PERFORMANCE ENHANCEMENT TYPE CHAMBER HEATING FURNACES BY EQUIPPING THEM WITH THE NEW AIR PREHEATER RADIATION PAR-MD

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Abstract*.This paper presents a new type of air preheater radiation PAR-MD equipping room type heating furnaces metal materials industry increased efficiency with which a forging furnace found in equipment, thermo technological Laboratory Aggregates " within FIMMR - Valahia University of Targoviste. Preheater radiation PAR-MD is basically a combination of a preheater radiation fins arranged in a spiral metal and radiation type preheater kiln clepsydra. Equipped forge this type of air preheater radiation resulted in decreasing heating time of the blank and emissions.*

Keywords: *Air preheater radiation heating furnace, Energy balance, heating time, NOx emissions.*

1. INTRODUCTION

In the context of general actions to optimize the specific energy consumption, special attention is given by the steel secondary energy recovery. An important secondary energy source is the natural heat of the exhaust gas evacuated from the heating furnace. These furnaces working at temperatures between 700 - 1400 ° C and heat for preforms future hot deformation.

The most frequent heating furnaces are [1]:

- Hearth furnaces with fixed room;
- Hearth furnaces with room mobile;
- Stepped hearth furnaces;
- Propulsion furnaces;
- Deepest heating furnaces;
- Rotational hearth furnaces stepped.

Exhaust flue gas temperature can achieve temperatures up to 1450 ° C.

Because higher heat losses principally owed to physical heat of exhaust flue gas, furnaces heating efficiency more than 30% and fuel consumption coefficient is between 15-60% [2].

Heat recovery from exhaust flue gas physical heating furnaces can be made in technological direction and energy direction. Recovery technological direction is made by preheating the combustion air by preheating the fuel gas with low calorific value and preheating preforms with ventilator that takes the flue gas after air preheater and send it through some nozzles arranged equidistantly, are obtained speeds of 80 m / s, the cast surface. Recovering energy direction results in the production of heat, usually in the form of steam [3].

Table 1 [4,5] are given roots in key categories of used heat recovery for preheating combustion air with the temperature range of flue gas that can be used.

Table 1. Main heat recovery types used for preheating the combustion air.

Heat recovery		Temperature ranges of the flue gas	Temperatures of the preheated air
Convection recovery	-With plain steel tubes -With acicular prominences	• 400-900 °C • 500-800 °C	• 200-600 °C • 300-450 °C
Thermo-bloc recovery		700-1150 °C	220-450 °C
Radiation recovery		800-1600 °C	500-800 °C
Mixed recovery		700-1200 °C	500-700 °C

Taking into account low thermal efficiency of heating furnaces, recovery should be made in the technological direction by higher recovery performance, the combustion air to warm to temperatures as high. The integrated steel works, where heating furnaces are supplied with combustible waste gases with low calorific value (mixed with blast furnace gas, coke furnaces gas or natural gas), their preheating becomes economically interesting in special preheaters, located after those combustion air. Preheating the preforms solution is rarely used because of high investment [4].

Lately, most of those engaged in the study of exhaust flue gas heat recovery heat treatment furnace, have reached a common denominator, namely that this recovery is not a collateral part of the technological process itself and must be treated simultaneously with it. For the purposes of this statement, it was found that the heat treatment furnace design take into account the weight of flue gas and heat oven with the delivery itself is also supplied and recovery solution (if I studied recovery of radiation).

To reduce losses by sensible heat of combustion is used, mainly, for heat recovery preheating combustion air preheating or material (batch). Recovery performance currently used are quite weak, the low recovery and intense degradation during operation. Therefore modernization trends recuperators were to obtain high temperature air preheating and / or combustible gases, simple construction to be energy efficient and low cost price.

Most times these objectives required by the recovery may not meet a common ground because, for example high temperature preheating leads to increasing surface heat exchange, so increasing the price of investment (for each 100 º C increase in temperature air preheating is necessary to double heat transfer surface). Also, increasing the preheat temperature increases the temperature to which they are subject to various components of the system, increasing the risk areas most requested destruction of thermally. Another drawback is the mechanical tensions faced by equipment, because appearance different thermal expansion of component parts.

