Comparative analysis of boiler efficiency between commercial sawdust briquettes and biomass briquettes

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Comparative Analysis of Boiler Efficiency between Commercial Sawdust Briquettes and Biomass Briquettes

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Abstract: During this research work, a theoretical study was done to compare the boiler efficiency by using two different fuels, i.e. commercial sawdust briquette and biomass briquette prepared using 850 µ coconut leaves, with sawdust as binder. For preparing the biomass briquettes leaves of coconut were gathered, dried, milled and sieved and sizes of 850µ were selected. The sized coconut leaves were then mixed in the company of sawdust that worked as a binder in 1:2 ratios, and compressed by means of a piston type briquette machine, which was fabricated for the same. Ultimate and proximate analyses were carried out on the biomass briquette to determine their various compositions. Results from analysis were used to calculate the boiler efficiency by indirect method using Indian Standard Boiler Efficiency IS 8753. Results from analysis showed that, boiler efficiency by indirect method for commercial sawdust briquette is 68.80% and boiler efficiency by indirect method for coconut leaves of 850µ, with sawdust as binder is 61.17%. The reason for higher boiler efficiency for commercial sawdust briquette is due to its higher calorific value (4451.37KCal/gm) when compared to that coconut leaves briquettes made from 850µ size with sawdust as a binder (3672.45KCal/gm). From proximate and ultimate analysis, the results showed a reduction in ash content percentage, moisture content and rise in volatile matter percentage, when the comparison was along with the marketable sawdust briquette, which is of considerable significance. Additional properties akin to percentage of hydrogen, fixed carbon, sulphur, nitrogen and oxygen were roughly same as that of the commercially availablesawdust briquettes. After calculating the boiler efficiency of the two biomass briquettes, coconut leaves with sawdust as binder exhibited most optimistic trait and as it is more easily and readily available, thus making it more economically viable.

Keywords: Biomass, briquetting, proximate analysis, ultimate analysis and boiler efficiency.

INTRODUCTION

In every division of the globe, energy is necessary for the monetary and social progress and furthermore to build up the personal satisfaction of individuals [1].The greater contented a human life is that's paid by using excessive energy usage in all its form [2]. During the preceding four decades, researchers have been focusing on alternative fuel resources to meet up the growing energy demand and to keep away from reliance on crude oil [3].

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Energy generated usingbriquettes prepared from raw biomass is a promising option. The energy source origin from organic biomass substance like plant materials, wood from the forest, agriculturalprocess,industrial and human or animal ravage [4]. The best way and most promising technology for solving these problems is briquetting that has been deliberated by various research scholars [5]. The process in which raw biomass is compressed; to shape homogeneous solid fuels is called briquetting or densification. Due to compression, these briquettes havemore density and energy content and less moist when measured with itsoriginal form. The raw biomass can be briquetted by means of quite a lot of techniques, either by means of or devoid of binder addition [6].

A lot of researchers are working in the field of biomass briquettes. Various examples of biomass studies are waste paper along with coconut mixture [8], sawdust [7],cashew nut shell [11], cotton stalk [9], spear grass [10],jatropha seed husks [13] corn cobs and rice husks [12], coconut shell, cocoa shell, and newspapers [14],and numerous others.

In coconut production, India's contribution to the world is about 15.46% in area and 26.34% in terms of production. In India coconut is a cash crop to the farmers in the states of Karnataka, Kerala, Andhra Pradesh and Tamil Nadu.Amongst the four, Karnataka takes second position in terms of area(507 thousand hectare) and production (5893 million nuts). In Karnataka, Tumkur is the chief grower of coconut with the production of 13496lakh nuts, followed by Hassan and Chitradurga. These three districts collectively have a croparea of 247986ha. Production of coconut from Tumkur district is 30.6%, followed byHassan contributing 14.1% of the state area under coconut and production [15].

Biomass briquettes can be manufactured in different ways; there is no set formula for the same. Briquettes are prepared from existing accessible biomass, and hence will vary as of from place to place, thusallowing for generation of biomass energy,which does not necessitate hauling of purchased materials from far-flung spot [16].

