THE EXERGETIC EVALUATION FOR THE STEAM BOILER

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Abstract: - This work presents the exergetic method of thermodynamic analysis applied generating steam in power plants. Using the result of the exergetic method, we emphasize the factors that reduce the fuel-steam conversion capacity.

Keywords: *steam boiler*, *thermodynamic analysis, exergy, exergetic evaluations, exergy loss, exergy destroyed*

1. Introduction

The exergetic analysis, as a thermodynamic analysis method, operates with different quantity of energy forms, ignoring the quality characteristics contained by this flows.

This classic way of approach leads to wrong appreciation of the thermodynamic efficiency coefficient, along with the negative consequences that follows.

The exergetic analysis of a thermo-electric plant presents the condenser as the main element responsible for the system loss, without taking to account of the thermal potential of the transferred heat to the environment, the exergetic analysis will evaluate the flows, that passes through the system, quantitative – qualitative.

Will be identified the plant components that are degrading the fuel – product conversion potential. The condenser will have an insignificant weight, destroying 3% of the fuel delivered exergy, the boiler being responsible for the most significant exergy depreciation (approximately 55% from the delivered fuel energy)

Because the boiler degrades a high quantum of exergy, results the necessity of emphasizing the irreversibility generating factors and implicit the possible measures outline for the thermo-economic efficiency.

2. The boilers exergetic balance sheet

The first step that has to be made to draw out the exergetic balance sheet is to establish the balance sheet outline and its references parameters.The environmental references state (for the draw out analysis moment) is characterized by the following atmospheric parameters: $t=25^{o}C$, $p=1$ bar, $\varphi = 75$ %.

Function of this parameters and hummed air diagrams, the hydrologic reference state will be characterized by: $t = 20\ ^{0}C$, $p = 1$ bar.

Another necessary stage for the exergetic balance sheet is the identification of the exergetic consumptions and products afferent for each component of the analyzed system.

For a component element of the analyzed unit, the product represents its existence purpose and function, and the consumption is represented of all exergetic resources used for the generation of useful effect (the product).

The correct establish of the combustible and produced exegetic flows will be leading, by balance sheet, to the determination of the lost and destroyed exergetic flows by each analyzed component, an extremely important indicator for the appreciation of irreversibility influence on the analyzed process.

Due the structural-functional complexity of the boiler, it will be studied on its elements components: focus, vaporizer, drum, overheat, heat-saver, air preheat.

For the fluids that are evolving in the plant the exergetic flows will be determined on the basis of the thermo-mechanical exergy definition relation, and for a fuel will be considered the chemical exergy that is identical with low caloric power.

