bit 0...21 mA: 0.34 mA/bit

Analog Input Module 1756-IF6I is connected to L32E controller. You can select from a series of operational ranges for each channel on your module. The range designates the minimum and maximum signals that are detectable by the module. The 1756-IF6I module offers multiple input ranges in both current and voltage applications. The **Table 1** lists the possible input ranges available for use with the 1756-IF6I module. [3]

2.3. RSLogix 5000

RSLogix 5000 software is an IEC 61131-3 compliant software package that offers relay ladder, structured text, function block diagram, and sequential function chart editors for you to develop application programs. Create your own instructions by encapsulating a section of logic in any programming language into an Add-On Instruction. [4]

2.4. Model of hot-blast stove

Figure 1 shows model of hot-blast stove with pipeline for air supply. On the right side of **Figure 1** you can see three points where the temperature senzors are connected. 1^{st} senzor is in the dome, 2^{nd} is in the center and 3^{rd} is in the bottom.

Figure 1 Model of hot-blast stove

3. COMPENSATION OF PT100 RTD NONLINEARITY

There are some digital and analog methods that can be used for compensating a PT100 RTD nonlinearity. We can implement digital linearization by implementing any equation, or by a lookup table. By implementing the generic equation we can calculate temperature values directly, based on the actual measured RTD resistance. A lookup table allows an application to convert a measured PT100 resistance to the corresponding linearized temperature. Those methods have some disadvantages, if we use generic equation method, some CPU time must be sacrificed to do the math. If we use the lookup table then we must first identify the two closest resistance values and then interpolate between them. A lookup table necessarily contains a limited number of resistance/temperature values. The main drawback of digital linearization is the need of a microprocessor. To avoid employing a microprocessor, we can use the analog approach to perform accurate linearity compensation [5]. **Figure 2** is the electronic compensation circuit created in CatSoft Eagle software. **Figure 3** is printed circuit board of compensation circuit fitted with components.

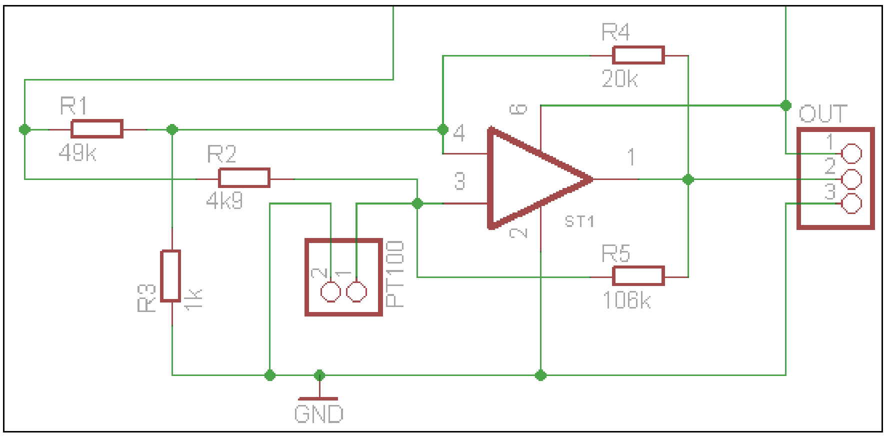

Figure 2 Analog compensation circuit

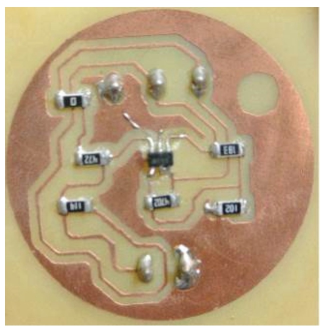

Figure 3 Printed circuit board

4. CONNECTION PT100 TO 1756-IF6I

Figure 4 shows how the temperature senzors are connected to PLC analog input modul 1756-IF6I. Every senzor is connected to compenzation circuit and power supply.[3, 6]

