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Temperature Measurements for Industrial Applications Using Virtual Instrumentations

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***Abstract* – The paper want to present how to realize a temperature measurements system for industrial applications who could be transferred to a domestic application regard of how to automatically heating the water, from a input value (around 5 Celsius degree) until an high output value (around 60-65 Celsius degree). Heated water could be used in different industrial technological processes (heating, supply, cleaning, washing etc.), also at domestic houses or office buildings to prepare hot water. In this paper it's described a temperature monitoring system for water which circulates through an automatic heating system – tankless, who have the advantage to use a small dimensions and could be mount in narrow spaces.**

Keywords – Temperature measurements, Virtual instrumentation, Heating system

I. INTRODUCTION

In this paper it's described a temperature monitoring system for water which circulates through an automatic heating system – tankless, who have the advantage to use a small dimensions and could be mount in narrow spaces. This tankless system it's powered from a low voltage electric line single-phase or three-phase and offer flow control and possibility to heat in steps the water.The key element of this water heating system is given by the use of power resistors who could be made with a linear classic geometry or in spiral with steady or variable steps. Automatic control of heating requires to monitoring the temperature values from input-output of the water, flow values and electrical power who is consumed.

The main purpose is to maintain a higher temperature of the heated water depending on the industrial or domestic application. Coupling or decoupling of different intermediate heating steps using power resistors is made with static contactors who is built with thyristor in antiparallel or ordered triacs mounted on their grids depend on output temperature

The paper describes water measuring system using thermocouples mounted at the input, output and in the median area of power resistor depend on the water flow and electrical power used. Temperatures could be measured in stationary regime or transient regime follow to obtain a higher evolution of temperature in shortly time.

The values obtained are process by data a quisition board and the results will be appear like a virtual measure instrument who contain the charts of temperature evolution (input, output, intermediate), amperage values from power resistor and total voltage.

II. DESCRIPTION OF THE INDUSTRIAL APPLICATION – ELECTRICAL HEATER (BOILER)

The boiler operates on the pressure principle, which means in the container or tank is a permanent water pressure from the cold water installation. By opening the hot water tap, water flows from the boiler due to the water pressure in the cold water supply system. Hot water is drains through the top and cold water stays in the bottom of the heater.

After connecting the boiler to the mains, the water is heated by the electrical resistance. Disconnecting and coupling electrical resistance is controlled by the thermostat. The thermostat can be adjusted as required from 0°C to + 65°C. This temperature of max. + 55°C guarantees optimal boiler operation, minimizing heat loss and power consumption.

In case the boiler is not used for a longer period of time the thermostat must be set to about 10°C to ensure frost protection or it is recommended to empty and unplug it from the power supply.

After reaching the set temperature, the thermostat disconnects the power supply and interrupts the heating of the water.

Technical Data:

Tank capacity: 30 l;

Heating time at 65C (hours): 1,1

Static cutter for 65 ° C (kWh / 24h): 1,6
Supply voltage (V) / Current frequency (Hz): 230/50
Electrical resistance KW): 2
Maximum working pressure (bar): 6
Tank tested pressure (bars): 12
Water connection dimensions (inches): 1/2
Boiler height (mm): 880
Boiler diameter (mm): 320
Product weight Kg): 16.5
Inner tank protection: Thermal zinc
Mounting position: Vertical on wall mount brackets
Benefits:
Safety in operation due to the solution chosen for tank construction.

Keeping hot water for 24 hours due to thermal insulation. Thanks to the hot galvanizing protection, the lifetime is great, diminishing the corrosion phenomenon. It is easy to maintain and repair.

Electric boilers are cylindrical and consist of:

Tank - It is made of steel sheet, resists the pressure of 6 bar (being tested at 12 bar) and is protected from inside and outside by thermal zinc coating.

Thermal Insulation - It is made with mineral wool casted with aluminum foil.

Electrical installation - It consists of 2000W electrical resistance, thermostat (thermostat) and signaling lamp.

Outer shell (mantle) - It is made of powder-coated sheet with powder in white electrostatic field.

Boiler protection is provided by the thermoregulator and the combined safety valve adjusted to 6 bar. Electric boilers are certified according to the Low Voltage Directive. Boilers up to 100 liters are single-phase, and over 150 liters are three-phase.

The electric boiler instant is a shower water heater with two thermal resistors in the copper sheath. The temperature of the heated water depends on the inlet water temperature and the water flow rate. Working mode of the resistors: separate (e.g. in economic mode - 2kW or 3kW) or together (maximum mode - 5kW) with light signaling. The flow of heated water is adjustable from the tap, depending on the desired inlet and outlet water temperature and the selected heating level.