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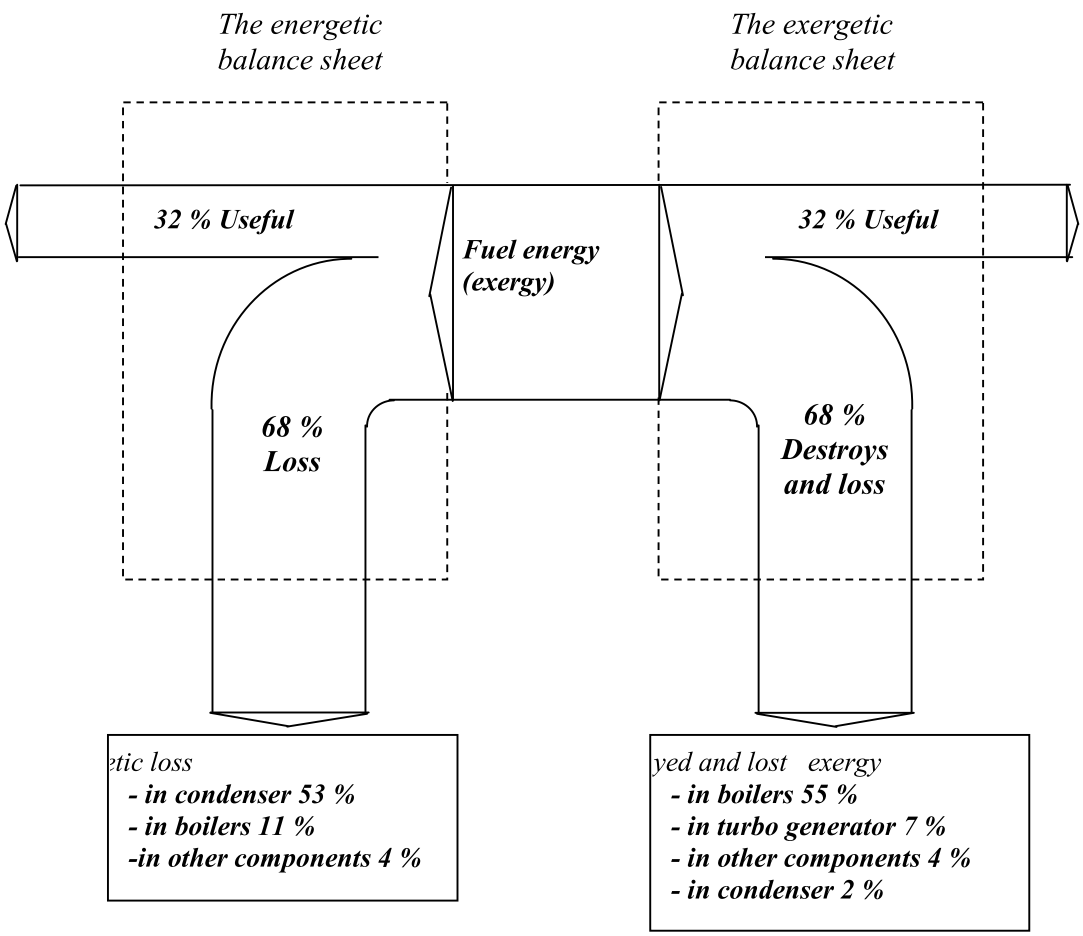

Fig. 1. The energetic - exergetic balance sheet

Table. 1. The exergy depreciation in the steam boiler

Component	*Irreversibility*	*Irreversibility generating factors*	*The exergetic relative destroys [%]*
Focus	*Combustion*	*Combustion, incomplete and imperfect chemical burn, losses by the external cover of the boiler*	*17*
Vaporizer	*Heat exchange*	*High differences of temperature between combustion gases and water*	*14*
Overheat	*Heat exchange*	*High differences of temperature between combustion gases and water*	*9*
Drum	*Mixture*	*Mixture*	*3*
Heat-saver	*Heat exchange*	*High differences of temperature between combustion gases and water*	*6*
Air preheat	*Heat exchange*	*High differences of temperature between combustion gases and water*	*4*

Table. 2. The exergy depreciation in the steam boiler

Component	*Losses*	*The losses generating factors*	*Exergetic relative losses [%]*
Stuck	*Evacuation*	*Evacuation of combustion gases*	*2*