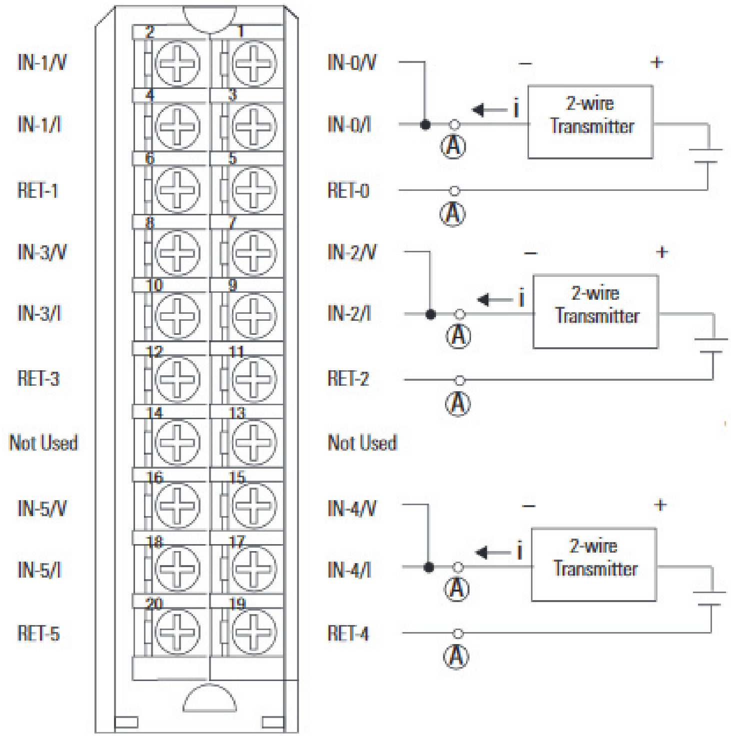

Figure 4 Connection of PT100 to 1756-IF6I [6]

5. MEASURING AND RECORDING OF TEMPERATURE

Senzors are connected to PLC, new program in RSLogix 5000software is created and heat guns are attached to the pipes. In RSLogix5000 is created new Trend [7]. It took 80 minutes to warm up the stove to maximum temperature. **Figure 5** shows temperature in dome, center and bottom during heating. Right after heating was sensor in dome moved to output of hot air from the stove and blowing was started. It took 40minutes to cool down the outlet air below 50 °C. **Figure 6** shows temperature in output, center and bottom during blowing. Data from trend are exported to a CSV file and processed in Microsoft Excel software.