Heat recovery systems are heat transfer equipment that transmit heat from one environment to another by contact with the wall separating the different faces. Heat transfer between the two areas is the wall that separates them. Heat transfer always occurs, the second principle of thermodynamics, the hotter medium in the cold. Heat transfer is stationary in time (continuously).

Radiation recuperators are made, in principle, the two metal tubes (interior and exterior), relatively large diameter, arranged concentrically, which are linked together by an elastic expansion compensator. Flue gas flows through tube inside, resistance gazodinamiqe inserted is negligible [4]. In fig. 1 is shown schematically a simple recovery radiation.

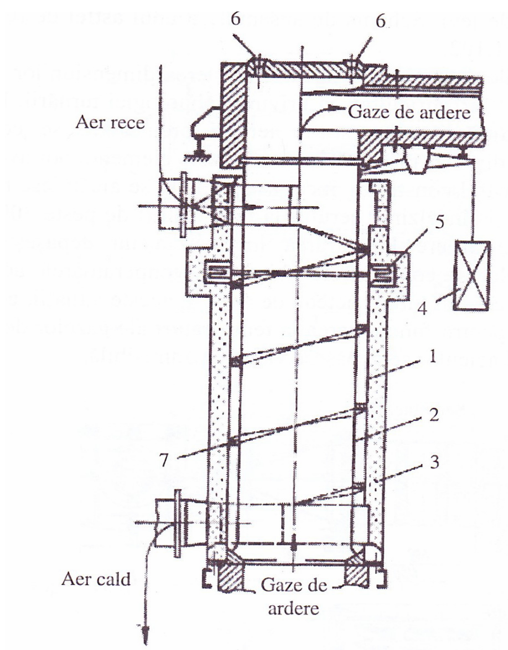


Fig. 1. Simple radiation recovery (unilateral)
1-outer shell ring; 2-inside shell ring; 3- insulation; 4-counterweight;
5-compensatory expansion; 6-access cover; 7-helical ribs

Flow of two fluids (air and flue gas) by radiation recuperator is made in the same direction (echicurent) fig. 2a) or opposite direction (countercurrent) fig. 2b)

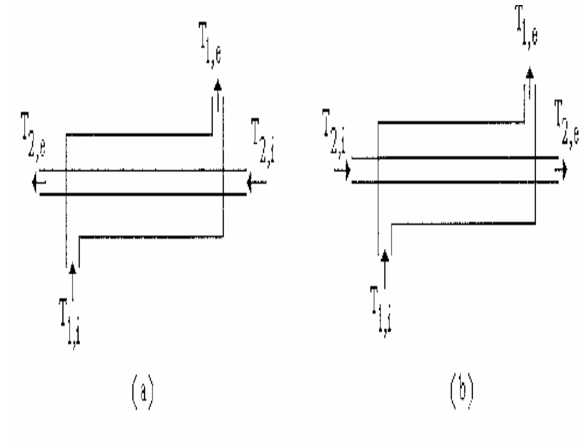


Fig. 2. Flow diagram of the two fluids
a-echicurent flow; b-flow countercurrent

The radiation recuperators heat flux density reaches maximum:

$$q_{max} = (58...93)*10^3 \quad W/m^2$$

Constructive form of radiation recuperators has suffered substantial changes because of the possibility to obtain fire-resistant steels at temperatures of 1100ºC, no oxidation or creep. t was so combustion air temperature to reach values of 950-1100ºC, for a flue gas temperature entering the recovery of 1650ºC. Unilateral radiation recuperators were the main disadvantage limited heat exchange surface. To remove this inconvenience and have developed bilateral radiation recuperators (fig. 3), recuperator hourglass with two roads on the air (fig.4 a) and recovery of radiation with two roads on the flue gas (fig. 4, b)

