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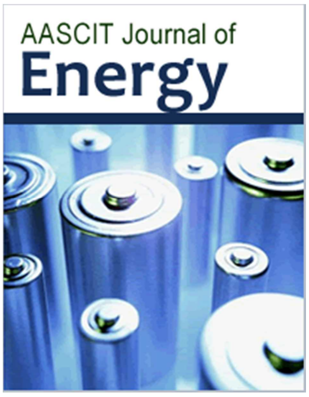

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Management of thermal quantity of hydrogen and sulphur during combustion of Kosova's lignite

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Abstract
The aim of paper is analyzing the issue related to the management of effective thermal quantity during lignite combustion and emissions of gases that are product of complete and non-complete combustion of lignite in the boilers. The real thermal amount of total burning lignite is 7524 kJ kg^{-1}. Thus, the losses of thermal quantity at ignition and during combustion of lignite directly depend on the diameter of lignite pieces intended for combustion. Paper contains the analyses of the thermal value, the composition of combustible and non-combustible matters of Kosova's lignite. The research on theoretical and practical field of management of thermal quantity of lignite is based and verified by DIN 1942, 1952, 1956 standards which describe effective thermal quantity. The paper reflects positively on management of the effective thermal quantity.

1. Introduction

Boilers, combustion of lignite coal and its components in "Kosovo Energy Corporation" are basic processes for economic and environmental sustainability of Energetic Corporation. The paper discusses the combustion process of hydrogen and sulphur in oxidizing zone while is minimized the carbon combustion associated with hydrogen. The main subject of this paper is related to the chemical composition, power and thermal value of lignite coal which is 7524 kJ kg^{-1} and depends on the percentage of carbon, hydrogen, sulphur, moisture and sterile parts. [1,2]

In particular will be analyzed the balance of thermal quantity for hydrogen and sulphur, of Kosova lignite. During complete combustion of hydrogen is acquired the good utilization of thermal quantity and as product we have gases with minimal thermal quantity. Furthermore is analyzed the amount of thermal balance of sulphur combustion, whereas as products are benefited sulphur oxides and sulphur, also appears that the thermal amount is lost during the combustion process in boilers. With incomplete combustion we will have gases richer with carbon monoxide, hydrogen and sulphur, which carrying away the thermal quantity in environment, pollute the environment and reduce economic sustainability in the technological process in energetic corporations. [3,5,10]

2. The Composition of Fuel

The main components of the fuel are carbon, hydrogen, sulphur, moisture and heterogeneous composition of oxygen, nitrogen and ash. The high content of moisture and ash in fuel, reduce its quality and is high impact factors for the quality determination [4].

2.1. Analytical Composition the Lignite

Lignite as fuel is composed of non-combustible and combustible matters which determine its thermal value. Carbon in the fuel is a free and as such is determining the thermal value of the fuel, is also associated with hydrogen as methane, ethane, propane, etc. (2.1)

$$C+H+O+N+S+W+A=100\% \quad (2.1)$$

Based on the analysis such as experimental, analytical and XR, [2,5] which are realized at the Laboratory of Energetic Corporation of Kosovo, results that the Kosova's lignite has the average percentage of elements that are described in bellow table (2.1):

Table 2.1. *Average percentage of elements in lignite*

Element	C	H	O	N	S	W	A
Percentage %	27	2.20	13,63	0,0100	0,63	40,7	14,8

3. Combustion of Lignite

Combustion of the lignite coal is a complex process and includes 4 zones: heating zone, reductionzone, oxidation zone and ash zone.

Oxidation – combustion zone is subject of studying in this paper.

During the complete combustion of lignite as products are obtained CO_2 and H_2O, whereas during the incomplete combustion of lignite products are CO and H_2.[6,7]

3.1. Combustion of Hydrogen

Hydrogen is matter that burns in fuels, is located as free and associated with other fuel elements. [6,8]

Complete combustion of hydrogen is accomplished by reaction (3.1).

$$H_2 + O= H_2O \qquad \Delta H =2416.04 \text{ kJ.} \quad (3.1)$$

To find the enthalpy for absolute combustion of one kilogram of hydrogen below expression is used (3.2):

$$\Delta H_H = 2416.04 \text{ x } 100\%/MWH \text{ kJ/kg} \quad (3.2)$$

100%- is percentage of hydrogen associated with the oxygen (complete combustion of hydrogen)

