STUDY ON INFLUENCE OF ENERGY EFFICIENCY OF A STEAM BOILER BENSON ON ENVIRONMENTAL POLLUTION

Professor **Racoceanu Cristinel,** University ”Constantin Brâncuşi” of Târgu Jiu
c_racoceanu@yahoo.com

***Abstract**: This paper presents a case study on the influence of the energy efficiency of a steam boiler of 330 MW energy group on the environment. The Benson boiler works with powdered lignite. We present the results of experimental measurements on immission and emissions of pollutants resulting from burning lignite: SO2, NOx, PM10, PM2,5, TSP. Experimental measurements were performed on the boilers of 330MW power units of the thermoelectric plant of Rovinari.*

Keywords: lignite, emissions of pollutants, SO2, NOx, ash, PM10, PM2,5, TSP.

1. INTRODUCTION

The energy groups of 330MW thermoelectric plant in Rovinari work with powdered lignite. The lignite reaches directly from the central mining area of the coal basin of Gorj. The construction is of tower boiler (Figure 1) and has a height of 92 m. In the lower part of the boiler it islocated the combustion chamber, while in the lower parts are located surfaces for heat exchange. The boiler has a nominal steam flow rate of 1035 tons / oră. The preparation of lignite dust is carried by 6 fan type mills DGS 100.

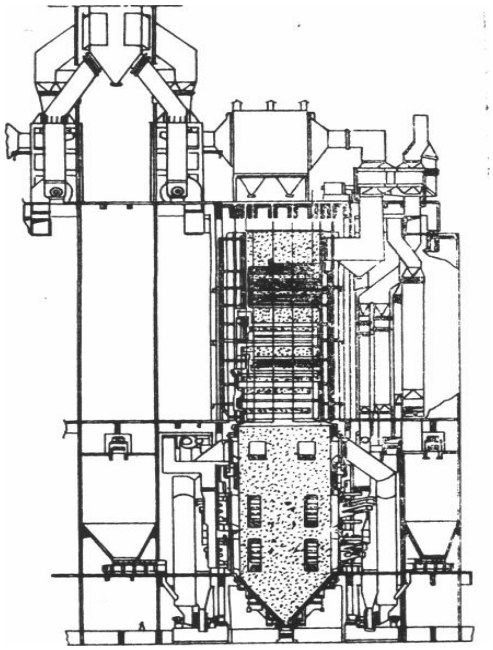

***Fig. 1** - Benson Boiler*

The coal combustion air is introduced by 2 air fans Axial type. To increase the air temperature are provided two rotary air heaters. The flue gases resulted are discharged with 2 axial gas fans. The resulting slag by burning coal is discharged at the bottom of the boiler with a conveyor type Kratzer. The ash contained in the flue gas is retained in two horizontal electric filters. The installation of the slag and ash discharge has the following technical features:

- ash discharged from the electrostatic filters 28,05 kg/s; 150^{o}C;
- ash discharged from funnel chimney 0,55 kg/s; 150^{o}C;
- ash discharged from funnel chimney at the disengages of electrostatic filters 11,11 kg/s;150^{o}C ;
- ash discharged from the funnels under preheater rotary air 2,22 kg/s; 310^{o}C;
- amount of slag discharged from the combustion chamber 4,44-8,33kg/s; 20^{o}C.

The Bagger pumps stations ensure the evacuation of the central slag and ashes. Ash and slag deposits are located 2-5 km from the central area of 478.9 ha occupied by Balta Uncheaşului, Cicani - Beterega, Gîrla. The flue gases are discharged into the atmosphere through smokestacks of power boilers which have a high 120 m.

2. EXPERIMENTAL MEASUREMENTS

For total suspension particles(TSP) the limit values and the alert thresholds and action under environmental law are presented in Table 1

Table 1. Limit values for air quality (µg/m3)

Pollutant	Limit values	The period of mediation	Limit Protection (recap-tors)	Year entry in force	Threshold alert
TSP	500	30 min	Population	Actual	350
	150	24 h	Population	Actual	175
	75	1 year	Population	Actual	52,5

Table 2 shows the parameters of physical dispersion of the chimneys and the corresponding emissions for steam boilers of power plant Rovinari.

