SOLUTIONS AND MODERNIZATION OF HEATING FURNACE INDUSTRY STEEL MATERIALS

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Abstract : This paper presents various solutions used in upgrading the heating furnace and results in reducing specific fuel consumption, reduce emissions pollutant increase technological performance. Also, modernization solutions are applied to a furnace forges metal materials industry, the conditions tn it will work for the achievement of thermal processes:

- use ceramic fiber;

- the use of advanced pulse burning;

- a facility use automation to meet the technological requirements and environmental energy, provided with a PC.

To forge furnace in the two cases analyzed, modernized and upgraded to create a mathematical model for performing energy balances.

The mathematical model developed was implemented in a Microsoft Excel program with the author that have been prepared using data obtained from thermal balance measurements of forging furnace before and after modernization. By comparing data from the program emphasizes increasing energy and technological performances of forging furnace under study after modernization.

The experimental results obtained in the operation of this oven upgraded without running the air preheater, are presented in the paper, along with overviews of the cabinet and the various installation made.

Keywords: modernization, oven, hot.

1. INTRODUCTION.

Metallic materials industry is a major branches consuming energy, most of which is required in the form of heat.

Efficient use of energy in metallurgy is not a simple problem due to high production capacities of industrial facilities, and because of the complexity of processes taking place. Because natural energy resources are depleting and increasingly expensive, their use should be re-saving measures, waste reduction, modernization of facilities and energy technologies.

Among the major energy consuming sectors important metallic materials industry include heating the ovens.

On the national level and on the world to reduce energy consumption of heating furnaces and to improve their technological performance in the following measures, grouped into two categories in terms of investment: 1. Measures that do not require investment in learning:

• operation with optimal productivity for which energy consumption is minimal;

• Drawing diagrams, heat treatments, in accordance with the established technology;

• operation with minimum coefficient of excess air furnace

• track performance so that openings so as to be opened on shorter time periods.

2. Measures requiring investment:

• replacement of thermal insulation based on solid masonry using bricks refractory ceramic fiber-based materials [1].

• replacement of burners performing combustion plant with the boost, allowing operation at excess air ratios lower in terms of reducing emissions of pollutants;

• use a facility which meets the requirements of automation technology, energy and environmental, equipped with a PC

• The introduction of air or preheater its modernization, so as to obtain air temperatures increased by preheating combustion of biogas, respectively, if applicable

• introduction of a Gas-dynamic sealing the openings of the oven work.

Since heating furnaces are energy-intensive facilities with high fuel consumption and reduced efficiency, it was a more detailed analysis of opportunities to improve operating conditions using modern technologies.

2. REPLACEMENT THERMAL INSULATION SYSTEMS BASED ON SOLID BRICK MASONRY REFRACTORY THERMAL

PROTECTION SYSTEMS MATERIALS WITH CERAMIC FIBERS.

Replacement of thermal insulation systems based on heating stoves massive brick masonry refractory insulation system that uses ceramic fiber material has become a priority in all areas of activity where these furnaces are used because of the advantages of using materials based ceramic fiber.

Advantages and disadvantages of using ceramic fiber materials are to traditional ones [2, 3]:
Advantages:
• Very low thermal conductivity, which allows a very good thermal insulation of ovens, top of all the materials used so far;
• extreme density low, providing a very small mass of refractory linings;
• exceptional resistance to thermal shock, high or any other dense insulating refractory products;
• very good resistance to vibration;
• very high flexibility and elasticity;
• Do not store heat in its mass, thereby eliminating heat loss through the accumulation batch ovens;
• Thermal resistance to high temperatures (even up to 1650oC fiber with high percentage of ZrO2)
• low cost labor to the assembly because of their ease of transport, handling and commissioning work
• The long life and very rapid depreciation costs (4 - 12 months).
Disadvantages:
• can not be used in direct contact with molten metal because of their fibrous and porous structure;
• low resistance to mechanical shock and can not be used to line furnaces fireplaces;
• low resistance net-reducing atmospheres at high temperatures and highly alkaline;
• Ceramic fiber surface is not even at high temperatures radiating characteristics, so alternatives are explored the plating solutions reflective fiber;
• relatively high purchase price.