The briquettes prepared using biomass serves the household purposes (cooking, heating, barbequing) as well as also industrialized sector (agro-industries, food processing) equally in rural and urban areas. The principal usage of briquettes for the most part is for replacing coal in manufacturing sector heat applications (steam generation, melting metals, space heating, brick kilns, tea curing, etc) and power generation through gasification of biomass briquettes. At the same time as biomasses is a renewable resource, these briquettes have better-quality and also they are environmental friendly in comparison with coal [17].

MATERIAL AND METHODS

In this experimental study, coconut leaves were obtained from a farm as shown in fig.1. In present scenario, coconut leaves are used to make temporary roofing, brooms or they are dumped as waste. Coconut leaves along with firewood aid in making of fire in rural areas, but as coconut leaves are burnt in slack form ensuing in environmental greenhouse gasses. These reasons and also as coconut leaves are easily available, they were chosen as the material for biomass briquette.

FIGURE 1: Coconut Leaf

The coconut leaves thus collected from farm were cut into minute pieces and sun dried for a few days and subsequently fed into a hammer mill. The milled coconut leaves are been sieved using ASTM E11 [18],and particle size of 850µ as shown in fig.2, was choosen for the intention of briquetting.

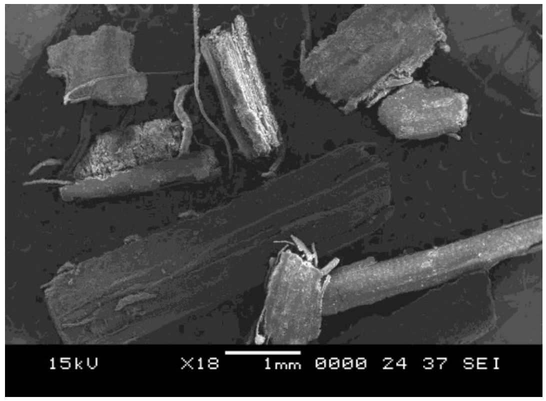

FIGURE 2: SEM images of Coconut Leaves of sizes 850µ

In this work, sawdust was used as a binding agent. The binding agent was mixed with biomass in the ratios 1:2, i.e., 100gms of coconut leaves and 50gms of sawdust alongside with the necessary amount of water. To ensure a proper mix, the mix of biomass, binders and water were stirred severely using a stirrer to guarantee an appropriate mix. To soften the whole blend, the concoction was set aside in a container for a couple of days. By using a piston type briquette, the softened mixture was formed into briquettes.

Per briquetting operation, one densified biomass briquette was produced as shown in fig 3. To get a stable briquette, the pressure on the biomass in the mold box was maintained for 5 minutes, and later the briquettes were taken out following the dwell time [19].

FIGURE 3: Briquette using coconut leaves

The wet briquettes were sun dried for 19days after been taken out of the mould cavity [20]. The damp weight and dried out weight of the briquettes prior to and following drying are as shown below in Table 1.

Table I: Wet Weight and Dry Weight of Coconut Leaves Briquette

Sl.No	**Type of briquette**	**Wet weight (kg)**	**Dry weight (kg)**
	Binder used: Saw dust		
1	Coconut leaves 850 µ	0.230	0.152

RESULT AND DISCUSSION

The gross calorific value were analyzed as per IS1448-7 [21],and proximate and ultimate analysis were done as per IS 1350 [22]on commercial sawdust briquette and 850 μ coconut leaves briquette with sawdust as binder are tabulated in Table 2 and 3.

Table II: Coconut Leaves briquette, when Sawdust is used as Binder

Sl.No	Parameters	Binders: Sawdust Coconut leaves 850μ
1	Gross calorific value kcal/gm	3672.41
	Proximate analysis, %	
1	Moisture content	6.90
2	Ash content	3.33
3	Volatile matter	85.05
4	Fixed carbon	4.72
Ultimate analysis, %		
1	Hydrogen	7.31
2	Nitrogen	0.40
3	Sulphur	0.59
4	Oxygen	20.92

Table III: Analysis Result for Sawdust Briquette Available in Market

Sl.No	Parameters	Commercial Sawdust briquette
1	Gross calorific value kcal/gm	4451.37
	Proximate analysis, %	
1	Moisture content	9.44
2	Ash content	3.36
3	Volatile matter	83.43
4	Fixed carbon	3.37
	Ultimate analysis, %	
1	Hydrogen	7.03
2	Nitrogen	0.43
3	Sulphur	0.58
4	Oxygen	21.77

The boiler efficiency of commercial sawdust has been done using the indirect method of estimation [23]. The analysis explored the boiler efficiency of commercial sawdust briquette and coconut leaves briquette prepared using 850µ, with sawdust as binder. A summary of the heat balance both are shown below in table 4 and 5.