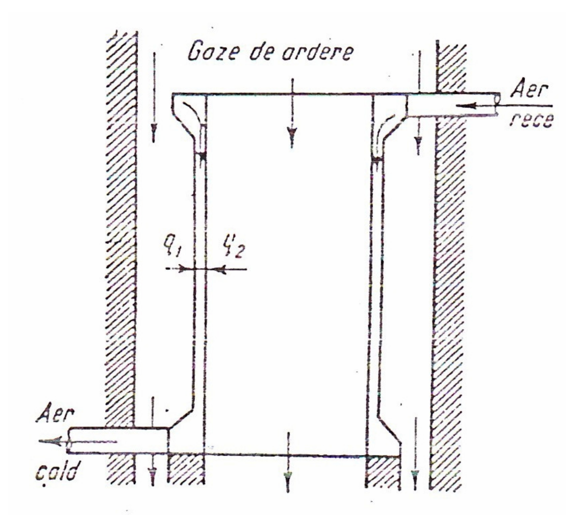
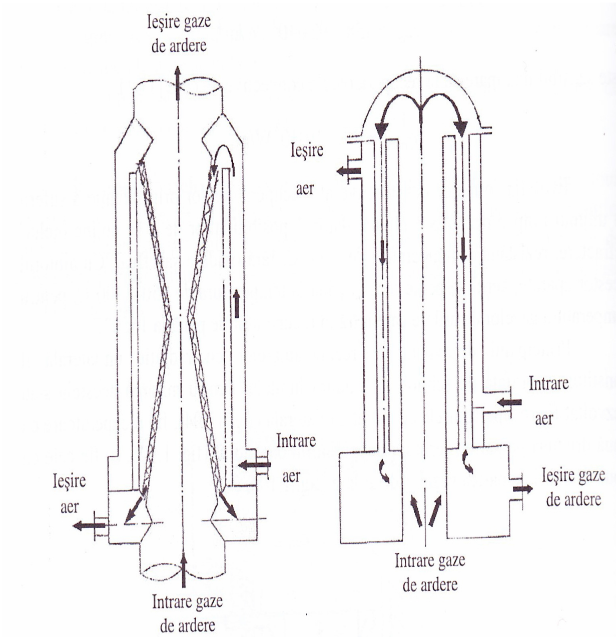


Fig. 3. Recovery with bilateral radiation



a b

Fig.4. Recovery of radiation with two roads

a-hourglass-type, b- with two roads on the flue gas

Today most experts agree that physical recovery of the flue gas heat evacuated from industrial installations is not an addition to the technological process itself, but must be treated simultaneously and in direct correlation with this. This statement is supported by the current method to design, build and deliver complete equipments beneficiaries, which includes a whole and physical heat recovery equipment for flue gas evacuated from these equipments.

2. PAR-MD RADIATION PREHEATER FOR HEATING FURNACES TYPE ROOM.

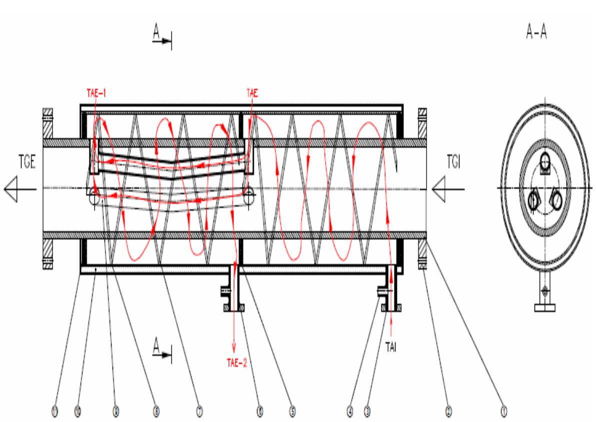


Fig.5. PAR-MD radiation preheater for heating furnaces type room.

1. Inner tube
2. Flange fixture.
3. Inlet air.
4. Socket fixing probe.
5. Recovery partition.
6. Outlet air preheating.
7. Metal fins spirals.
8. Outer pipe.
9. Metal tubes.
10. Exterior insulation.
11. Cover preheater.