Heating furnace which will be referred to in this paper is a forging furnace metallic materials used in industry and will be subject to modernize in order to reduce specific fuel consumption, reduce emissions of pollutants and increasing technological performance. The forging furnace can function as a heat treatment furnace. Maximum internal temperature of the refractory lining is 1250 ° C and maximum temperature of the metal outer shell side walls corresponding area is 250 °. Maximum and minimum canopy temperatures are 1250 ° C 385 ° C respectively.

The effective area of the hearth is 1.15m^2. Side wall construction is made of two layers of refractory brick as follows:
• making diatomite brick exterior wall thickness of 0.1m;
• making firebrick inside a wall thickness of 0.23m.

The vault is constructed of a single layer of firebrick with 0.23m thick.

Density of heat flow that goes through the furnace lining is calculated with [4];

$$q = \frac{t_{\text{int}} - t_{ext}}{\sum \frac{\delta}{\lambda}}, \text{ W/m2} \qquad (1)$$

where:
• t_{int} - the internal temperature of refractory lining, ^oC;
• t_{ext} - the outside temperature refractory lining, ^oC;
• δ - thickness making up each layer of masonry lining, m;
• λ - the coefficient of heat transfer by thermal conductivity, W / m °C.

Heat flux density crossing the furnace lining the side walls is W/m^2 heat flux density crossing the arch of the oven side walls is W/m^2

Forging furnace modernization provides the first point system replacing traditional thermal oven is equipped with a more efficient thermal insulation materials based on ceramic fiber composition have.

He opted for the use of fiberglass mats for padding and the side walls of the vault where the heat transfer coefficient is between 0.2 and 0.4 W / m ° C [4].

The design results are outside of the shell requires that the temperature does not exceed outside walls of 50^{o}C and the vault to be 80 °C.

Given that three TEMIC flow densities have the same values as those calculated for the modernized furnace, we can calculate the thickness of ceramic fiber mats using equation (1) the minimum thickness of the mattress where the extract, „ $\delta_{\min}$ '':

$$\delta_{\min} = \frac{\left(t_{\text{int}} - t_{ext}\right) \cdot \lambda}{q}, \text{ m} \qquad (2)$$

For Forging the side walls of the oven:

$$\delta_{\min} = \frac{(1250 - 50) \cdot 0.4}{1562.5} = 0.307 \text{ m}$$

the canopy forge furnace:

$$\delta_{\min} = \frac{(1250 - 80) \cdot 0.4}{4362.6} = 0.107 \text{ m}$$

Following calculations shows that the sidewall thickness decreases from 0.33m to 0.307m, while the vault of 0.23m to 0.107m, which leads to weight reduction and lower oven location its space.

Forging furnace has a batch mode operation. Because of this heat accumulated in the oven side walls and vault adversely affect optimal thermal balance of the oven. In what follows we calculate the heat accumulated in the walls and vault its oven before and after upgrading to highlight the fuel savings that is realized by replacing conventional masonry, ceramic fiber mats. Ceramic fiber mats are used DUALFLEX PRISMO RX3 type and have the following technical data:

• Reference temperature: 1550 ° C.
• Start by soaking temperature: 1740 ° C.
• Density: 210 kg/m3. • Thermal Conductivity: 0.18 ... 0.4 W / mK.
• Linear shrinkage: <3% (1450 ° C, 24 h).
• The temperature on the caldă/rece1250 º C / 80 ° C.

Q_{ac} - accumulated heat masonry oven side walls and the vault is calculated with the equation [7]:

$$Q_{ac} = \frac{\Sigma VZ_i \cdot GZ_i \cdot CPZ_i \cdot \left(TZF_i - TZI_i\right)}{PP \cdot t_{inc}} \text{ [kJ / t]. (3)}$$

where:

VZi [m^3] - volume of the layer of masonry side walls and dome of the oven;
GZi [kg/m^3] - density layer of masonry side walls and dome of the oven;
CPZi [kcal / kg ° C] - layer average specific heat masonry vault and side walls of the oven;
TZIi [° C] - average temperature of the layer of masonry vault and side walls of the oven at the beginning of burden;
TZFi [° C] - average temperature of the layer masonry vault and side walls of the oven at the end cast,
PP - furnace productivity (t / h)
t_{inc} - the total heating of the cast (h).