MWH- is molecular weight of hydrogen

Hydrogen enthalpy for complete combustion is described through the expression (3.3).

$$\Delta H_H = 2416.04 \text{ x } 100\%/PMH=2416.04 \text{ x } 1//2= 1208.02 \text{ kJ/kg} \quad (3.3)$$

Alternative I with relative combustion, where 80% of hydrogen is related to oxygen, then enthalpy is described through the expression (3.4):

$$\Delta H_H'=2416.04 \text{ x } 80\%/PMH=966.41 \text{ kJ/kg} \quad (3.4)$$

Alternative II with low combustion, where 50% of hydrogen is related to oxygen, then enthalpy is described through the expression (3.5):

$$\Delta H''_H= 2416.04 \text{ x } 50\%/PMH=604.01 \text{ kJ/kg} \quad (3.5)$$

To find the thermal quantity earned with combustion of hydrogen we use the expression (3.6):

$$Q= m \text{ x } \Delta H \text{ kJ/h} \quad (3.6)$$

m-weight of hydrogen

ΔH-enthalpy

By 100% hydrogen combustion, the thermal amount earned is based in expression (3.7):

$$Q=100\% \text{ x } \Delta H_H= 1208.02 \text{ kJ/h} \quad (3.7)$$

Alternative I with 80% of hydrogen combustion, the thermal amount earned is realized according the expression

$$Q'=80\% \text{ x } \Delta H'_H=773.13 \text{ kJ/h} \quad (3.8)$$

Alternative II with 50% of hydrogen combustion, the thermal amount earned is realized according the expression (3.9) :

$$Q''=50\% \text{ x } \Delta H''_C= 302.005 \text{ kJ/h} \quad (3.9)$$

3.2. Combustion of Sulphur

Sulphur as an element in the composition of lignite is matter that is burned and release thermal quantity, which should be well used in the process of lignite combustion in boilers. Sulphur in fuels is located as free and as sulphate, which is considered as mineral matter with negative effects on the quality of fuel and in the environment. [6,8]

Combustion of sulphur becomes by the reaction (3.10):

$$S+O_2 =SO_2 \quad \Delta H =279 \text{ kJ} \quad (3.10)$$

To find the enthalpy for the complete combustion of one kilogram of sulphur is used the expression (3.11):

$$\Delta H_S= 279 \text{ x } 100\%/MWS \text{ kJ/kg} \quad (3.11)$$

100% - is sulphur percentage associated with oxygen (complete combustion of sulphur).

MWS- is molecular weight of sulphur

To find the enthalpy for the complete combustion of one kilogram of sulphur is used the expression (3.12):

$$\Delta H_S=279 \text{ x } 100\%/PMS=279 \text{ x } 1/32= 87.187 \text{ kJ/kg} \quad (3.12)$$

Alternative I with relative combustion, where 80% of sulphur is associated with oxygen, then enthalpy is calculated through the expression (3.13):

$$\Delta H'_S =279 \text{ x } 80\%/PMS= 69.75 \text{ kJ/kg} \quad (3.13)$$

Alternative II with poor combustion, where 50% of sulphur is associated with oxygen, then enthalpy is is calculated through the expression (3.14):

$$\Delta H''_S = 279 \text{ x } 50\%/PMS=43.53 \text{ kJ/kg} \quad (3.14)$$

To find the thermal amount earned during sulphur combustion the below expression is used (3.15):

$$Q= m \text{ x } \Delta H_S \text{ kJ/h} \quad (3.15)$$

m-weight of sulphur ,
ΔH_S - enthalpy of Sulphur
By 100% of sulphur combustion, the thermal amount earned is based in expression (3.16) :

$$Q=100\% \text{ x } \Delta H_S =87.187 \text{ kJ/h} \quad (3.16)$$

Alternative I with 80% of sulphur combustion the thermal amount earned is based in expression (3.17) :

$$Q'=80\% \text{x } \Delta H'_S =55.8 \text{ kJ/h} \quad (3.17)$$

Alternative II with 50% of sulphur combustion the thermal amount earned is based in expression (3.18) :

$$Q''=50\% \text{x } \Delta H''_S=21.76 \text{ kJ/h} \quad (3.18)$$

Table 3.1 and figure3.1, presents the data related the thermal quantity gained by combustion of hydrogen and sulphur

