STUDY REGARDING ENERGY BALANCE SHHETS OF FLUE GASES PLANT OF STEAM BOILERS OPERATING WITH LOW QUALITY COAL DUST

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Abstract: Abstract. The paper presents a case study on the energy balance sheet of combustion air plant from the steam generator of the 330 MW energy group. The Benson steam generator works with dust lignite belonging to Oltenia Energy Complex. Lignite-fired resulting gases are sucked from the combustion steam generator air with two axial fans placed vertically. Two operating modes are analyzed for combustion air fans

Keywords: Flue gas flow, flue gas temperature, losses in the electric motor, fan efficiency.

1.INTRODUCTION

The 330 MW energy units constituting of Rovinari and Turceni (Gorj county, Romania) thermal power plants belong to Oltenia Energy Complex. The 330 MW energy group is composed of a generator with a steam flow rate of 1 035 t h, a steam turbine with nominal power of 330 MW and an electric generator with nominal power of 330 MW.

The steam generator works with lignite extracted from quarries of the Oltenia Mining Basin. Preparation of lignite dust is carried by 6 hammer mill fans. The air needed for lignite combustion is provided by two axial air fans, horizontally arranged outdoors on a concrete foundation. At full load operation of the boiler, each fan provides 50% of the total amount of air circulated. The main characteristics of the drive motor of the fan air are:

- Fan type: axial, operating position horizontal, direct drive electric motor;
- Power 3100 kW;
- Intensity 6000 V;
- Frequency 50 Hz;
- rated current 357 A;
- revolution 742 rot/min;
- Yield 0,95;
- cos φ =0,88.

2.EXPERIMENTAL RESULTS

In Tables 1 and 2 are presented measured values for the development of the real balance sheet of fan No.1 and fan No.2 of the energetic group no.4 from Rovinari thermoelectric plant during 2015.

Table 1

No	Measured value	Symbol	U.M.	Operating regime I	Operating regime II
1	Current drawn from the network	I_{abs}	[A]	241,5	200,2
2	Pressure differential	H (□p_{ga})	[mmH_2O]	228	189
3	Coefficient of air excess	□	-	1,418	1,593
4	Moisture contained in the air	x	[g/kg]	10	10
5	Yield flue gas fan	□$_{VG}$	-	0,36	0,305
6	Efficiency electric driving motor	□$_{em}$	-	0,91	0,90
7	Power consumption of the driving motor	$P_{m,el}$	[kW]	2248,12	1889,45
8	Transmission efficiency flue gas fan motor	□$_{tra}$	-	0,99	0,99
9	Fuel consumption	B_c	[kg/s]	124,6	95,8
10	The flue gas temperature to the chimney	$t_{coș}$	[□C]	162,30	170,50
11.	Ambient air temperature	t_{ma}	[□C]	12,30	12,30
12.	Lower calorific value of the fuel used	H_i	[kJ/kg]	8248	8975

Table 2

No	Measured value	Symbol	U.M.	Operating regime I	Operating regime II
1	Current drawn from the network	I_{abs}	[A]	232,40	201,30
2	Pressure differential	H (□p_{ga})	[mmH_2O]	225	186
3	Coefficient of air excess	□	-	1,418	1,593
4	Moisture contained in the air	x	[g/kg]	10	10
5	Yield flue gas fan	□$_{VG}$	-	0,362	0,311
6	Efficiency electric driving motor	□$_{em}$	-	0,92	0,90
7	Power consumption of the driving motor	$P_{m,el}$	[kW]	2173,15	1864,28
8	Transmission efficiency flue gas fan motor	□$_{tra}$	-	0,99	0,99
9	Fuel consumption	B_c	[kg/s]	131,5	96,4
10	The flue gas temperature to the chimney	$t_{coș}$	[□C]	162,30	170,50
11.	Ambient air temperature	t_{ma}	[□C]	12,30	12,30
12.	Lower calorific value of the fuel used	H_i	[kJ/kg]	8248	8975