For oven unmodernized:
Q'_{ac} = 163,608.47 kJ / T
modernized furnace:
Q_{ac} = 20774.3 kJ / t

of heat accumulated difference side walls and vault for the two cases furnaces oven and microwave modernized modernized,' ΔQ_{AC} will calculate the relationship:

$\Delta Q_{AC} = Q'_{ac} - Q_{ac}$, [kJ / t] (4)

Substituting Q'_{ac} and Q_{ac} with previously obtained values we obtain:

Δ QAC = 142,834.1 kJ / t

3. AUTOMATION MODERNIZATION AND INSTALLATION OF HEATING COMBUSTION OVEN.

Modernization and automation of plant burning oven is heating to replace old fuel burners consuming more ultimate performance, with superior energy performance compared to the furnace replaced and provide an automatic driving system.

To equip new furnace burners are burning forge PYRONICS pulse, 601 nm with a consumption-type zone ea 25 Nm^3 / h, compared to old ones, which together had an average consumption of 85Nm^3 / h. Figure 1. pulse is presented PYRONICS burner, type 601 NM. Value measured for oven exhaust emissions is upgraded to 60mg/m^3N CO maximum value of the 100mg/m^3N legislation and 150 for NO_2 mg/m^3N to maximum effect permitted by law 350mg/m^3N . Value measured for oven exhaust emissions have modernized mg/m^3N values for CO and 230 to 485 mg/m^3N for NO_2.

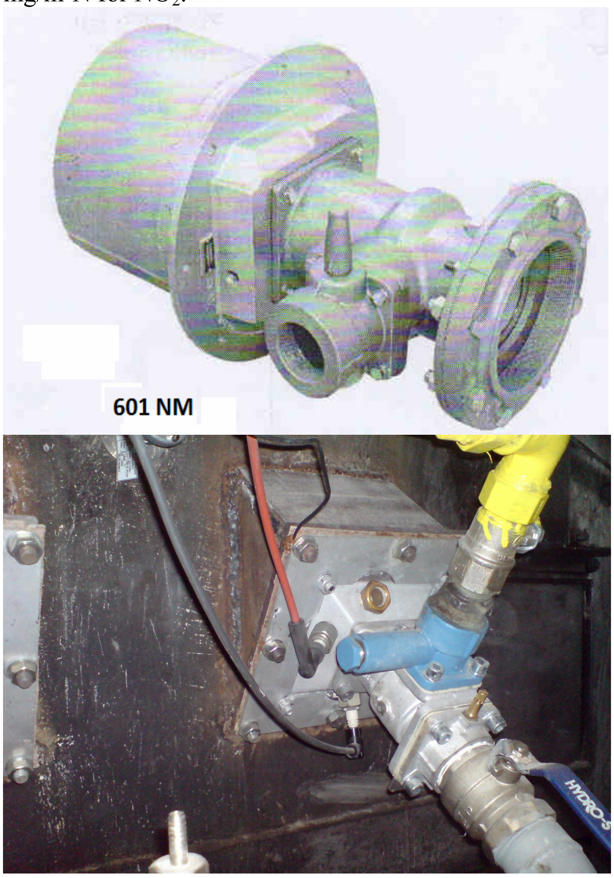


Figure 1. PYRONICS pulse burner type 601 NM

The advantages of these burners are:
- very good flame stability throughout the adjustment
- power burners can vary between 10-100% capacity, if the air
-fuel ratio is varied in proportion compared with a regulator
- each burner is provided the aperture of the gas jet assembly can develop speed. Aperture also cast refractory materials can withstand temperatures up to 1750°C developed flame .
- ignition burners is achieved via a mounted ignition electrode on the side burner, as shown below. In the picture, mounted vertically, it is noted electrodes aimed ionization flame detection products based on blood electromotors combustion gases.
Laterally mounted ignition
- very low level of NO_2 in the flue gas due to a very good mixture of gas and combustion air, as ambrazurii ensure complete combustion of the mixture - in such a capacity and 250 kW burner direct light is not necessary for pilot burner ignition
- No flame formation takes place at the entrance to taper ambrazurii refractory, such as the body burner operating at full load, the body of the burner, combustion air is cooled

Automation for forging furnace was designed so as to ensure the functioning and performance burners parameters imposed by adhering ISCIR C 39-83.
Automatic driving system for forging furnace out the following functions:
• preventilation;
• ignition and flame monitoring UV cell;
• Continuous adjustment of the load while maintaining constant air-fuel ratio;
• stable operation of the burners in the minimum-maximum;
• measurement and indication of functional parameters;
• automatic management of the combustion process by using a temperature controller programmer quality and reliability.