Technical information:
Power supply: 230V
Maximum power: 5000W
Selective work steps: 2000W, 3000W, 2000W + 3000W
Maximum temperature of heated water: 64ºC
Heating Elements: Heat-resistant electrical resistors in copper sheath and sintered insulation
Heating power: 2kW first stage / 3kW second stage

Working mode of the heating resistors: in economy mode (separately 2kW or 3kW)/in maximum mode (simultaneously 5kW); The operation of each resistor is illuminated by the LED incorporated in the corresponding control button;

Maximum temperature of heated water: 60°C, overheating: 40°C at a flow rate of 1.5 liters/min. (Maximum power output 5kW);

Minimum water pressure at the entrance of the apparatus: 0.04 MPa (0.4 bar = 4 meters water column);

Heating water flow: adjustable from the tap, depending on the desired inlet and outlet water temperature and the selected heating stage;

Degree of protection: IP 54

Protection against electric shock: Class I (all active electrical components are insulated from the water heating circuit and the manual controls of the appliance, it is provided with a protective conductor)

Protection against humidity: IP X4 (against water splash)

Functional protection: at over temperature and accidental drop in water supply flow (thermolithmizer and double-acting pressure switch)

Sanitary protection: the water heating circuit is made of sanitary approved components (not corroded and does not contain toxic components).

INSTANT BOILERS heat water directly without using a water storage enclosure. When the tap is open, cold water passes through a hose to the unit. An electrical resistance heats the water. As a result, instantaneous water heaters provide constant hot water. You do not have to wait for a tank to be filled with water and then warm up.

The accessories supplied with the appliance are sufficient for proper operation of the appliance. Depending on the cold water temperature and the heating stage used, an instant boiler can heat the water up to 40°C at a rate of 1.5 liters / minute.

III. EXPERIMENTAL DATA

This tankless system, Fig. 1, it’s powered from a low voltage electric line single-phase or three-phase and offer flow control and possibility to heat in steps the water.The key element of this water heating system is given by the use of power resistors who could be made with a linear classic geometry or in spiral with steady or variable steps.

Automatic control of heating requires to monitoring the temperature values from input-output of the water, flow values and electrical power who is consumed. The technical data related to the proposed tankless system are the following:

Cable demand: 2.5 mm^2 square
Voltage: 220V~50Hz
Rated water pressure: 0.5-0.6Mpa
Rated power:5000W
Waterproof level: IPX4
Electric shock type: 1class

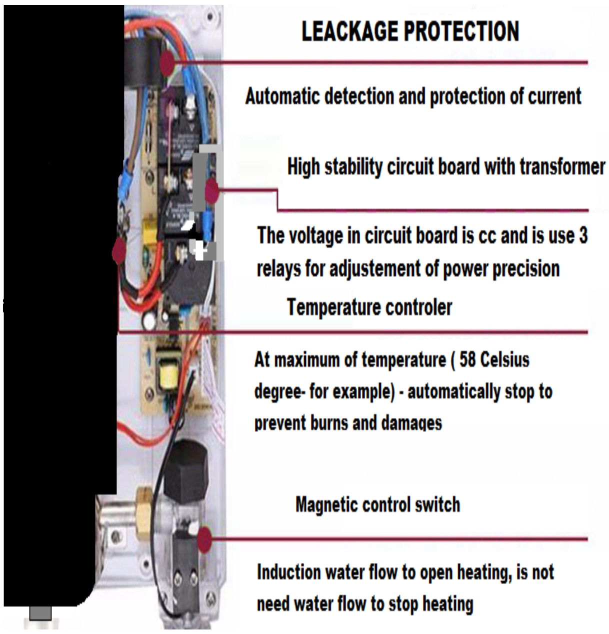


Fig. 1. Tankless system proposed

The main purpose is to maintain a higher temperature of the heated water depending on the industrial or domestic application. Coupling or decoupling of different intermediate heating steps using power resistors is made with static contactors who is built with thyristor in antiparallel or ordered triacs mounted on their grids depend on output temperature.

The paper describe water measuring system using thermocouples mounted at the input, output and in the median area of power resistor depend on the water flow and electrical power used.

Temperatures could be measured in stationary regime or transient regime follow to obtain a higher evolution of temperature in shortly time, as shown in Fig. 2. In the right side from Fig. 2 is represented current evolution temperature-time at the heating system and in the left side at the automatic heating system – tankless proposed by authors.

The values obtained are process by data aquisition board and the results will be appear like a virtual measure instrument who contain the charts of temperature evolution (input, output, intermediate), amperage values from power resistor and total voltage.

The experimental installation required to acquire the temperature values used a DAQ NI, Fig. 3, data acquisition board connected to a PC with the following features:

- analog inputs: 16 (8 differential channels), 12 bit resolution, sampling rate 250kS / s;
- analog outputs: 2, 12 bits;
- digital inputs / outputs: 8;
- counting / timers: 2, 24 bits;
- Trigger: analog, digital, start / stop;
- advanced control, PID control, built-in specific functions.