Table IV: Summary of Heat Balance for Commercial Sawdust briquette

Input/output parameters	Kcal/kg of commercial sawdust briquette	% loss
Heat input	4451.37	100
Losses in boiler		
Heat loss in dry flue gas,L_1	600.48	13.49
Heat loss due to evaporation of water formed due to H_2 in fuel, L_2	449.58	10.10
Heat loss due to moisture present in fuel, L_3	66.77	1.50
Heat loss due to moisture present in air, L_4	22.70	0.51
Heat loss due to incomplete combustion,L_5	160.69	2.78
Heat loss due to radiation and convection, L_6	66.77	1.5
Heat loss due to unburnt in fly ash, L_7	0	0
Heat loss due to unburnt in bottom ash, L_8	21.81	0.49

Table V: Summary of Heat Balance for Coconut leaves briquette with sawdust as binder

Input/output parameters	Kcal/kg of commercial sawdust briquette	% loss
Heat input	3672.41	100
Losses in boiler		
Heat loss in dry flue gas, L_1	656.62	17.88
Heat loss due to evaporation of water formed due to H_2 in fuel, L_2	467.49	12.73
Heat loss due to moisture present in fuel, L_3	66.83	1.82
Heat loss due to moisture present in air, L_4	24.97	0.68
Heat loss due to incomplete combustion, L_5	133.30	3.58
Heat loss due to radiation and convection, L_6	66.67	1.5
Heat loss due to unburnt in fly ash, L_7	0	0
Heat loss due to unburnt in bottom ash, L_8	21.22	0.58

The comparison graphs obtained after the comparison between briquettes made from coconut leaf of size 850µ using sawdust as additive and wheat flour as a binder and commercially available sawdust briquette are shown below.

