ГОДИШНИК на Минно-геоложкия университет "Св. Иван Рилски", Том 54, Св.III, Механизация, електрификация и автоматизация на мините, 2011
ANNUAL of the University of Mining and Geology "St. Ivan Rilski", Vol. 54, Part III, Mechanization, electrification and automation in mines, 2011

BALANCE ANALYSIS FOR THERMAL STEAM BOILERS OPERATED LIGNITE

Cristinel Racoceanu [1] Emil Cătălin Şchiopu [2]

[1] *University "Constantin Brâncuşi" of Târgu Jiu, Romania, cristi@utgjiu.ro*

[2] University "Constantin Brâncuşi" of Târgu Jiu, Romania, schiopu_catalin81@yahoo.com

ABSTRACT. This work is based on a case study on thermal balance analysis of a steam boiler of 1035 t / h, which works with lignite. To achieve thermal balance measurements were performed with specialized equipment in boiler No. 4 of the energy group of 330 MW thermal power plant thermal balance Turceni provides information on the operation of steam boiler. Based on this information can establish the necessary technical measures to increase efficiency of operation of steam boiler

АНАЛИЗ НА ТОПЛИННИЯ БАЛАНС НА ПАРНИ КОТЛИ С ЛИГНИТНО ГОРИВО

***Кристинел Ракоцеану*[1], *Емил Каталин Шиопу* [2]**

[1] *Университет "Константин Бранкуш", Таргу Жиу, Румъния, cristi@utgjiu.ro*

[2] *Университет "Константин Бранкуш", Таргу Жиу, Румъния, schiopu_catalin81@yahoo.com*

РЕЗЮМЕ. Настоящата разработка се основава на експериментално проучване на топлинния баланс на парен котел с капацитет 1035 т/ч, който работи с лигнитни въглища. При постигане на топлинен баланс на котел № 4 от енергийна група с мощност 330MW в топлоелектроцентрала Търсени са извършени измервания със специализирана апаратура, които осигуряват информация за работата на котлите. На базата на тази информация може да се определят необходимите технически мерки за повишаване ефективността на работа на парните котли.

Introduction

By highlighting the energy balance is defined in table form, chart or other form of equality between the quantity of energy introduced into a given system and useful amounts of energy lost and out of the outline scheme. In developing the energy balance must take into account all phases and processes of extraction yields, processing, transport, distribution and proper use of all forms and energy carriers considered as inputs and outputs of the contour system. CTE is a central condensing Turceni equipped with energy blocks of 330 MW, designed as a basic central energy system, with a regimen of continuous operation and long-term maximum uniform loads.

The plant was carried out in two stages:

- Phase I - with an installed capacity of 1320 MW consisting of blocks 1 to 4 gradually put into operation during 1978-1982;;
- Phase II - the original one installed power of 1320 MW consisting of blocks 5-8

Each block is equipped with:

- un cazan de abur de 1035 t/h, 192 bar, 540/540 ^oC tip turn, cu circulaţie forţată (tip Benson);
- a steam turbine of 330 MW, 182 bar, 535/535 ° C;
- an electric generator 330 MW/388 MVA, 24 kV, 50 Hz;
- a transformer of 400 MVA, 24/400 kV.

Basic fuel is lignite coal basin Oltenia - extracted mainly from mines stall and Peşteana - lower calorific value of 1400 - 1800 kcal / kg

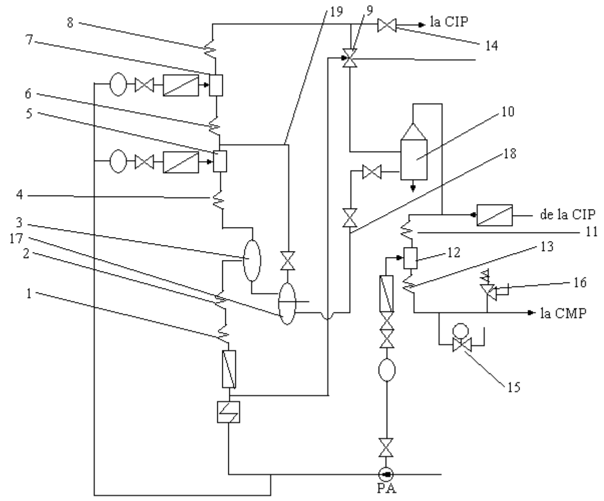
Boiler steam energy group 330 MW

Steam boiler 1035 t / h, shown in Figure 1, fitted energy group no. 4 of 330 MW power plants Turceni. In the steam boiler thermal balance was achieved.