Table 3.1. *Thermal quantity of hydrogen and sulphur combustion*

Percentage of hydrogen and sulphur combustion (%)	Weight of hydrogen and sulphur (kg)	Enthalpy of hydrogen (kJ/kg)	Enthalpy of sulphur (kJ/kg)	Earned quantity for hydrogen (kJ/h)	Earned quantity for sulpfur (kJ/h)
100	1	1208.02	87.187	1208.02	87.187
80	0.8	966.41	69.75	773.13	55.82
50	0.5	604.01	43.53	302.005	21.76

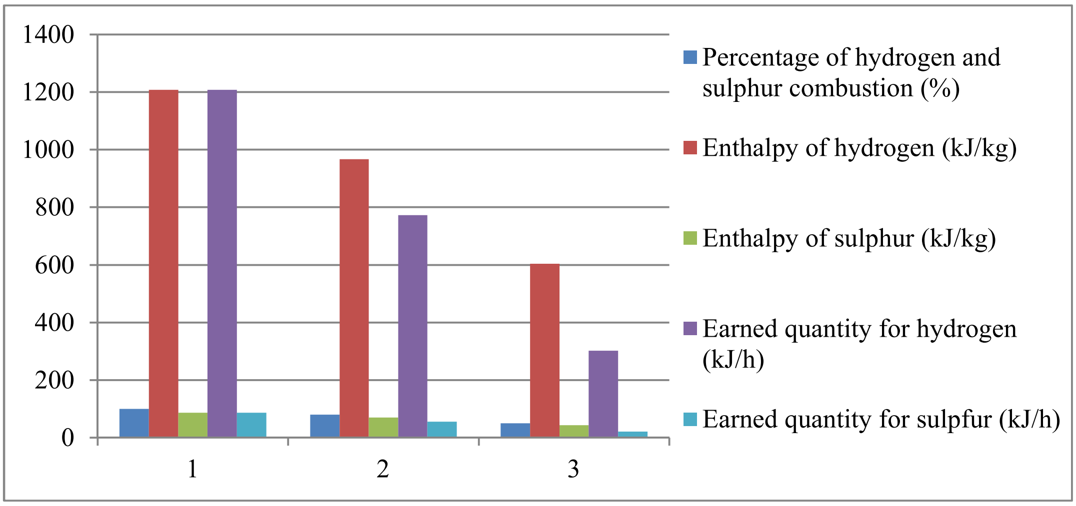

Figure 3.1. *Thermal quantity of hydrogen and sulphur combustion*

4. Balance of Thermal Quantity

Analytical and graphical analysis of hydrogen and sulfur combustion in the oxidation zone, treating the management of the lignite combustion process in boilers in this zone [7,9]. Furthermore, is analyzed in details the thermal quantity gained with combustion of hydrogen and sulpur and is proven to have different values. This changing of thermal quantity is the potential for losses, or thermal quantity without the well managed of process of lignite combustion in boilers. The data related to this issue are presented in table 4.1 and figure 4.1.

Table 4.1. *Changing of thermal quantity eraned with H and S combustion*

Percentage of hydrogen and sulphur combustion (%)	Thermal quantity earned with hydrogen combustion (kJ/h)	Thermal quantity earned with sulphur combustion (kJ/h)	Changing of thermal quantity (kJ/h)
100	1208.02	87.187	1120.833
80	773.17	55.82	717.35
50	302.005	21.76	280.25