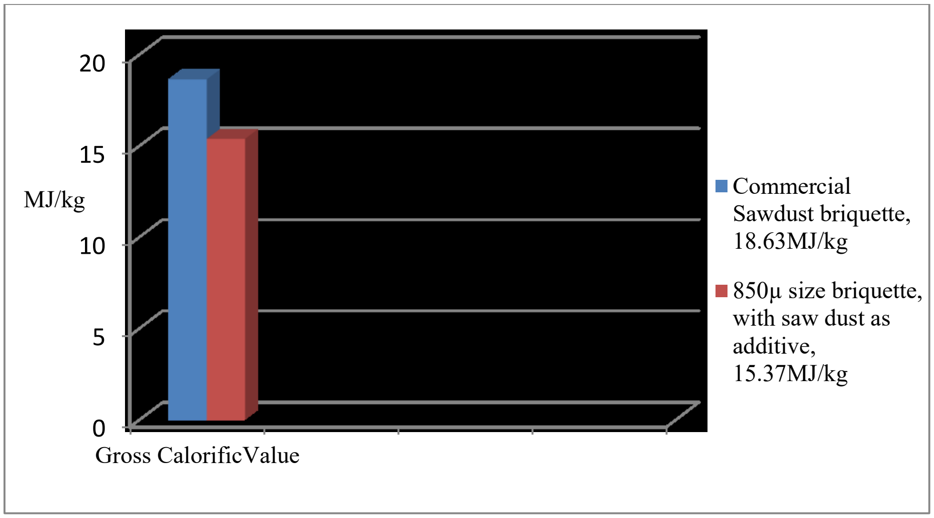

FIGURE 4: Heat Input

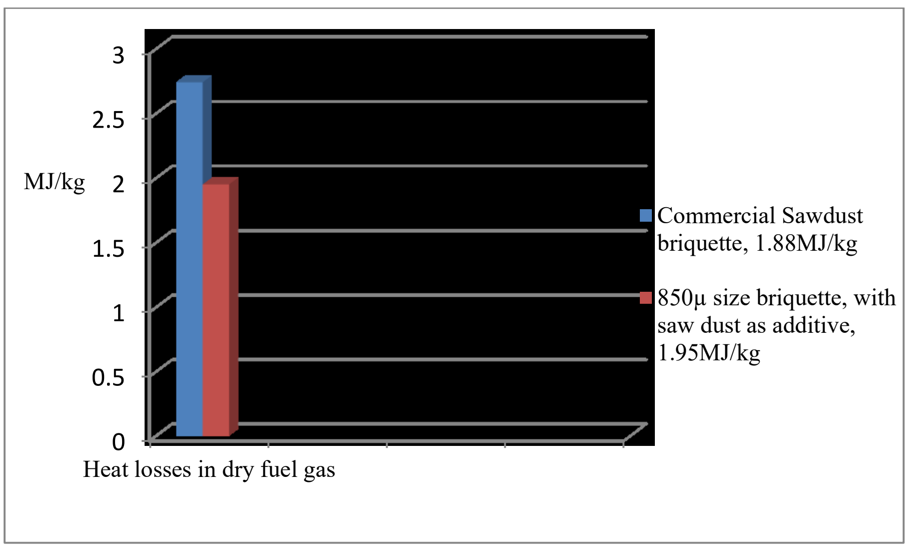

FIGURE 5: Heat losses in dry flue gas (L_1)

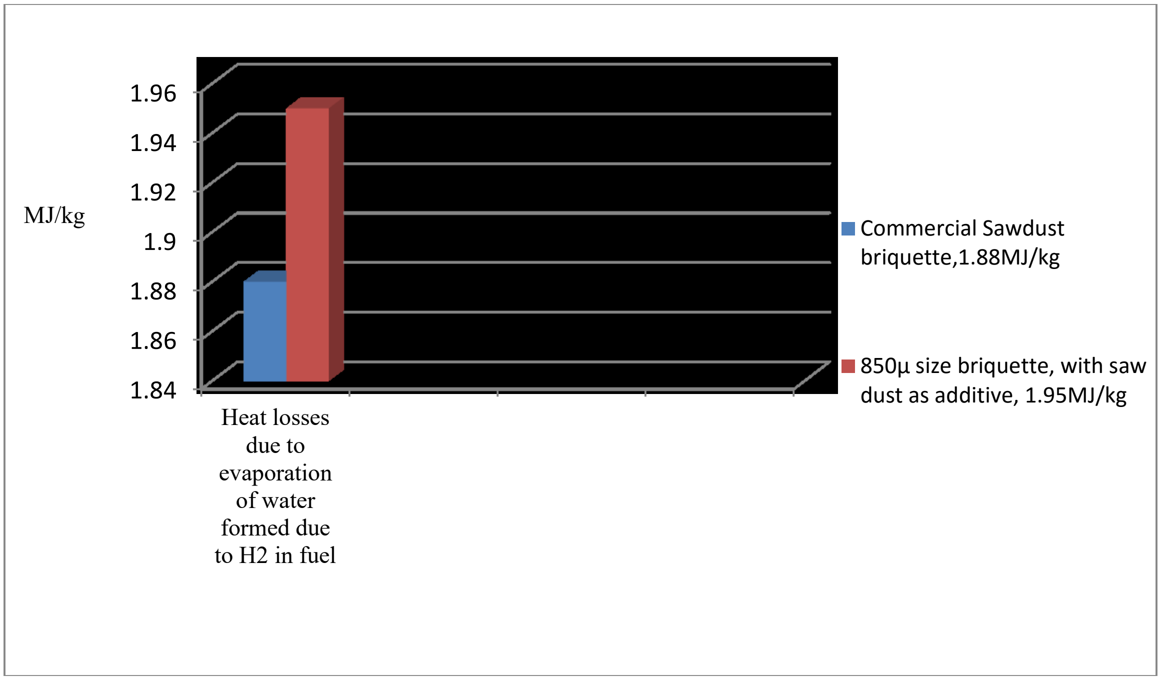

FIGURE 6: Heat losses due to evaporation of water formed due to H_2 in fuel (L_2)