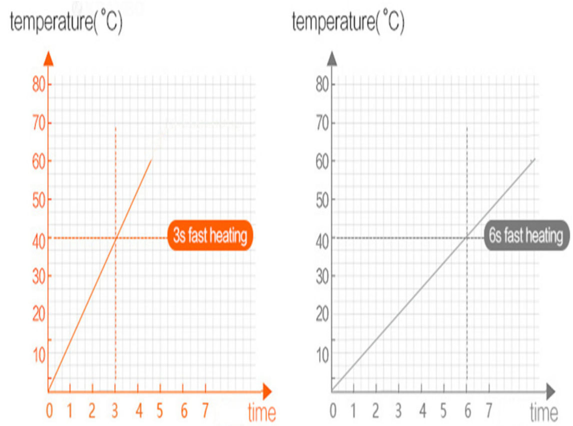


Fig. 2. Evolution of temperature vs. time in the case of existing and proposed heating system

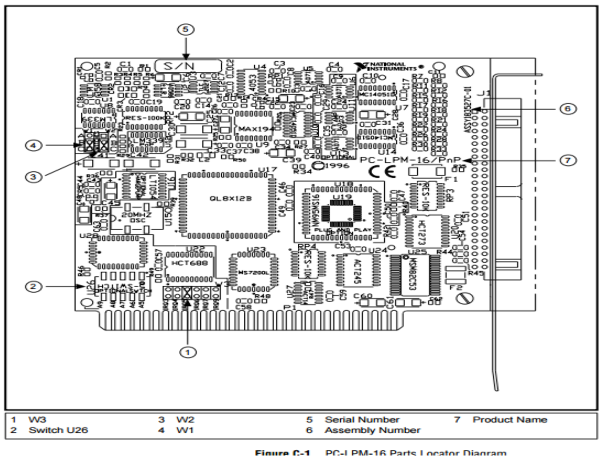
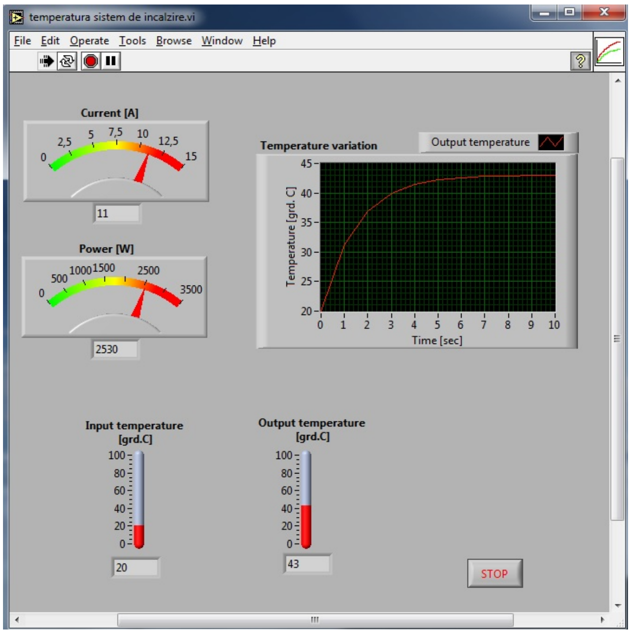


Fig. 3. Data acquisition board - main components

Such data acquisition boards are programmable using the specialized graphics programming environment, LabVIEW. In order to measure temperatures from thermocouples, an application developed in the Fig. 4.

As can be seen from the figure, the front panel allows for the measurement of the electric current passing through the power resistance, the value of the power consumed can be calculated considering the fact that the supply voltage was 230V and the values of the inlet temperatures, 20°C, and output 43°C, these being the analog inputs that must be conditional at a maximum of 10Vdc, for reasons of voltage protection of the data acquisition board. It is possible to record the temperature evolution in time, the instantaneous values being displayed on the main panel of the application, Fig. 4. The figure shows the case when a 11A current has passed through the power resistor, the power being consumed is 2530W, and after the stabilization of the transient regime, the temperature measured at the exit of the heating system for the thermal agent, the water in this case being 43°C. Heating has occurred from an initial temperature of 20°C. It can be observed that the stabilization of the



transient regime occurs after about 6...7 seconds.

Fig. 4. Application in the case of current value of 11A, power of 2530W and output temperature of 43^0C

The power resistor has passed current values of 7A, 11A, 16A, the power being consumed being 1650W, 2530W, 3820W, resulting in final water outlet temperatures of 30^0C, 36^0C, 43^0C, as shown in Fig. 5. The data are presented in the Table 1, below.