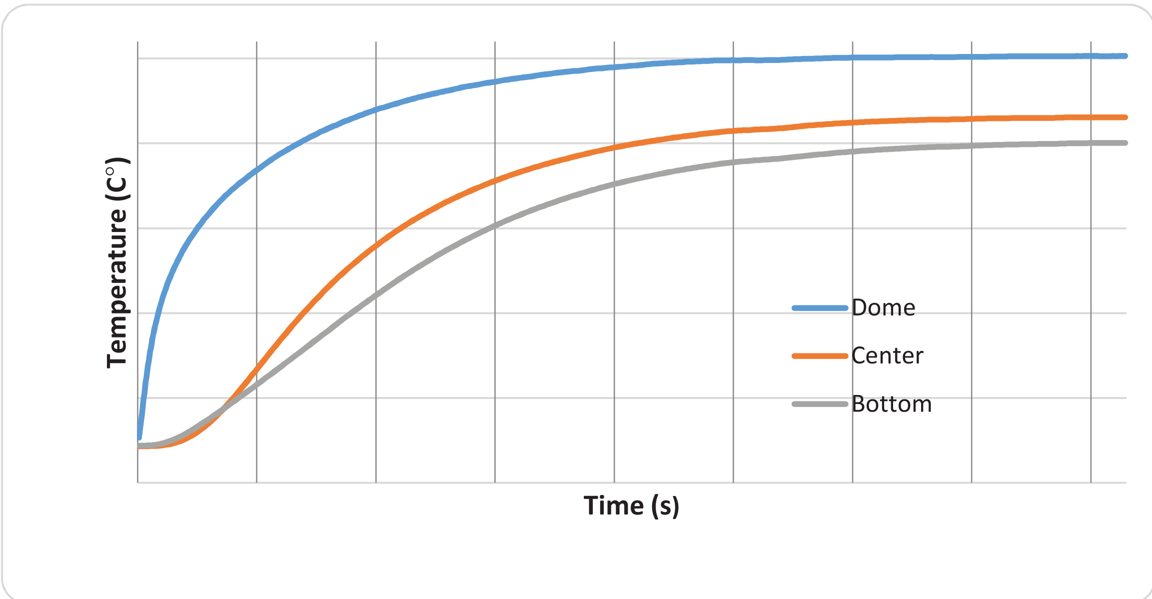

Figure 5 Heating of the hot-blast stove

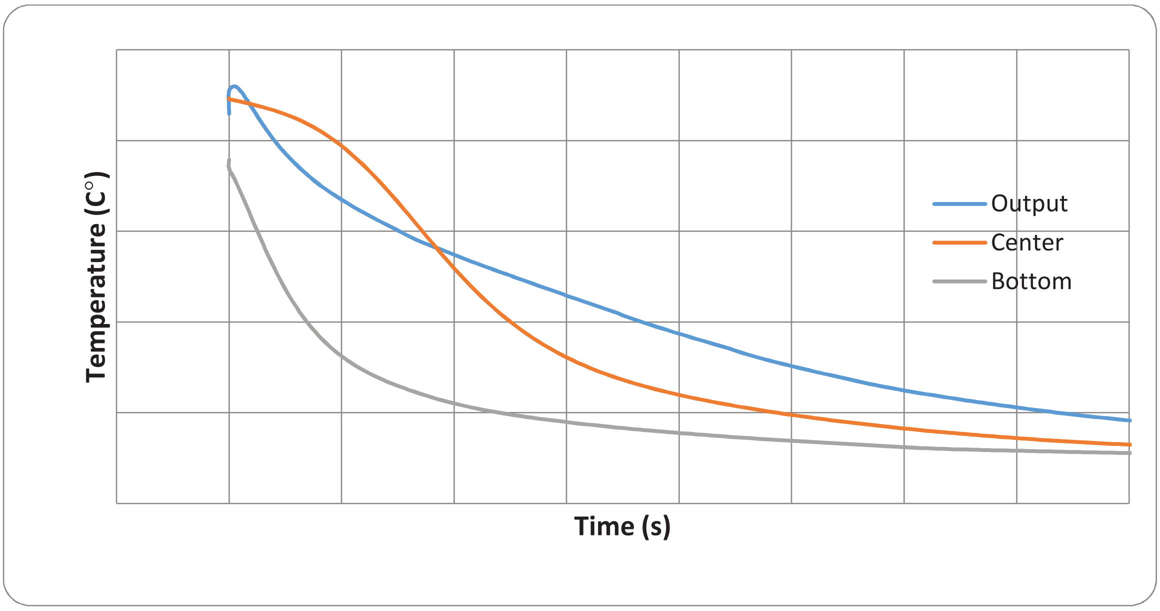

Figure 6 Blowing of the hot-blast stove

CONCLUSION

Temperature measurement was designed and realized, measured values are shown in **Figure 5** and **Figure 6**. Analog input module 1756-IF6I is well suited for measuring of temperature for physical model of hot-blast stoves, module offers multiple input ranges in both current and voltage applications. With the proposed compensation circuit is not necessary to use CPU of PLC to linearize PT100 RTD output. There are other ways how to solve linearization problem. For example1756-IR6I module offers direct conversion ohms to temperature. It is now possible to use the model for educational purposes, when the measuring procedure is created.

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