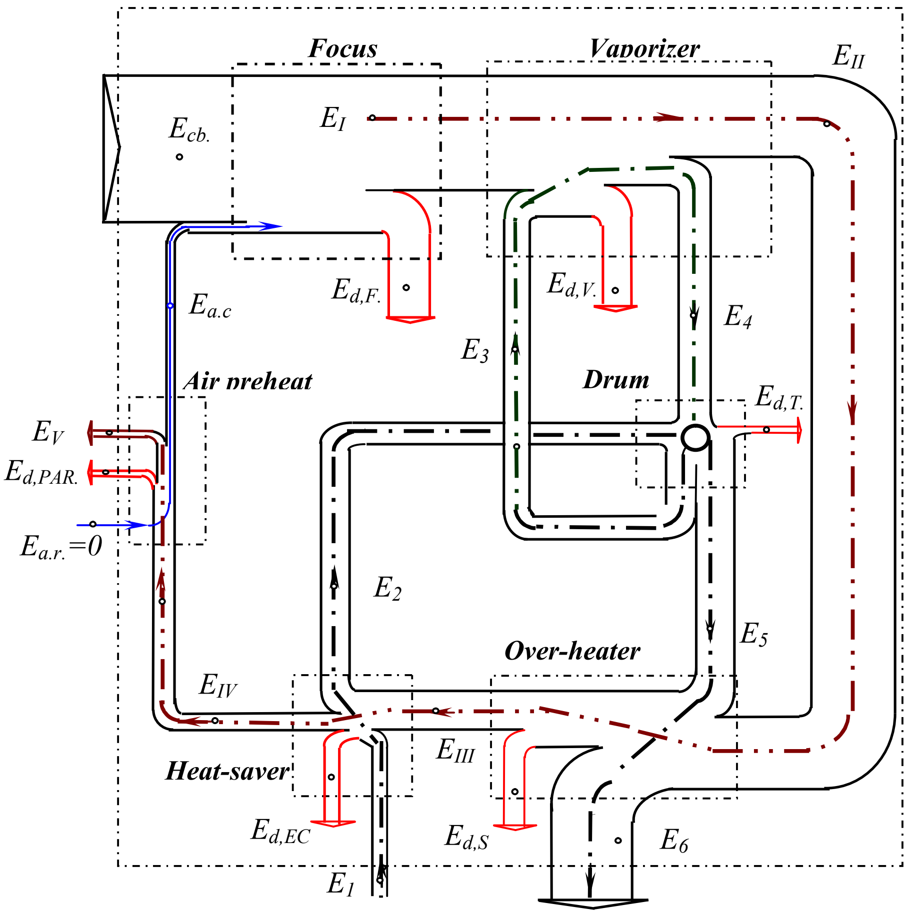

Fig. 2. The scheme of exergetic flows evolution in the boilers

Legend:

Air

Water, steam

Burn gases

$E_{cb.}$[kW] fuel exergy;

E_I [kW] combustion gases formed in focus exergy;

E_{II} [kW] combustion gases evacuated from the vaporizer exergy;

E_{III} [kW] combustion gases evacuated from the over-heater exergy;

E_{IV} [kW] combustion gases evacuated from the heat-saver exergy;

E_V [kW] combustion gases evacuated at the stuck exergy;

E_l [kW] feeding water exergy

E_2 [kW] feeding water exergy at the exit from heat-saver;

E_3 [kW] feeding water exergy at the exit from the boiler drum;

E_4 [kW] produced steam exergy at the exit from the vaporizator;

E_5 [kW] saturated steam exergy;E_6 [kW] over-heat steam exergy;

$E_{a.r.}$ [kW]atmospheric air exergy;

$E_{a.c.}$ [kW] pre-heated air exergy;

$E_{d,F.}$ [kW] focus destroyed exergy;

$E_{d,V.}$ [kW] vaporizer destroyed exergy;

$E_{d,T.}$ [kW]drum destroyed exergy;

$E_{d,S.I..}$ [kW] over heater destroyed exergy;

$E_{d,E.C..}$ [kW] heat saver destroyed exergy;

$E_{d,PAR.}$ [kW] air pre-heater destroyed exergy;

3. CONCLUSIONS

The exergy degradation, as the scheme of exergetic flows evolution in the boiler shows, is caused by the irreversible process of combustion, heat exchange between combustion gases and water (steam), heat exchange between combustion gases and air, as well as the mixture process.

Due to the low thermal potential of the combustion gases at the exit of the boiler, the exergy that is contained by those will be insignificant, losing approximate 2% from the exergy delivered to the steam generator. It is known that combustion irreversibility manifest itself by this: in the moment combustion gases are formed, a part of the elements exergy that takes part of combustion wont be found in the combustion gases.

The measures that has to be made for the combustion irreversibility decrease, are those that have as target the increase of maximum temperature of combustion gases, measures that lies on assurance of conditions for complete and perfect combustion with an minimum air ration, on the decrease of losses thru the external surface in the chamber where combustion takes place, on high grades of reactants pre-heating.

All this measures that have as a purpose the decrease of exergy destroys in the combustion process, can lead to the transformation of the saved exergy into anergy because of the heat exchange process that follows the combustion process.

The irreversibility of the heat exchange process is caused by the finite differences on which takes place the heat exchange between the agents, the combustion gases temperature increase leads to the increase of destroyed exergy by heat exchange. It is observed that a measure efficient for a thermodynamic process, may have contrary manifestation in other processes, by this results the necessity of studies for the minimize of destroyed exergy on the whole process.

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