Schematic diagram of an automatic driving system for furnace combustion zone is shown in Figure 2.

Composed of: Ball Valves (VS) that are designed to ensure natural gas supply interruption landfill gas components and the burners and make fine tuning of the latter is put into operation or during the operation, function needs of the forging process.

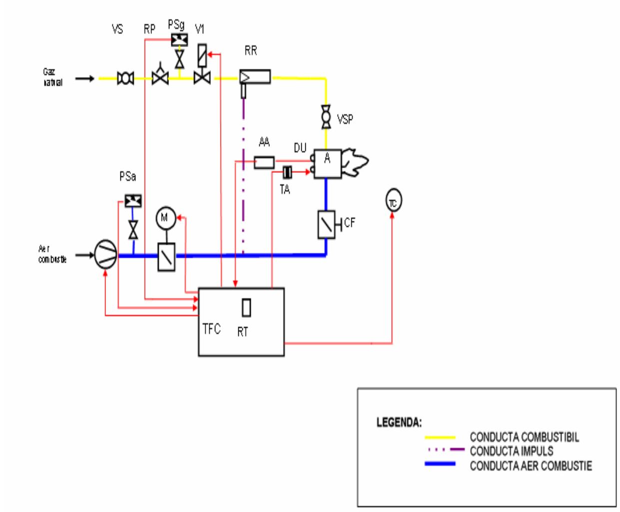


Figure 2. Schematic diagram of the automated installation of flue

The pressure regulator (PR) is a direct drive set off membrane and sealed by a line at zero flow.
Pressure at the outlet of the pressure is kept constant and equal to the adjusted line pressure regardless of fluctuations which occur in upstream gas pressure regulator.
The value of output pressure can be adjusted in a range of 18-55 mbar. Switch gas / air (PSG, PSA) provide permission flash program only when there is a minimum pressure of natural gas and air power and firing the burner failure of this condition during operation.

Minimum pressure value can be adjusted via a button provided with scale adjustment for reading the gas pressure switch adjusted value and for setting air pressure switch can be done via a set screw mounted inside the pressure switch.
Electromagnetic valve (V1) is an electromagnetic drive valve, slow opening and closing fast.
Air-to-gas regulator (RR) type 12 bzr mark Pyronics ESA aims to maintain a constant air-fuel ratio to the amount prescribed (set mechanically via a spring mounted inside the controller) by changing the pressure for varying gas pressure air change before the regulator through an outlet pressure that receives the signal from the air duct.
Butterfly damper for air (M) type 24 EBV-CMAP mark ESA - Pyronics is driven by an actuator that provides precise adjustment of throttle position between 0 and 90 º. Butterfly valve actuator acting through a metal rod. Actuator control is achieved by a temperature controller mounted on the switchboard front panel power and control (TFC).

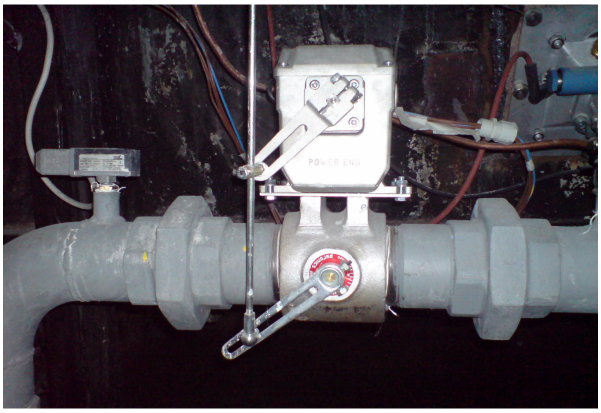


Figure 3. Overall view of the air damper and actuator controller and temperature (RT) read the temperature inside the oven, sent by the thermocouple (TC) masonry oven mounted between the two burners of the furnace to 12 cm.