Also, it has been measured the current values which flows through the power resistor used to warm the water to be used in different industrial applications.

Table 1. Output temperatures at different values of the consumed power.

	1650W	2530W	3820W
Initial temperature [°C]	20	20	20
Output temperature - computed value [°C]	32	38	48
Output temperature - measured temperature [°C]	30	36	43

Table 2. Current values at different consumed power.

	1650W	2530W	3820W
Current - theoretical value [A]	7	11	16
Current - measured temperature [A]	7.1 7	11	16.6

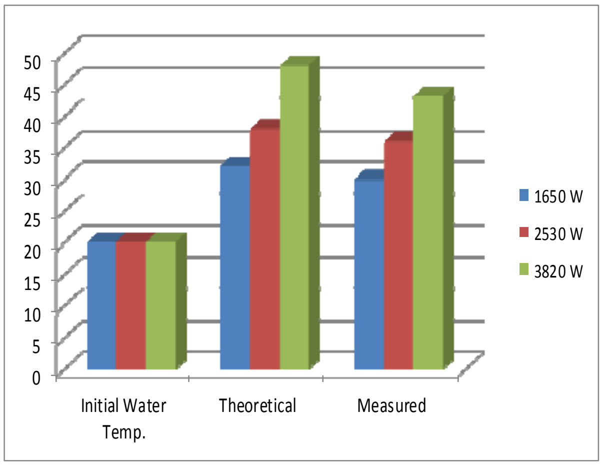


Fig. 5. Temperature values vs. consumed power

The measured current values have been compared with the theoretical ones, and the data are presented in the next table and Fig. 6.

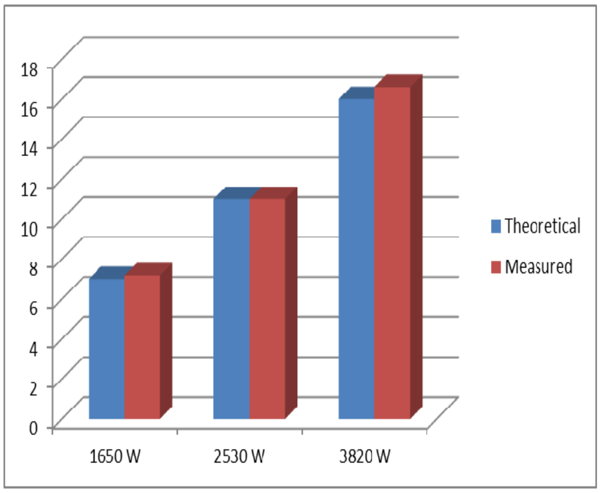


Fig. 6. Current values vs. consumed power

IV. CONCLUSIONS

From experimental data taken from the used installation that includes a heating system tankless it was possible to record water temperature values (input values and output values) corresponding to the 3 power levels.

It is noticeable as the power provided by the heating system increases, the temperatures value at output, also increase at a 55^0 C maximum for the all power produced by the system. It is considered for further research the optimization of the heating system in order to obtain the same maximum output temperature for a minimum power consumption value and it is also desirable to minimize the transient time required to warm water from ambient temperature to an optimal operating temperature. This can be done by adopting new solutions for resistive elements or increasing the efficiency by using different types of geometry for the power heating resistor, as shown in Fig. 7.

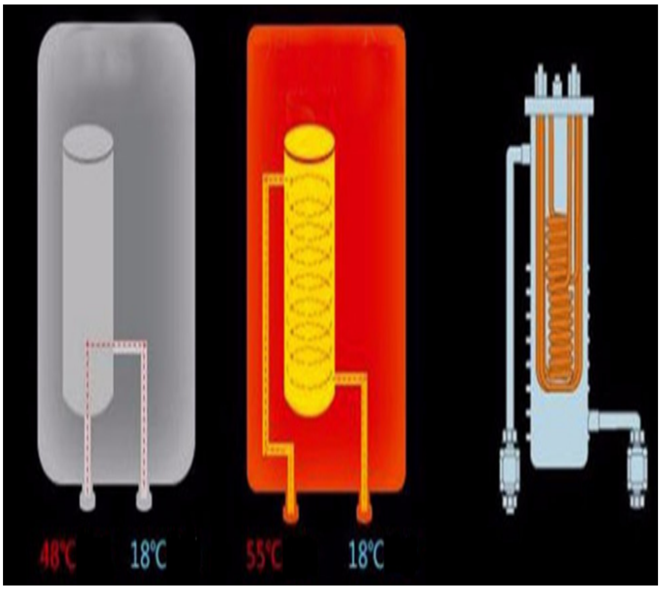


Fig. 7. Solutions using different types of power resistor

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