The boiler of 1035 t / h boiler is a unique type forced cross the Benson and aims to produce steam at subcritical pressure. Heat exchange surfaces of the boiler - the high-pressure - are in series, water circulation pumps made with power. The economizer feedwater heating occurs with flue gas temperature at economizer exit temperature reaching a value close to saturation. The boiler is the turn with a single path of flue gases.

Steam boiler works with lignite. Lignite is extracted from coal basin Oltenia. Steam boiler is designed for operation with fuel oil. Burning coal dust burners is 16 slots.

Preparation of lignite is made with 6 fan hammer mills. The grinding mills and drying fan is dust.



.Fig.1 Scheme boiler 1035 t / h
1 - saver, 2 - evaporator, 3 - separator drops, 4 - superheater IP1, 5 – No 1 injection. , 6 - IP2 superheater 7 – No 2 injection. , 8 - IP superheater 3, 9 - by-pass IP 10 - power expander, 11 - No intermediate superheater. 1, 12 - shot no. 3, 13 - No 2 intermediate superheater. , 14 - valve line, 15 - valve eşapare intermediate, 16 - safety valve pressure on average, 17 - start container, 18 - piping hot start in state, 19 - Start of the container vent pipe

Thermal balance of the steam boiler - experimental results

Thermal balance has been prepared for three tasks: 306 MW, 250 MW and 220 MW. The technical characteristics of the steam boiler are presented in Table 1.

Meters used

In order to achieve the steam boiler measurements were used following meters:
- Static pressure transducers;
- Differential pressure transducers;
- Digital thermometers;
- Infrared thermometers;
- Flue gas analyzer TESTO 350 XL type;
- Alumel thermocouples Cromel-different lengths;
- Ultrasonic flowmeter.

General conditions for making measurements

Measurements were made according to the charging turbine, respectively, across the power generator, thus obtaining the following test loads:
- Sample no. 1-306 MW;
- Sample no. 2-250 MW;
- Sample no. 3-220 MW

Appropriate powers for the boiler were obtained following charges:
- Sample no. 1-920 t / h (88.88% Dn);
- Sample no. 2-840 t / h (81.16% Dn);
- Sample no. 300-800 t / h (77.10% Dn).

Boiler load (steam flow) is the result of achieving load turbo generator;

1. Solid fuel calorific value was in the range 1700 kcal / kg - 1980 kcal / kg;
2. High pressure heats have been in operation;
3. Heaters did not work;
4. Fans have provided a working gas with depression in center;
5. All samples were in use two gas burners;;
6. Auger speed was virtually flat, it is not possible to set
7. Mills were available, to test a boiler operated with 5 mills (1/2/3/5/6) to sample 2 boiler operated with 5 mills (1/2/3/5/6) in sample 3 boiler operated with 4 (2/3/5/6)..

Table 1. Specifications steam boiler

Nr	Parametru		U.M.	Valoare
1.	High pressure steam	flow	t/h	1035
		temperature	ºC	540
		pressure		191
2.	Medium pressure steam	flow	t/h	974
		Temperature entering SI	ºC	348
		Temperature exit SI	ºC	540
		Pressure entering SI	bar	49,2
		Pressure exit SI	bar	47,2
3.	Water supply	Temperature entering ECO	ºC	260
		Pressure entering ECO	ºC	245
4.	Flue gas temperature after PAR		ºC	160
6.	Yield		%	85,9

Boiler efficiency calculation of 1035 t / h

Real thermal balance of a boiler can run through two methods: direct, indirect.

The direct method involves direct measurement of all parameters which allow calculation of quantities of heat in, respectively out of balance sheet accounts.

The amount of heat inside, Qi, consists of:
- Chemical heat of the fuel, Qch;
- Heat sensitive fuel, Qf, CB;
- Heat sensitive water supply, Qa;
- Sensible heat of the air in the boiler, Qf, A.

The amount of heat out, QE, includes:
- Heat useful, Qu;
- Heat lost through the flue gas sensible heat, Qga;
- Heat lost through chemical combustion incomplete Qga, ch;
- Heat lost through incomplete combustion machine, Qga, m;
- Heat lost by radiation and convection environment, Qcv;
- Heat sensitive heat lost through the slag, Qzg;
- Heat lost by water purged, QP;
- Heat lost through cooling water recovered, QR.

