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THERMAL ANALYSIS OF TANKLESS HEATING SYSTEM

BY

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Abstract. The paper presents a thermal analysis of tankless heating system for industrial applications regarding of how to heat automatically the water, from an input value until a height output value. Heated water could be used in different industrial technological processes to prepare hot water. In this paper it is described an automatic heating system – tankless, which has the advantage to use a small dimensions. The main purpose is to maintain a higher temperature of the heated water depending on the different parameters (input temperature, output temperature, amperage, time, and water flow). Coupling or decoupling at different intermediate heating steps using power resistors is achieved with static contactors which are built with thyristor in antiparallel or triacs mounted on their grids depending on output temperature. Temperatures could be measured in steady-state or transient regime. One of the goals is to obtain a higher increasing of the temperature in shortly time.

Key words: resistors; heated water; temperature; electrical power.

1. Introduction

The most commonly used solutions for obtaining hot water using electricity are electrical heater (boiler) and instant boiler.

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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 (Pintilie, 2013a).

After connecting the boiler to the mains, the water is heated by the electrical resistance. Disconnecting and coupling the electrical resistance is controlled by the thermostat. The thermostat can be adjusted as required from 0 to +65°C. The 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.

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 – 2 kW or 3 kW) or together (maximum mode – 5 kW) 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.

Instant boiler heats 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 key point of our approach is the use of automatic control of the power of probe heating (Rutin *et al.*, 2017),

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.

A model of a domestic hot water electric boiler is presented by (Farooq *et al.*, 2015). An improved realization of an electric boiler considering the reliability is described in (Lyczco, 2014), by identifying the causes of failures in the boiler construction (pollution of water and surges in the electricity network).

In this paper it is described an automatic heating system – tankless, which has the advantage to use a small dimensions and could be mount in narrow spaces. The main purpose is to maintain a higher temperature of the heated water depending on the industrial or domestic application.

2. Tankless Heating System

The tankless system, Fig. 1 (Vermeersch & De Mey, 2009; Falconi, 2013; Pintilie, 2013a, 2013b), is 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 that is consumed.

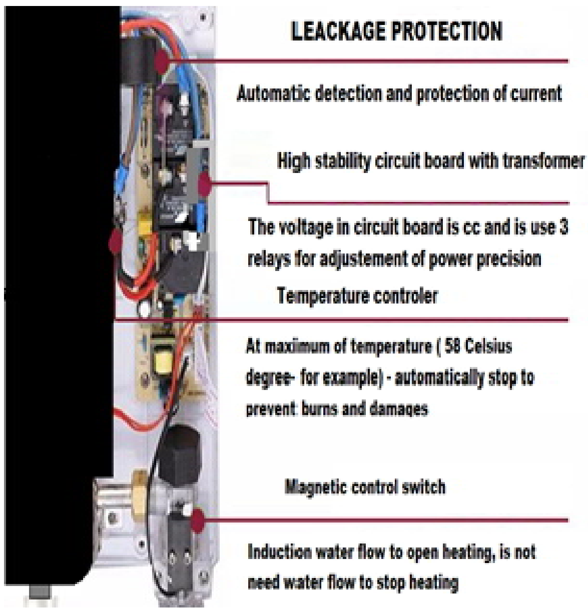

Fig. 1 – Tankless heating system.

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 are built with thyristor in antiparallel or ordered triacs mounted on their grids depend on output temperature.

The paper describes tankless heating 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 steady-state or transient regime. The goal is to obtain a higher evolution of temperature in shortly time.

Most usually solution for temperature control is to use a thermostat which also means a suitable temperature transducer. For switching on the power side, the use of thyristors is best suited to switching the network voltage to zero, to avoid disturbance. Incorporating a thyristor controlled series capacitor is very effective (Deepak *et al*., 2017).

Using 50 A thyristors, we can put them in antiparallel to use both semi-alternating. For this variant we will have to ensure the correct command of these thyristors, with high impulse currents in the gates, otherwise in time they will depreciate and trigger uncontrollably but without endangering them.

3. Experimental Tests

The experimental assembly includes four thermocouples type K, a flowmeter, ampermetric clamp and timer. For different heating steps were analysed values of temperature from input-intermediate-output, the water flow, amperage and time.

In Table 1 are presented for the water flow value of 2 litters per minute, a relative constant value of electric current about 16 A and different values for output temperatures with a maximum of 36°C how it is exposing in Fig. 2.