Table 3 indicates the formulas for calculation of the values in the energy balance

No	Calculated value	Formula
1	Power absorbed by the flue gas fan	$P_{abs} = \frac{D_{Vga} \cdot H}{3600 \cdot 1{,}02 \cdot \eta_{em} \cdot \eta_{tra} \cdot \eta_{Vga}}$
2	Flue gas flow circulated by fan	$D_{Vga} = \frac{T_{cos}}{T_{ma}} \cdot v_{ga} \cdot B_c$
3	The flue gas temperature to the chimney	$T_{cos} = 273{,}15 + t_{cos}$
4	Ambient temperature	$T_{ma} = 273{,}15 + t_{ma}$
5	Theoretical flue gas volume	$v_{ga} = v_{ga}^0 + (1 + 0{,}00161 \cdot x) \cdot (\lambda - 1) \cdot L_{min}$
6	Theoretical minimum volume of combustion gas	$v_{ga}^0 = 1{,}375 + \frac{0{,}226 \cdot H_i}{1000}$
7	Theoretical minimum volume of air necessary for combustion of fuel	$L_{min} = 0{,}5 + \frac{0{,}241 \cdot H_i}{1000}$
8	Gas fan power	$P_{VG} = \frac{P_{th}}{102 \cdot \eta_{VG}}$
9	Technological power of the gas fan	$P_{th} = D_{Vga} \cdot H$
10	Losses in electric driving motor of the gas fan	$P_{abs} \cdot (1 - \eta_{em})$
11	Losses in electric motor and fan motor transmission	$P_{abs} \cdot (1 - \eta_{em} \cdot \eta_{tra})$
12	Losses in fan	$P_{u,VGA} \cdot (1 - \eta_{VGA})$

In Tables 4 and 5 are presented the values resulting from the calculation for the 2 air fans, needed for the real balance sheet elaboration.

Table 4

No	Measured value	Symbol	U.M.	Operating regime I	Operating regime II
1	Power absorbed by the flue gas fan	P_{abs}	[kW]	2247,12	1898,34
2	Flue gas flow circulated by fan	D_{Vga}	[m^3/s]	335,5	286,3
3	Flue gas temperature to chimney	$T_{coș}$	[K]	445,35	452,65
4	Ambient temperature	T_{ma}	[K]	282,65	282,65
5	Theoretical flue gas volume	v_{ga}	[m^{3}N/kg]	4,7	5,6
6	Theoretical minimum volume of combustion gas	v_{ga}^0	[m^{3}N/kg]	3,68	3,89
7	Theoretical minimum volume of air necessary for the	L_{min}	[m^{3}N/kg]	2,56	2,74

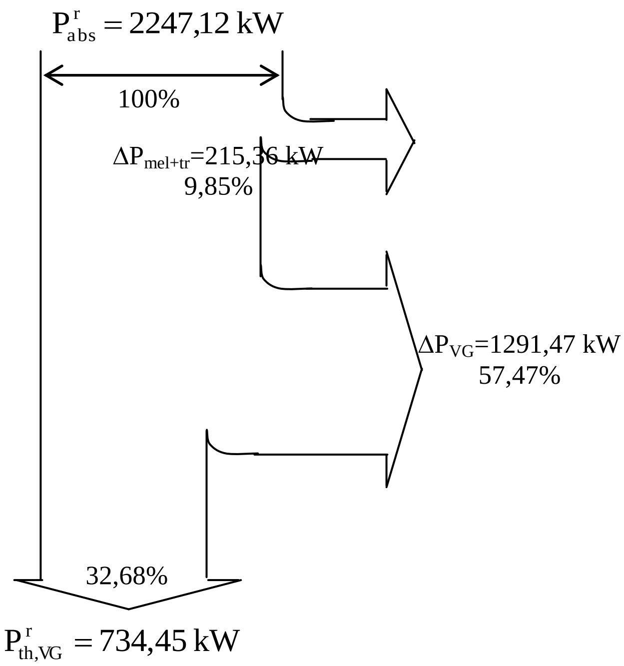
	combustion of fuel				
8	Gas fan power	P_{VG}	[kW]	2032,36	1691,53
9	Technological power of the gas fan	P_{th}	[kW]	734,45	518,68
10	Losses in electric driving motor of the gas fan	□$P_{m,el}$	[kW]	198,12	194,28
11	Losses in electric motor and fan motor transmission	□$P_{m,el+tr}$	[kW]	215,36	212,48
12	Losses in fan	□P_{VG}	[kW]	1291,47	1176,67