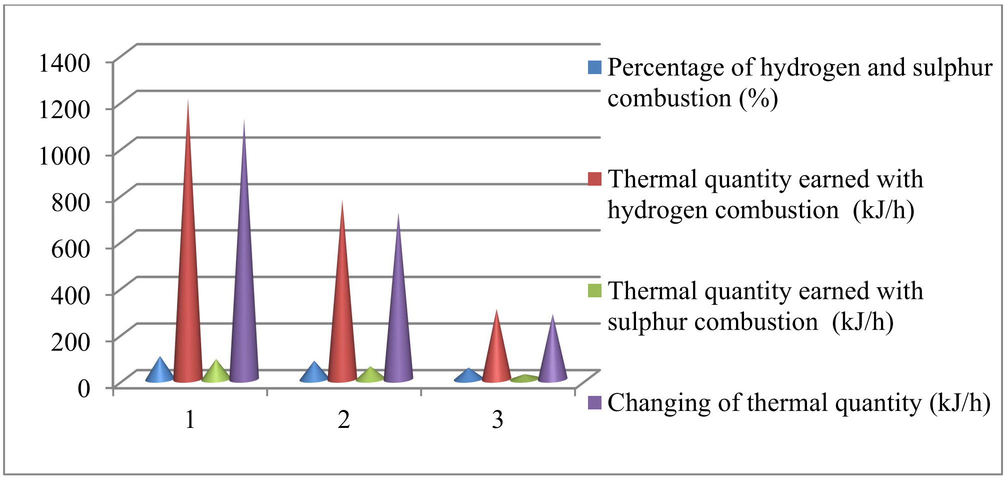

Figure 4.1. *Changing of thermal quantity earned with H and S combustion*

Based on the analysis of sulphur and hydrogen combustion and thermal value gained with their combustion, and the thermal value of the lignite basin of Kosovo is treated the thermal amount gained with complete and incomplete combustion of hydrogen and sulphur. Furthermore is treated the remaining quantity of the thermal value ,which is unused during the technological process of hydrogen and sulphur combustion in oxidizing zone that is potential for losses and for environmental pollution. The data related to this issue are presented in table 4.2 and figure 4.2.

Table 4.2. *Remaining quantity of the thermal value of H and S during combustion*

Percentage of H and S combustion (%)	H and S weight (kg)	Remaining thermal quantity of H (kJ/h)	Remaining thermal quantity of S (kJ/h)
100	1	0	0
80	0.8	434.99	31.357
50	0.5	906.05	65.4477

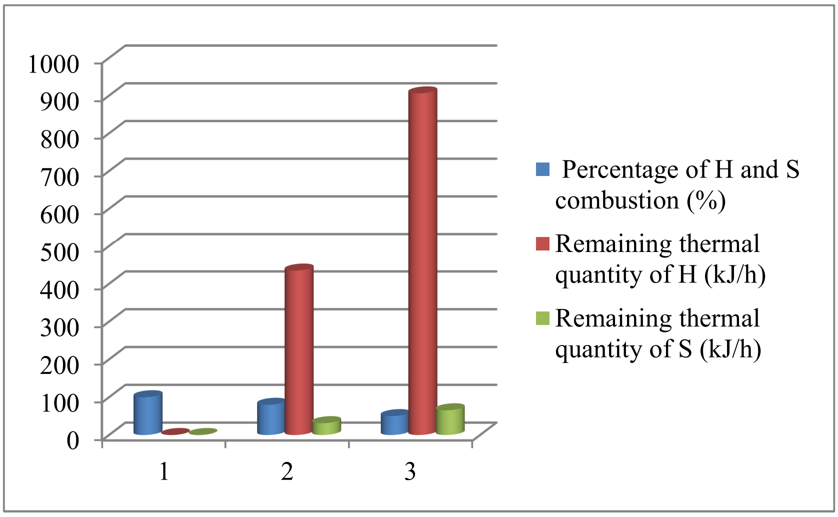

Figure 4.2. *Remaining quantity of the thermal value of H and S during combustion*

5. Impacts of Sulphur and Hydrogen in the Environment

Sulphur and hydrogen in Kosova's lignite, during the combustion process release the thermal amount that is managed to be transformed into electricity.

The combustion process of sulphur and hydrogen in boilers is inclined to the formation of gases, especially the oxide gases. [5,8]

Oxide gases of sulphur, occupying a special place in this paper related to the treatment, management and their impact on the environment.

The main characteristics of sulphur and hydrogen in normal conditions

1. Sulphur
   a) The melting point 115.21 ^{o}C,
   b) The boiling point 444.72 ^{o}C,
   c) The starting point of melting - 31.51 ^{o}C,
   d) The critical point - 1041 ^{o}C,

e) The powder density - 1960 kg/m^3,
f) The molar volume - 1553 cm^3,
g) The thermal conductivity - 0.205 W/m K.

2. Hydrogen
h) The melting point - 259.2 °C,
i) The boiling point - 252.8 °C,
j) Density of powder hydrogen 8.99 kg/m^3,
k) Molar volume - is associated with air,
l) The thermal conductivity – easy combustion

The main parameters of the elements that result in the creation and emission of gases, that polluting the environment are the melting point and thermal conductivity table 5.1 and figure 5.1.