Table 1
Heat Step 1

t, [s]	θ input, [°C]	θ output, [°C]	*I*, [A]
0	19	20	0
5	20.3	24	16.02
10	20.6	29	16.01
15	21.2	31	16
20	21.6	33	16
25	21.8	33.4	16
30	21.83	33.9	16
40	22	34.9	16
45	22	35	16
50	22	35.11	15.94
60	22	36	15.88

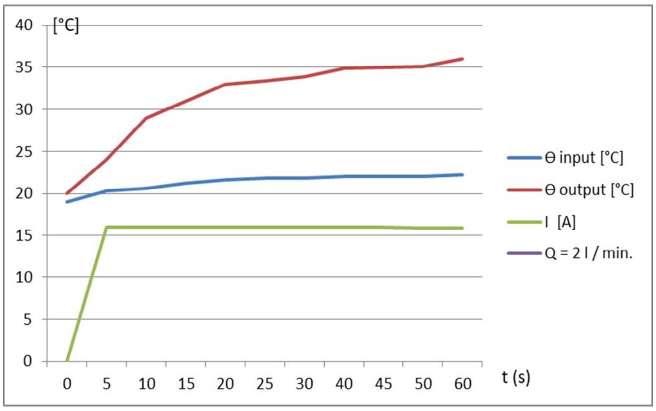

Fig. 2 – Temperature for heat step 1.

For the second heat step, in Table 2, it is used a value of water flow about 3.5 litter per minute, resulting a relative value of electric current about 15.93 A and different values for output temperatures with a maximum of 28.6°C show in Fig. 3.

Table 2
Heat Step 2

t, [s]	θ input, [°C]	θ output, [°C]	*I*, [A]
0	17.4	19	0
5	17.55	23.23	15.96
10	17.86	25.61	15.96
15	18	27	15.96
20	18.1	27.1	15.94
25	18.1	27.3	15.94
30	18.1	27.38	15.94
40	18.4	28	15.94
45	18.4	28.3	15.93
50	18.6	28.6	15.93
60	18.6	28.5	15.93

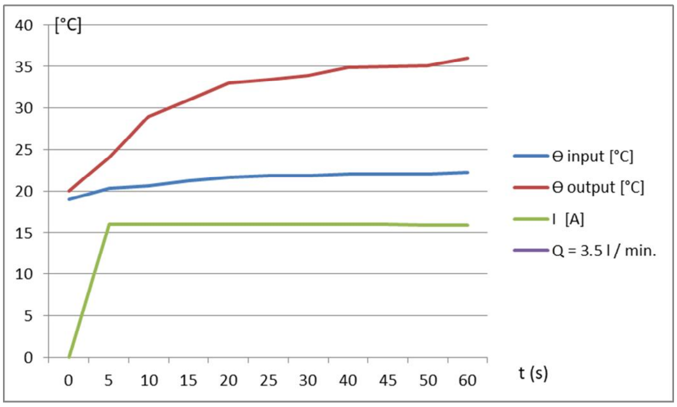

Fig. 3 ─ Temperature for heat step 2.

Table 3
Different water flow

t, [s]	θ output, [°C] *Q* = 2 l/min.	θ output, [°C] *Q* = 3.5 l/min.	θ output, [°C] *Q* = 4.3 l/min.
	I = 20.28 A	*I* = 20.35 A	*I* = 20.40 A
0	18	18	18
5	21	19	18.9
10	23	23	25
15	30	29	29
20	31	33	30
25	33	34	32
30	34.6	34	32
40	36	35	32.1
45	40	35	32.1
50	49	35	32
60	50	35	32

From this data the conclusion is for a bigger value of water flow the output temperature is smaller (Fig. 3).

For example for the same heat step but different water flow in Table 3 the value of electrical current it is approximate the same, 20.40 A.

In the Fig. 4 from 0 second to 15 seconds the tankless heating system go to a value from 18°C to 30°C, after that between 15 and 25 seconds the temperature grows to around 34°C and after that depends of the water flow.