Heat balance general equation is:

$Q_i = Q_e$ [kW] sau [kJ/h] (1.1)

or

$$Q_{ch} + Q_{f,cb} + Q_a + Q_{fa} = Q_u + Q_{ga} + Q_{ga,ch} + Q_{ga,m} + Q_{cv} + Q_{zg} + Q_p + Q_R \quad (1.2)$$

The various components can be calculated as follows:
all the heat-sensitive determination reported:

$Q_f = D \cdot c \cdot t$ [kW] sau [kJ/h] (1.3)

where D is the agent flow in kg / s or m3N / s, c - specific heat of the agent, in kJ / kgoC or kJ/m3N ° C, t - medium temperature in oC.

-all chemical heats determined by the relationship:

$$Q_{ch} = DH_i \quad \text{[kW] sau [kJ/h]} \qquad (1.4)$$

where D is the agent flow in kg / s or m3N / s Hi - lower calorific agent, kJ / kg or kJ/m3N.

Gross thermal efficiency of the boiler is determined by the relationship :

$$\eta_{tb} = \frac{Q_u - Q_a + Q_p}{Q_i - \left(Q_a + Q_{fa} + Q_{f,cb}\right)} \qquad (1.5)$$

Indirect method allows calculation of boiler gross thermal efficiency at a stabilized state without having to measure the flow of steam and water supply.

The method involves determining heat loss and the relationship to determine the gross thermal efficiency is:

:

$$\eta_{cazan} = 100 - \left(q_2 + q_3 + q_4 + q_5 + q_6\right) \qquad (1.6)$$

where:

q2 - loss of heat from the flue gas exhaust stack;

q3 - loss of heat by burning chemical incomplete;

q4 - heat loss through mechanical unburned;

q5 - heat loss by radiation and convection in the environment;

q6 - loss of solid waste heat discharged from the boiler.

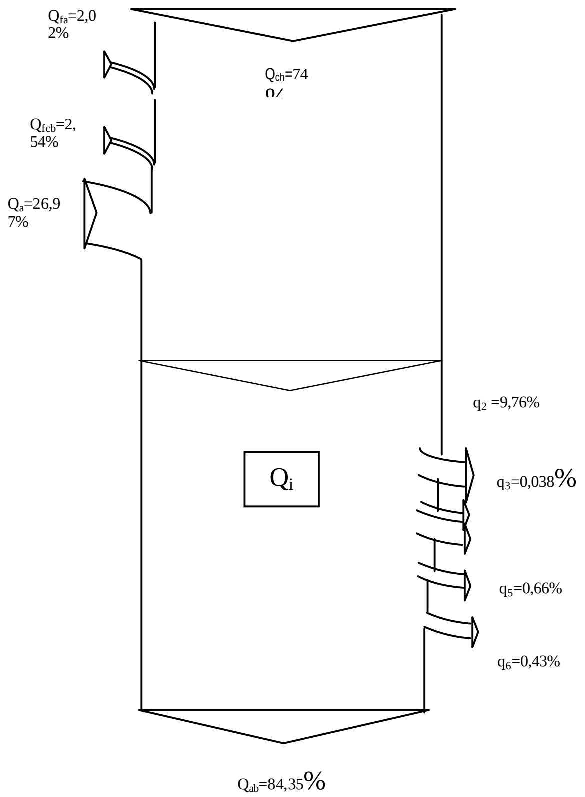


Fig.2 Sankey diagram – No 4 steam boiler power block

Table 2. Real thermal balance result

No	Parameter	Symbol	Proba nr. 1	
			Value	
			x10[6]kJ/h	%
1.	The amount of heat resulting from the combustion	Q_{ch}	3182,182	74
2.	Physical heat of fuel	$Q_{f,cb}$	109,33	2,54
3.	Physical heat of combustion air	$Q_{f,a}$	87,19	2,02
4.	Physical heat of water	Q_a	921,84	26,97
5.	Total heat	Q_i	4300,54	100
6.	Useful heat	Q_u	3627,54	84,35
7.	Heat loss in flue gas discharged from exhaust flue chimney flue	q_2	419,73	9,76
8.	Heat loss by incomplete combustion of chemically	q_3	1,63	0,038
9.	Heat loss by incomplete combustion of mechanically	q_4	172,88	4,02
10.	Heat loss through radiation and convection in the environmen	q_5	28,38	0,66
11.	Loss of solid waste heat discharged from the boiler	q_6	18,49	0,43
12.	Total heat out of the contour	Q_e	4268,65	100
13.	boiler efficiency	η_{caz}	85,1%	