PAR -MD radiation preheater shown in Figure 5 is basically a combination of a metal preheater radiation fins arranged in a spiral and an hourglass type preheater radiation . The flue gas temperature which crosses the

inner tube 1 has input value TGI = 1000 ^{0} C -1250 ^{0} C

and the inner tube exit flue gas temperature TAE take values depending on the size preheater radiation PAR-MD . Combustion air flow is done concurrently in the first and second section of the heat recovery and counter the third section . Combustion air enters through the subject preheating the inlet 3 to the ambient temperature TAI , in co-current flow passes through the preheater and is the first to exit from the cocurrent TAE temperature . Heat of combustion air taken from the inner pipe is 1 August and spiral metal outer barrel in July . Area two is crossed by all the co-current combustion air and outlet air temperatua will TAE_1 value . Heat of combustion air taken is made from metal tubing 9 disposed in the inner tube 1 . The last area of the recuperator is crossed by counterflow combustion air and output air temperature will TAE_2 value . In this part of preicălzitorului air heat will be taken in the same manner as the first area of the recuperator .

In Figure 6 is shown in the endowment forge furnace, thermo technological Laboratorului Aggregates "within FIMMR - Wallachia University Targoviste radiation furnace equipped with preheater old and in Figure 7 is the same kiln preheater equipped this time with radiation PAR-MD.

Figure 6. Fixed hearth furnace room

1. Preheater old radiation

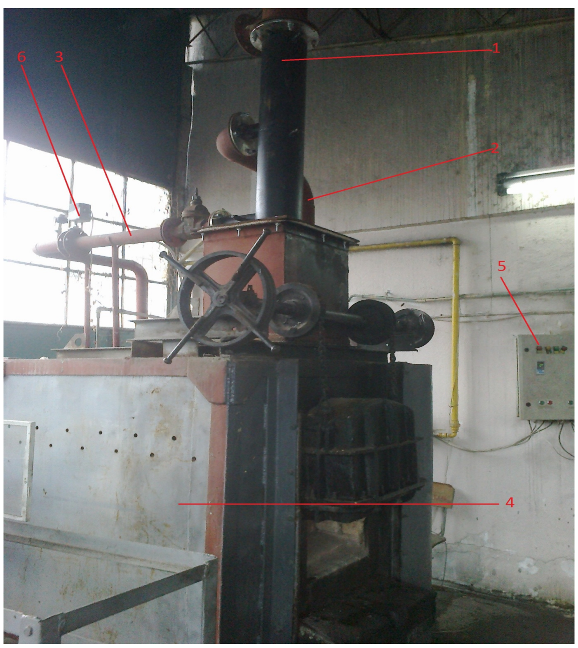


Figure 7. Fixed hearth furnace room

1. PAR-MD radiation preheater

3. EXPERIMENTAL METHODOLOGY.

Testing methodology established by facility type and objectives to be pursued.

Thus, we determined the operational parameters of the oven equipped with preheater PAR-MD radiation changes have occurred since the air paths. Determine the areas of stability, achieving airflow ratio - fuel flow to the burner flame emerges.

Measurements were performed for the determination of the characteristic curves: flow rate of fuel based on the pressure of the fuel and comburent flow rate based on the pressure of the comburent.

Also, the ventilation measurements have been carried out for developing the heat balance of the furnace equipped with the driving system in automatic mode.

The following parameters were measured:
- The flow of fuel and combustion air;
- The temperature inside the oven and the outer surface of the furnace;
- Material temperature at the exit of the oven;
- Temperature flue gas and chemical analysis;
- Surface pressure leaks. Heating was performed 10 XC 25 steel ingots, weighing 7 kg each, respecting the proper warming chart.

By drawing heat balance seeks comparing specific fuel consumption of the classic oven equipped with driving system in automatic mode.

To determine exhaust emission measurements were performed at different temperatures flue gas composition of the enclosure.

4. BALANCES THERMAL RADIATION FURNACE EQUIPPED WITH PREHEATER PREHEATER OLD AND EQUIPPED WITH RADIATION PAR-MD.

Balances thermal radiation furnace equipped with preheater preheater old and equipped with radiation PAR-MD**.** was made in Laboratory Termotehnological Aggregates University of Targoviste Valahia, aboratory equipped with a heating furnace equipped with a heat recovery from radiation-size table 2. Heating furnace shown in Figure 11 is equipped with a pulse burner PYRONICS, tip 601 NM with consumption schedule / pcs of 25Nm^3/h.