Depending on the temperature you set it so opened or closed to control air actuator. The column of air, before air into burner ball valves are mounted manually adjustable combustion air. They are necessary for individual adjustment of each burner and adjust the quality of combustion in the furnace. Coarse adjustment of combustion air is achieved by the butterfly valve and fine adjustment is achieved by the ball valves of air into the burners.

By varying the air control actuator air pressure air supply pipe to the burners. If oven temperature is higher than the set value then the command controller will be closing damper. By closing the throttle to reduce the air pressure downstream of the valve.

Pulse pressure regulator over the air-fuel ratio will cause a membrane regulator of pressure on smaller, resulting in a decrease in the volume of gas, so a pressure drop in pipeline gas supply to the burner. This (a corresponding decrease in gas pressure and air) causes the flame length to decrease (weakening of the burner) so will reduce the oven temperature. Reverse process (ie open damper will cause an increase in temperature in the oven.

Gas Burners (A) was equipped with oven are of NM 601 Pyronics mark with a power of 250 kW / burner (up to 280 kW) at a gas consumption approx. 25 Nm^3 / h. The total installed capacity is 500kW on the oven.

Temperature controller (RT) is a PID controller (proportional, Integral, Derivative) 15 FCR model R / M MA fitted with a programmable fuzzy logic SHINKO brand.

Temperature controller is equipped with two displays - PV display to indicate the amount of process and SV display - the size indicating the amount to be adjusted. The controller takes the temperature information from the thermocouple mounted between the two burners, comparing the measured value (shown in minutes) with the process set value (SV) and air sevomotor command to open or close the butterfly valve according to the difference between the two values temperature.

Combustion machine (AA1, Aa2) is an electronic control and monitoring of operation of the burners.

Burning machines are model C Pyronics estrogen and ensure achievement of the following functions: - preventilation combustion chamber - ignition transformer control and opening gas solenoid - flame monitoring by ion electrode - indicating officials burners - depending on the flame length The ionization current signal recorded by light (LED GUP) - controlled operations steps alphanumeric signs - signs of damages and specify its type - manual reset of the state of emergency; estrogen automaton C is for combustion ignition burners directly (without pilot burner) with a single solenoid control and continuous monitoring of gas combustion.

Picture of power and control (TFC) provides supervision and control of the entire process. It contains elements of force (contactors, fuses, thermal relays, etc..) Associated control and protection management system automatically operating on natural gas.

A view of the landfill gas forge kiln is shown in Figure 4

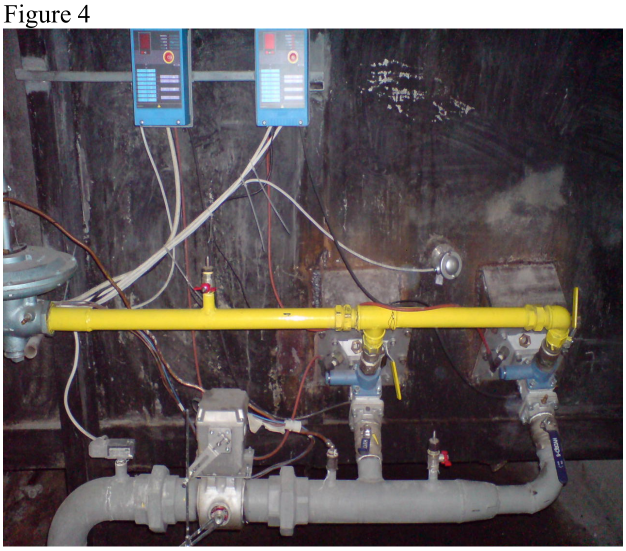


Figure 4. Overview of the landfill gas

4. EXPERIMENTAL RESULTS

The values of physical quantities, the values of thermophysical quantities and values of thermodynamic quantities obtained by forging furnace measurements before and after modernization