Tabel 2parameters of physical dispersion of the chimneys on Rovinari power plant

Chimney	Flue gas temperature [0C]	speed gas [m/s]	Real flue gas flow [Nmc/h]	Real flue gas flow [mc/h]	The level of oxygen in the flue gas [%]
Chimney1-boilers3and4	143,00	19,12	2432417,36	4161816,20	7,5
Chimney2-boilers 5and6	143,00	19,24	2495742,29	4012258,40	
Chimney1-boiler4	143,00	9,85	1287356,12	2073549,38	
Chimney2-boiler 5	143,00	9,48	1295839,86	1944985,18	

Sampling for gaseous pollutants was performed by pump shown in Figure 2.

***Fig. 2** -Pump for gaseous pollutants sampling*

By the chimneys of boiler from the energy groups are dispersed into the environment large amounts of pollutants: SO_2, NO_x, CO_2, dust ash. These pollutant substances have harmful effects on human health and on the environment. For inclusion of emissions into the emissions limits set by environmental legislation, the energy units of the thermoelectric plant Rovinari were equipped with flue gas remediation technologies.

Table 3 presents the results of experimental measurements for pollutants discharged into the atmosphere by dispersion chimney No.1.

Table no. 3 pollutants emissions related to release chimney no. 1

Chimney1-boilers3and4						
Pollutant	Mass flow	Dried gas flow	The level of oxygen in the flue gas	Concentration in emission	Limit onemission	Observations
	[t/an]	[Nm^3/h]	[%]	[mg/Nm^3]	[mg/Nm^3]	
SO_2	73426,00	2.213.528,20	6,2	189,02	200	<VL
NO_x	8486,00			421,36	500	<VL
TSP	1007,00			52,26	50	>VL
PM_{10}	348,50			21,22		
$PM_{2,5}$	109,00			5,65		

Table 4 presents the results of experimental measurements for pollutants discharged into the atmosphere by dispersion chimney no.2

Tabel nr. 4. Pollutants discharged by the dispersion chimney no.2

Chimney 2-boilers 5and6						
Pollutant	Mass flow	Dried gas flow	The level of oxygen in the flue gas	Concentration in emission	Limit onemission by HG 440/2010	Observations
	[t/an]	[Nm^3/h]	[%]	[mg/Nm^3]	[mg/Nm^3]	
SO_2	70854,00	2.247.138,00	6,2	190,40	200	<VL
NOx	8512,00			441,28	500	<VL
TSP	1113,00			54,12	50	>VL
PM_{10}	402,00			28,37		
$PM_{2,5}$	128,50			6,18		

3. CONCLUSIONS

Issues on environmental protection on the cases of thermoelectric plant Rovinari's boilers are related on the pollutant emissions of these facilities. Pollutant emissions depend on the technical condition and of the conditions they are exploited.

Economic operation of boiler

Economic operation of the boiler means, for the same production of energy, less and cheaper fuel burned in the furnace and lower energy consumption of the auxiliary boiler equipment.

The two are, in turn, subject to the following:

- High Gross yield of boilers;
- Technological consumption of small boiler;
- Low consumption of hydrocarbons;
- Small number of starts; short duration of impulses.

Operation with high gross yield of the boiler

The Gross yield of the boiler depends on the size of heat loss. The main losses of the heat boiler are:

- Loss with heat from flue gases discharged on chimney (q2);
- Losses with radiation outward (Q5);
- Loss with heat discharged from the boiler as slag and ashes (Q6);
- Loss withnon-burned chemical and mechanical substances (q3 and q4).

The yield (ηk) calculated of boiler and the corresponding losses from loads of 100%, 70% and 40%, the operation only on coal with calorific value of 1,600 kcal / kg, are:

Load 100%	load**70%**	**Load40%**
η_k = 88,23 %	η_k = 90,12 %	η_k = 90,05 %
q_2 = 8,14 %	q_2 = 7,73 %	q_2 = 7,48 %
$q_{3,4}$ = 1,03 %	$q_{3,4}$ = 1,02 %	$q_{3,4}$ = 1,02 %
q_5 = 0,208 %	q_5 = 0,347 %	q_5 = 0,574 %
q_6 = 0,658 %	q_6 = 0,302 %	q_6 = 0,302 %

Heat losses decrease with the load, which is why gross yield, computed, of the boiler load is higher at 40% as respect the oneat 100% load. This is, however, not a reason to operate at 40% load. To function economically with the boiler means to is to operate as close to the yield calculated on the irrespective load.