CONCLUSIONS

Analyzing the operation of steam generator and thermal balance actual results shows that:

1. amount of flue gas temperature after air heater is high, ranging between 170 ^{0} C - 175 ^{0} C;
2. produced live steam boiler temperature is close to the nominal value (535 ^{0}C);
3. supply water temperature was within normal limits ranging between 234 ^{0}C-245 ^{0}C;
4. solid fuel use is relatively low calorific value, the same for all three samples.

For optimum balance preparing to propose the following measures:

- Reducing the oxygen content in flue gases after preîncălzitorul air;
- Reduce flue gas temperature after air heater to 170 ^{0}C - 175 ^{0}C to 160 ^{0}C - 162 ^{0}C;
- Reduce excess air coefficient;
- Operation parameters as close to nominal values

.

References

1. Racoceanu C, Şchiopu C. – *Tehnologii de protecţie şi depoluare a aerului*, Editura Academica Brâncuşi; Târgu Jiu, , ISBN 978-973-144-346-1 , 2010.

2. Berinde, T., *Întocmirea şi analiza bilanţurilor energetice, vol. I şi II,* Editura Tehnică, Bucureşti, 1974.
3. Neaga, C: *Indrumar. Calculul termic al generatoarelor de abur*, Editura Tehnică, 1988.
4. Racoceanu, C., Popescu C. *Analiza impactului complexelor energetice asupra mediului*, Editura Sitech, Craiova, ISBN 978-973-746-679-2, 2007 .
5. Popescu, C. Racoceanu, C. *Eficientizarea activităţii termocentralelor în condiţii de protecţia mediului*, Editura Sitech, ISBN 973-746-380-3, ISBN 978-973-746-380-7, 2006 , cod CNCSIS 170.
6. Racoceanu C. - *Studiul de audit al centralelor termoelectrice.* Editura Sitech, Craiova, ISBN 973-746-163-0, 2006 , cod CNCSIS 170.
7. Racoceanu C., Popescu C. – *Evaluarea emisiilor poluante rezultate prin arderea lignitului în CTE de mare putere,* Editura Sitech, Craiova, ISBN 973-746-211-4, 2006, cod CNCSIS 170.
8. Racoceanu C., Căpăţînă C.- *Emisiile de noxe ale centralelor termoelectrice*. Editura Matrix Rom, Bucureşti, ISBN973-685-882-0, 2005 , cod CNCSIS 39.
9. Racoceanu C. - *Impactul centralelor termoelectrice asupra mediului*. Editura Focus, Petroşani, ISBN 973-8367-12-3, 2001, cod CNCSIS 4.
10. Pănoiu, N: *Cazane de abur*, EDP, 1982.
11. Gorun, A., Popescu, L.G., Gorun, H.T., Cruceru M., *Sustainable Energetic Development Strategy of Gorj, County*, 2nd INEEE Conference: ENERGY, ENVIRONMENT, DEVICES, SYSTEMS, COMMUNICATIONS, COMPUTERS, Venice, February, 8-10 2011,
12. Gorun, A., Popescu, L.G., Gorun, H.T., Mihai Cruceru, *The impact of Globalization on the Development of Rural communities from Romania. Case study: The main social problems generated by degradation of the environment in the rural communities from Gorj County, 6th* IASME/WSEAS International Conference in the University on Energy & Environment, Published by WSEAS Press ISSN: 1790-5095, Cambridge, February 23-25, 2011.
13. Cruceru M., Diaconu, B., Popescu L. G., *Self oxidation of romanian lignite during storage*, *6th* IASME/WSEAS International Conference in the University on Energy & Environment, Published by WSEAS Press ISSN: 1790-5095, Cambridge, February 23-25, 2011.
14. Huidu, E., Mining monograph of Oltenia. Vol. I , Basin Rovinari 1950-2000, Ed Foundation „Constantin Brâncuşi" Târgu Jiu 2000.

Recommended for publication
of Editorial board