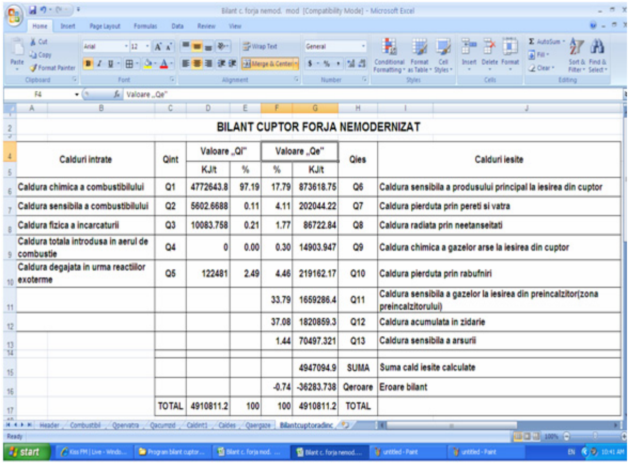
modernization were introduced in the newly created computer program to determine optimal thermal balance. Qi heat in the heat balance is the amount of heat the following:

Q1 - Chemical heat of fuel,
Q2 - heat sensitive fuel,
Q3 - physical heat load,
Q4 - total heat introduced into the combustion air;
Q5 - heat from exothermic reactions .

Qe extraordinary thermal heat balance is the sum of heat:

Q6 - the main product is heat sensitive out of the oven;
Q7 - heat lost through walls and fireplace;
Q8 - radiant heat through leaks,
Q9 - chemical heat of flue gases out of the oven ,
Q10 - heat lost through outbursts,
Q11 - heat sensitive gas out of the preheater (the preheater)
Q12 - heat accumulated in masonry,
Q13 - sensible heat of the burn.

Figure 5 is shown the graphical user interface, implemented in EXCEL, the heat balance for forging furnace modernized, and in Figures 6 and 7 are plotted the components of heat input and output for the same oven.



BILANT CUPTOR FORJA NEMODERNIZAT

Calduri intrate	Qint	Valoare „Qi" KJ/t	Valoare „Qi" %	Valoare „Qe" %	Valoare „Qe" KJ/t	Qies	Calduri iesite
Caldura chimica a combustibilului	Q1	4772643.8	97.19	17.79	873618.75	Q6	Caldura sensibila a produsului principal la iesirea din cuptor
Caldura sensibila a combustibilului	Q2	5602.6688	0.11	4.11	202044.22	Q7	Caldura pierduta prin pereti si vatra
Caldura fizica a incarcaturii	Q3	10083.758	0.21	1.77	86722.84	Q8	Caldura radiata prin neetanseitati
Caldura totala introdusa in aerul de combustie	Q4	0	0.00	0.30	14903.947	Q9	Caldura chimica a gazelor arse la iesirea din cuptor
Caldura degajata in urma reactiilor exoterme	Q5	122481	2.49	4.46	219162.17	Q10	Caldura pierduta prin rabufniri
				33.79	1659286.4	Q11	Caldura sensibila a gazelor la iesirea din preincalzitor(zona preincalzitorului)
				37.08	1820859.3	Q12	Caldura acumulata in zidarie
				1.44	70497.321	Q13	Caldura sensibila a arsurii
					4947094.9	SUMA	Suma cald iesite calculate
				-0.74	-36283.738	Qeroare	Eroare bilant
	TOTAL	4910811.2	100	100	4910811.2	TOTAL	

Figure 5. Graphical interface, implemented in EXCEL, the heat balance for forging furnace modernized.

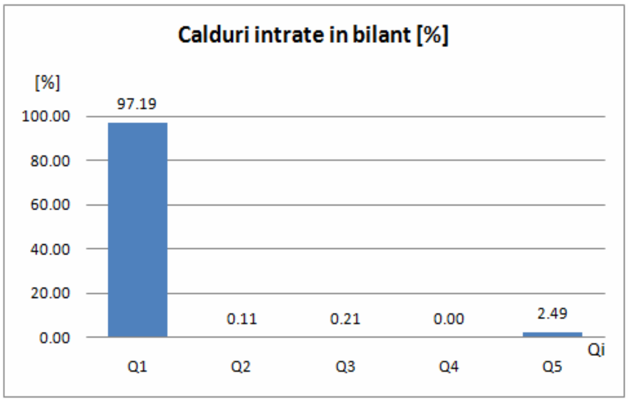


Figure 6. Heat between the heat balance for forging furnace modernized.