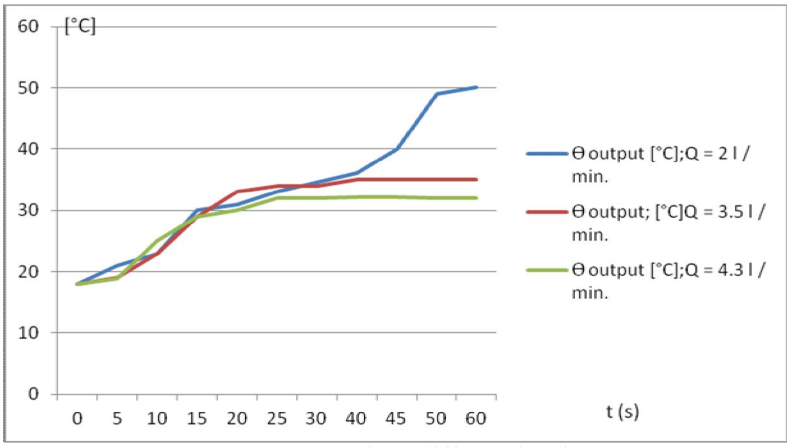

Fig. 4 – Temperature for 3 different heating steps.

4. Conclusions

Tankless heating systems that are actually used to prepare heat water for industrial or domestic domain are made with power resistors, who are coupling or decoupling at different intermediate heating steps by using power resistors. They are achieved with static contactors which are built with thyristor in antiparallel or triacs mounted on their grids depend on output temperature. From experimental data it results a value who indicates a relationship between the output temperature of the tankless heating system and the heat flow. When the water flow increase the value of output heat water decrease, the value of electrical current is constant and to improve the heating process the solution is to use another type of heating elements, another type of resistors, carbonic tapes and volcanic rocks for maintain the temperature of the heated water.

REFERENCES

Deepak M., Senapati D., Abraham R.J., *Damping of Low Frequency Oscillations in a Hydro-Thermal Power System Using Thyristor Controlled Series Compensator*, Internat. J. of Power and Energy Conversion, **8**, *1*, 1-19 (2017).

Falconi C., *Systematic Design of Micro-Resistors for Temperature Control by Quasi-Simultaneous Heating and Temperature Sensing*, Sensors and Actuators B: Chemical, **179**, 336-346 (2013).

Farooq A.A., Afram A., Schulz N., Janabi-Sharifi F., *Grey-Box Modeling of a Low Pressure Electric Boiler for Domestic Hot Water System*, Applied Thermal Engineering, **84**, 257-267 (2015).

Łyczko M., *Improving the Reliability of an Electric Central Heating Boiler*, Problemy Eksploatacji, **1**, 45-55 (2014).

Pintilie G.C., *Electrician In Energy Equipment*, Course Support, 1st Volume POSDRU PROJECT, POSDRU/108/2.3/G/79511, Title of project: Qualify, it's your chance", 2013a.

Pintilie G.C., *Electrician In Energy Equipment*, Course Support, 2nd Volume POSDRU PROJECT, POSDRU/108/2.3/G/79511, Title of project:"Qualify, it's your chance", 2013b.

Rutin B., Galkin A., Skripov V., *Returning to Classic Conditions of THW-Technique: A Device for the Constant Heating Power Mode*, Internat. J. of Heat and Mass Transfer, **115**, 769-773 (2017).

Vermeersch B., De Mey G., *Dynamic Electrothermal Simulation of Integrated Resistors at Device Level*, Microelectronics Journal, **40**, 1411-1416 (2009).

ANALIZĂ TERMICĂ A SISTEMELOR DE ÎNCĂLZIRE INSTANT

(Rezumat)

Lucrarea prezintă o analiză termică a sistemului de încălzire fără rezervor pentru aplicaţii industriale privind modul în care se încălzeşte automat apa, de la o valoare de intrare până la o valoare de ieşire ridicată. Apa încălzită ar putea fi utilizată în diverse procese tehnologice industriale pentru prepararea apei calde. În această lucrare este descris un sistem automat de încălzire – fără rezervor (instant), care are avantajul de a avea dimensiuni mici. Scopul principal este menţinerea unei temperaturi mai ridicate a apei încălzite în funcţie de parametrii diferiţi (temperatura de intrare, temperatura de ieşire, amperajul, timpul şi debitul de apă). Cuplarea sau decuplarea la diferite trepte de încălzire intermediare folosind rezistenţe de putere se realizează cu contactori statici care sunt construiţi cu tiristor în antiparalel sau triacuri montate în diferite puncte în funcţie de temperatura de ieşire. Temperaturile pot fi măsurate în regim normal sau în regim tranzitoriu. Unul dintre obiective este obţinerea unei creşteri a temperaturii în cel mai scurt timp.