Table 5.1. *Melting point and thermal conductivity of S and H*

Element	Melting point (°C)	Thermal conductivity (W/m K)
Sulphur	115.21	0.205
Hydrogen	-259.2	Easily combustion

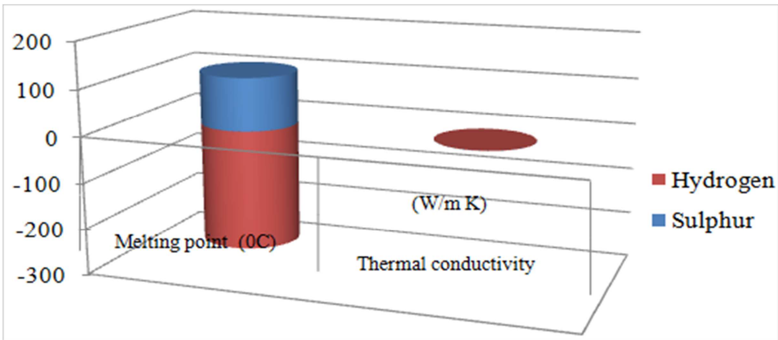

Figure 5.1. *Melting point and thermal conductivity of S and H*

5.1. Enthalpy of Elementary Sulphur and Hydrogen

The presence of sulphur and hydrogen in the environment as products of coal combustion in boilers, have their multi impacts on the environmental ecology. Based on the physical and chemical properties, and technological process of hydrogen combustion, is minimized the impact of hydrogen on the environment.

Enthalpy for sulphur. Enthalpy of fusion (mixture) is 1.73 kJ mol^{-1}. Enthalpy of evaporation is 9.8 kJ mol^{-1}. Enthalpy of powdering is 279 kJ mol^{-1} (table 5.2 and figure 5.2).

The hydrogen enthalpy. Enthalpy of mixture is minimized. Evaporation enthalpy is minimized. [3, 4]

Enthalpy of powdering is 2416.04 kJ mol-1. (table 5.2).

Table 5.2. *Enthalpy of S and H kJ kg^{-1}*

Element	Mixture Enthalpy kJ kg^{-1}	EvaporationEnthalpy kJ kg^{-1}	Powder Enthalpy kJ kg^{-1}
Sulphur	0.054	0.30	8.71
Hydrogen	0	0	1208.02

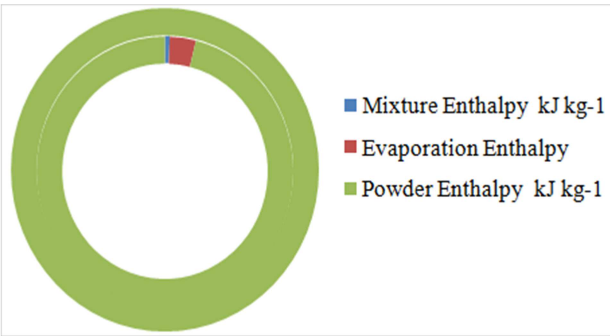

Figure 5.2. *Sulphur and hydrogen enthalpy kJ kg^{-1}*

6. Conclusion

The paper analyzes the effective thermal value that depends on the percentage of combustion matters and necessary amount of air entered in technological process for the lignite combustion process. In particular in this paper is analyzed the thermal amount that is gained with the complete and incomplete combustion of hydrogen and sulphur, as well and gases released in the oxidation zone during technological process. As a result of analytical and graphical analyzes, led us to conclude that with the complete hydrogen combustion the thermal amount earned is 1208.02 kJ / h, while with the complete sulphur combustion the thermal amount earned is

87. 187 kJ / h. Grounded on the thermal value and its use during the combustion of hydrogen and sulphur, and obtained results will be an overview as follows. With complete combustion of hydrogen use of the thermal value of coal is comprehensive and has an average value of 4.12%. While with the complete combustion of sulphur, use of the thermal value of the coal is weaker and has an average value of 0.297%.

It can be concluded, that with the complete hydrogen combustion, we will have a good use of the thermal quantities during the combustion process of the coal. Complete combustion of sulphur which results with lower thermal value, does not have any major impact on the thermal amount of lignite combustion process in boilers. Sulphur and its oxide gases have huge impact on environmental pollution. The paper as such reflects positively on the management and utilization of the thermal amount in the oxidation zone of boilers and closely is associated to positive effects on the economic and environmental sustainability.

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