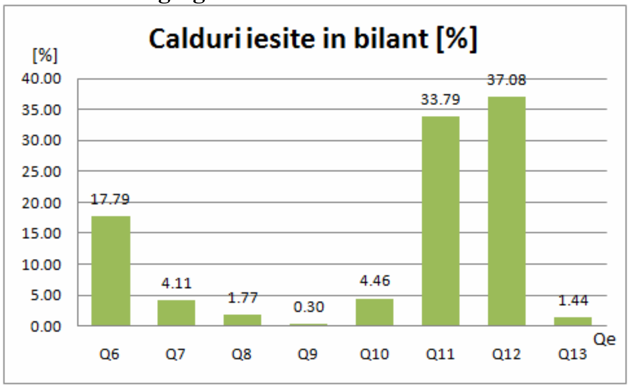
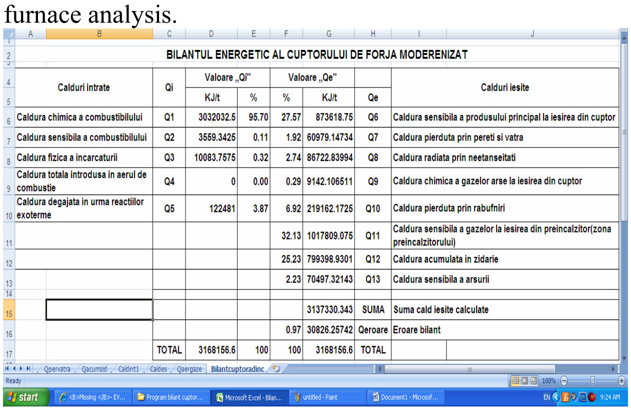


Figure 7. Heat oven out of thermal balance of forging modernized.

Figure 8 is shown the graphical user interface, implemented in EXCEL, the heat balance for forging furnace modernized, and in Figures 9 and 10 are plotted heat input and output components for the furnace analysis.



BILANTUL ENERGETIC AL CUPTORULUI DE FORJA MODERENIZAT

Calduri intrate	Qi	Valoare „Qi" KJ/t	Valoare „Qi" %	Valoare „Qe" %	Valoare „Qe" KJ/t	Qe	Calduri iesite
Caldura chimica a combustibilului	Q1	3032032.5	95.70	27.57	873618.75	Q6	Caldura sensibila a produsului principal la iesirea din cuptor
Caldura sensibila a combustibilului	Q2	3559.3425	0.11	1.92	60979.14734	Q7	Caldura pierduta prin pereti si vatra
Caldura fizica a incarcaturii	Q3	10083.7575	0.32	2.74	86722.83994	Q8	Caldura radiata prin neetanseitati
Caldura totala introdusa in aerul de combustie	Q4	0	0.00	0.29	9142.106511	Q9	Caldura chimica a gazelor arse la iesirea din cuptor
Caldura degajata in urma reactiilor exoterme	Q5	122481	3.87	6.92	219162.1725	Q10	Caldura pierduta prin rabufniri
				32.13	1017809.075	Q11	Caldura sensibila a gazelor la iesirea din preincalzitor(zona preincalzitorului)
				25.23	799398.9301	Q12	Caldura acumulata in zidarie
				2.23	70497.32143	Q13	Caldura sensibila a arsurii
					3137330.343	SUMA	Suma cald iesite calculate
				0.97	30826.25742	Qeroare	Eroare bilant
	TOTAL	3168156.6	100	100	3168156.6	TOTAL	

Figure 8. Graphical interface, implemented in EXCEL, the heat balance for forging furnace upgraded.

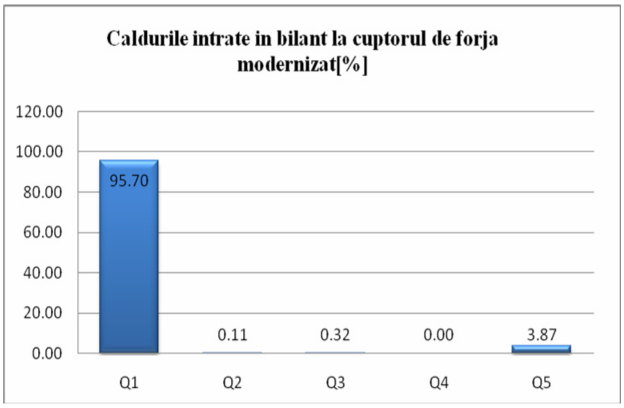


Figure 9. Heat between the heat balance for forging furnace upgraded.