Automatic driving system for heating furnace made the following functions:

-preventilare;

-ignition and flame supervision with 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 programmer-controller high quality and reliability.

Was heated furnace until the flue gas temperature at the exit from recovery TAE reached 1200^{0}C and combustion air temperature measured at the entrance of recovery, respectively out of recovery. Temperature combustion air from entering the recovery TAI has value 20^{0}C, and combustion air temperature at the exit from recovery TAE had value 260^{0}C.

Table.2 Data for calculating the thermal balance sheets drawing furnace

Nr. crt	Date computing	Notation	U/M	Value	
				Equipment with the old radiant preheater	Preheater equipment with radiation PAR-MD
1	2	3	4	5	6
1.	The average natural gas flow zone	D_c	Nm^3/h	17,0	13.26
2.	Calorific value of natural gas	H_i	$kcal/Nm^3$	8050	8050
3.	Gas temperature	t_c	°C	20	20
4.	Specific heat of gas	c_c	$kcal/Nm^3.grd$	0,396	0,396
5.	Average hourly flow rate of combustion air	D_a	Nm^3/h	171	136.8
6.	Combustion air temperature	t_a	°C	450	450
7.	Specific heat of air	c_a	$kcal/Nm^3.grd$	0,319	0,319
8.	Weight material to be warming	G_m	kg	70	70
9.	Material from entering the furnace temperature	t_{mi}	°C	20	20
10.	Specific heat of the material	c_{mi}	kcal/kg.grd	0,011	0,011
11.	During heating	τ_i	h	5,5	4.4
12.	The temperature of the material at the exit of the oven	t_{me}	°C	1200	1200
13.	Specific heat of the material at the outlet of the furnace	c_{me}	kcal/kg.grd.	0,167	0,167
14.	Wet flue gas volume	V_{gam}	Nm^3/Nm^3	11,065	8.85
15.	The flue gas temperature	t_{ga}	°C	650	650
16.	Flue gas enthalpy	i_{ga}	$kcal/Nm^3$	220	220
17.	Area by radiating oven leaks	S_n	m^2	0	0
18.	Coefficient diafragmare	φ	-	-	-
19.	The average temperature of the furnace enclosure	T_c	K	-	-
20.	The ambient temperature	T_{ma}	K	293	293
21.	Volume masonry oven: - Type I - Type II	V_{z1} V_{z2}	m^3 m^3	0,884 0,802	0,884 0,802

From thermal bilaturile above can be easily seen that during heating blanks shrinks by about 25% for radiation preheater furnace equip PAR-MD.

Exhaust emissions if the oven is equipped with preheater radiation PAR-MD and whose values are presented in Table 3 are lower by about 25% than exhaust emissions furnace equipped with the old radiant preheater shown in Table 2, and are much lower than the limit values MAPPM Order 462/1993.

Table 3. NOx content in the flue gas for α = 1.05 for radiation furnace equipped with preheater old.

Temp. furnace [oC] / NOx [ppm]	750	850	950	1050	1200
NO_x	63	80	90	97.5	115
CO	33.75	31.25	28.5	25	21.25

Table 4. NOx content in the flue gas for α = 1.05 for preheater furnace equipped with radiation PAR-MD

Temp. furnace [oC] / NOx [ppm]	750	850	950	1050	1200
NO_x	52	64	72	78	92
CO	27	25	23	20	17

Automatic driving system for heating furnace made the following functions:

-preventilare;

-ignition and flame supervision with 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 programmer-controller high quality and reliability.

4. CONCLUSIONS

- Duration blanks warming shrinks by about 25% for radiation preheater furnace equip PAR-MD.
- Values emitted pollutants are lower by about 25% for radiation preheater furnace equip PAR-MD.
- Recorded substantial savings through a reduction in the duration of heating of the semi reported to reduce fuel consumption

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