The losses of heat from flue exhaust chimney increase with gas temperature at the chimney, with flue gas flow.

Small number of starts, small duration of the starting.

Starting from cold condition is three times longer than the longest starting from hot state. This is a good reason to create the possibility of starting the boiler from hot state.

SO_2 and NO_x from flue gases.

SO_2 in the flue gas depends on the percentage of sulfur in the fuel. The decreasing of the SO_2 content in the flue gas, to discharge into the atmosphere, is achieved by means of desulphurization plants that treats flue gas after releasing the boiler (after electrostatic filters).

NO_x formed in the combustion chamber, where high temperatures favor the oxidation of nitrogen from fuels and from the combustion air. It increases with increasing of excess air in the furnace and decreases with decreasing of it. The exaggerated decrease of excess air on the one hand can lead to incomplete combustion (occurrence of CO in the flue gas), and secondly, to increase flue gas temperatures in the furnace and the appearance of slagging.

CO from flue gases is limited, for safety and economic reasons, to a maximum of 200 mg / Nm^3.

Modernization to increase efficiency by improving combustion.

- Effective arrangement of vortex combustion in a zone located furthest at the end of the furnace
- Eliminating leaks which will eliminate future false air penetration into the furnace that produces a serious imbalance in the proper functioning and control of the combustion process.
- The provision of slits in the walls of the furnace,over the recirculation mouths of furnaces gases, for future tertiary air redistribution.

BIBLIOGRAPHY

1. Racoceanu, C., Popescu, L.G., Popescu, C. *RESEARCH ON THE IMPACT OF THE APPLICATION OF CLEAN TECHNOLOGIES FOR BURNING COAL ON AIR QUALITY IN THE AREA OF ROVINARI AND TURCENI POWER PLANTS*, 16 th International Multidisciplinary Scientific GeoConference &EXPOSGEM 2016, 28 June -7 July 2016, Albena, Bulgaria, conference WSEAS.
2. Racoceanu, C., Popescu, L., Popescu, C. Cruceru, M. *Research on particulate matter PM10 pollution due to coal burning in Oltenia Energy Complex,* 2nd International Conference on Energy and Environment Technologies and Equipment (EEETE '13), Brasov, Romania, 1- 3 iune 2013, conferinţă WSEAS, pag.137-142, ISBN: 978-1-61804-188-3.
3. Racoceanu Cristinel, Popescu Luminiţa Georgeta, Popescu Cristinel, Cruceru Mihai, *Research on reducing by ash and no_x cuased burning lignite in energy units of 330 MW power plant Turceni*, The 13th International Multidisciplinary GeoConference SGEM 2013**,** 16 - 22 June, 2013,Albena Co., Bulgaria, pag. 839-845, ISBN 978-619-7105-04-9.
4. Racoceanu ,C., Popescu, L., Filip, V., Popescu, C. *RESEARCH REGARDING ENVIRONMENTAL RISKS DUE TO COMPLEX OPERATION ROVINARI* , Proceedings of the 12th International GeoConference SGEM 2012 will be held in the period of 17 - 23 June, 2012, pag.715-722.
5. Racoceanu C, Şchiopu C. – *Environmental protection and air pollution,* Academic Publishing Brancusi, Targu Jiu, ISBN 978-973-144-346-1, 2010.
6. Racoceanu, C., Popescu C. *Analysis of the environmental impact of energy complexes*, Ed Sitech, Craiova, ISBN 978-973-746-679-2, 2007.
7. Racoceanu, C., Popescu C.*Environmental impact analysis energy complexes*, Sitech Publishing,, Craiova, ISBN 978-973-746-679-2, 2007.
8. Popescu, C. Racoceanu, C. *Improve the work environment in terms of power plants*, Sitech Publishing, ISBN 973-746-380-3, ISBN 978-973-746-380-7, 2006.