Table 5

No	**Measured value**	**Symbol**	**U.M.**	**Operating regime I**	**Operating regime II**
1	Power absorbed by the flue gas fan	P_{abs}	[kW]	2161,16	1864,58
2	Flue gas flow circulated by fan	D_{Vga}	[m^3/s]	335,47	295,82
3	Flue gas temperature to chimney	$T_{coș}$	[K]	445,35	452,65
4	Ambient temperature	T_{ma}	[K]	282,65	282,65
5	Theoretical flue gas volume	v_{ga}	[m^3N/kg]	4,7	5,6
6	Theoretical minimum volume of combustion gas	v^0_{ga}	[m^3N/kg]	3,68	3,89
7	Theoretical minimum volume of air necessary for the combustion of fuel	L_{min}	[m^3N/kg]	2,56	2,74
8	Gas fan power	P_{VG}	[kW]	1972,44	1668,56
9	Technological power of the gas fan	P_{th}	[kW]	711,42	518,37
10	Losses in electric driving motor of the gas fan	□$P_{m,el}$	[kW]	180,29	192,58
11	Losses in electric motor and fan motor transmission	□$P_{m,el+tr}$	[kW]	209,56	205,49
12	Losses in fan	□P_{VG}	[kW]	1253,38	1149,44

3.CONCLUSIONS

In figure 1 is presented the diagram Sankey for No.1 and No.2 air fans analyzed.



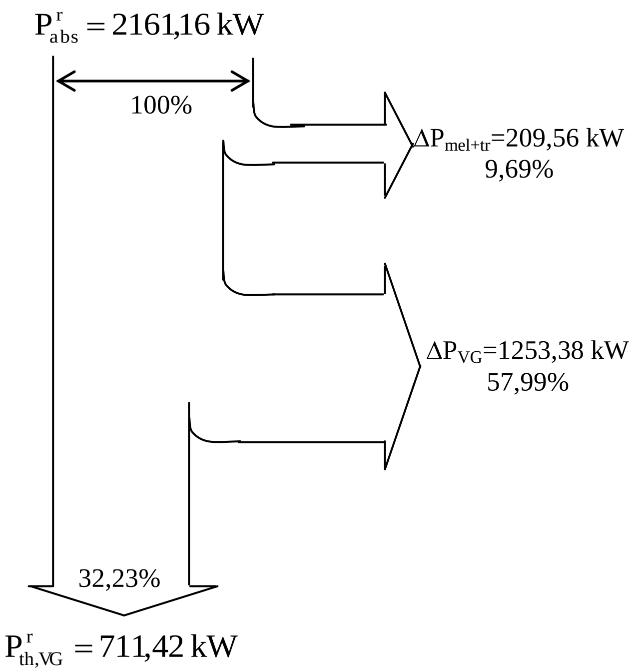


Figure 1

Analyzing the use of electricity can result the following conclusions:

- The losses in electrical installations are relatively large; it can be observed the influence of machinery life-long use, with effect in increasing of technological losses;
- Can be observed lower yields for both fans of air between 0,39□0,43 below their project value of 0.88

  To reduce energy consumption it is recommended:
- Achieve operating at full capacity of the flue gas fan
- Making regular cleaning of flue gas fan to reduce the influence of deposits of scum
- Monitoring the electricity consumption.

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