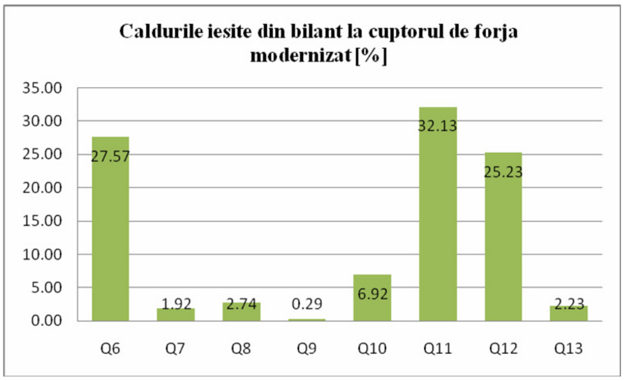


Figure 10. Heat output from the thermal balance forge furnace upgraded.

Forging furnace modernization effects can be seen better in the graphs in Figures 11 and 12 which are shown by comparing heats of entry and exit from the heat balance for both furnace forge for the modernized and upgraded.

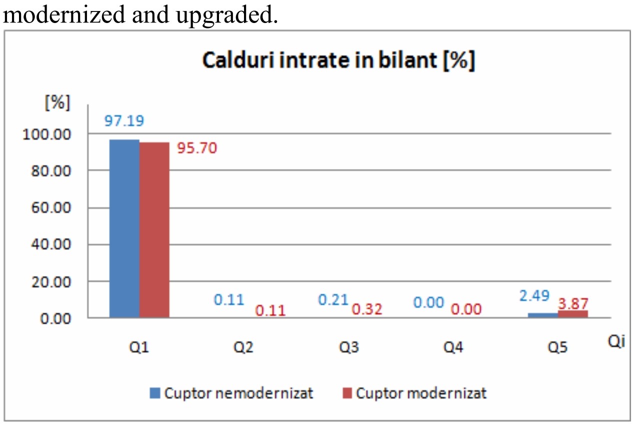
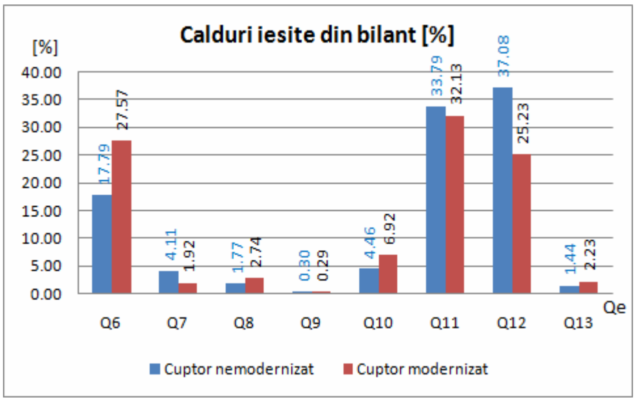


Figure 11. The balance sheet for the oven heat between modernized and upgraded.



5. CONCLUSIONS

• Review the operation of a forge furnace modernization before and after modernization.
• The analysis was based on comparison of thermal balance sheets prepared by forging furnace before and after modernization. Heat balances were obtained by creating a mathematical model has been implemented in a Microsoft Excel program that have entered the data obtained from measurements made on forging furnace modernized and upgraded.
• By comparing the data obtained by running the program for the two situations can be seen that the use of ceramic fiber mats reduces the amount of heat stored in the masonry Q12 30%, which increases the sensible heat of the main product out of the oven all Q6 30 %.
• Replacing old burners with pulse PYRONICS NM 601 and combustion control unit led to the following effect:
- Reduce consumption by 35% fuel schedule.
- Shortening the time required to cast 4.5h 8h at a rate of 40%.
- The amount of CO and NO2 emitted pollutants are well below the amount allowed by law.
- Increase the safety of operation.

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