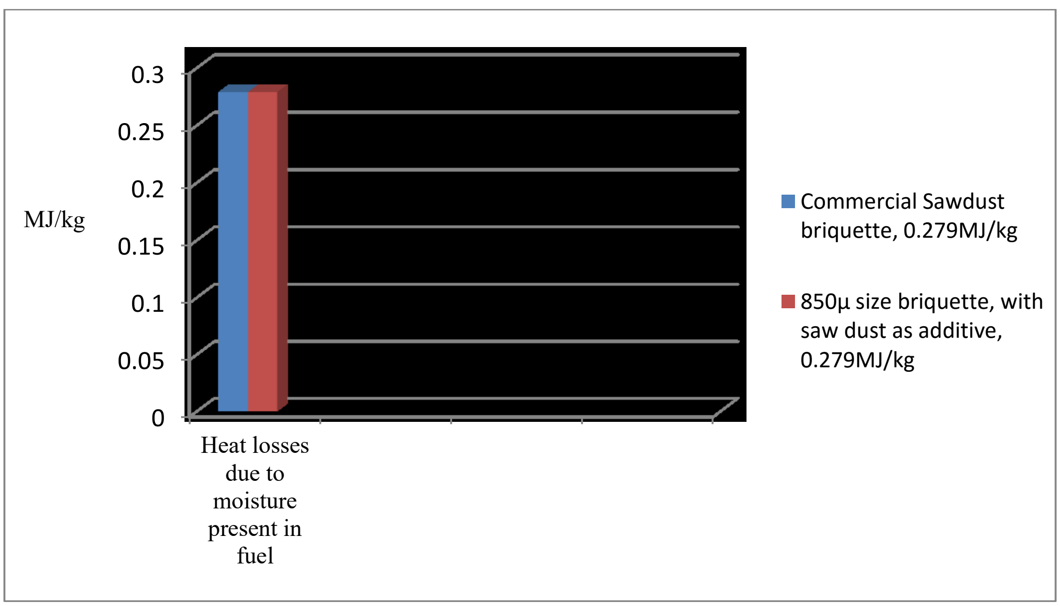

FIGURE 7: Heat losses due to moisture present in fuel (L_3)

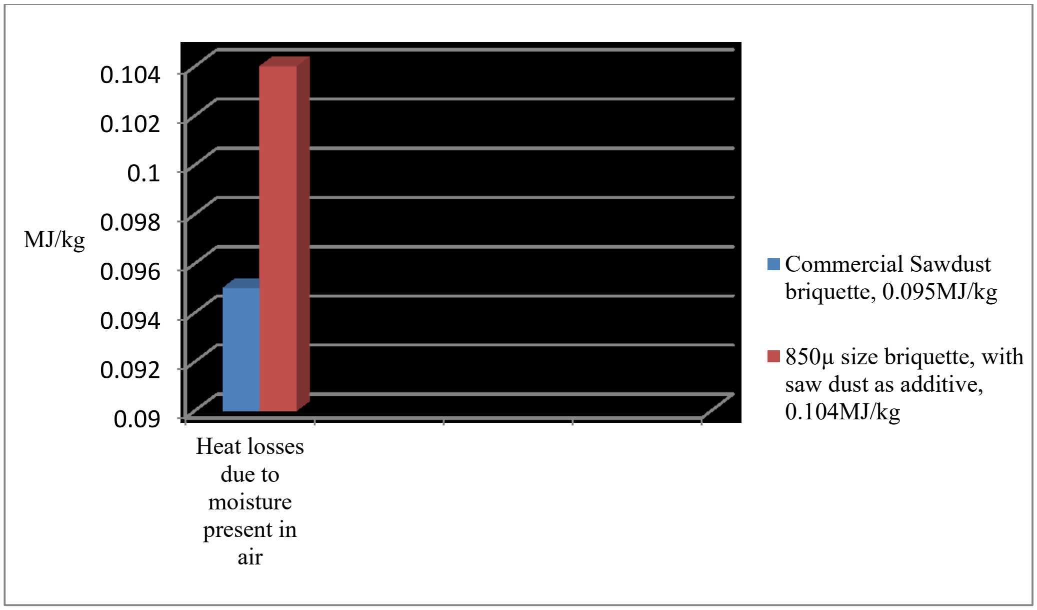

FIGURE 8: Heat losses due to moisture present in air (L_4)

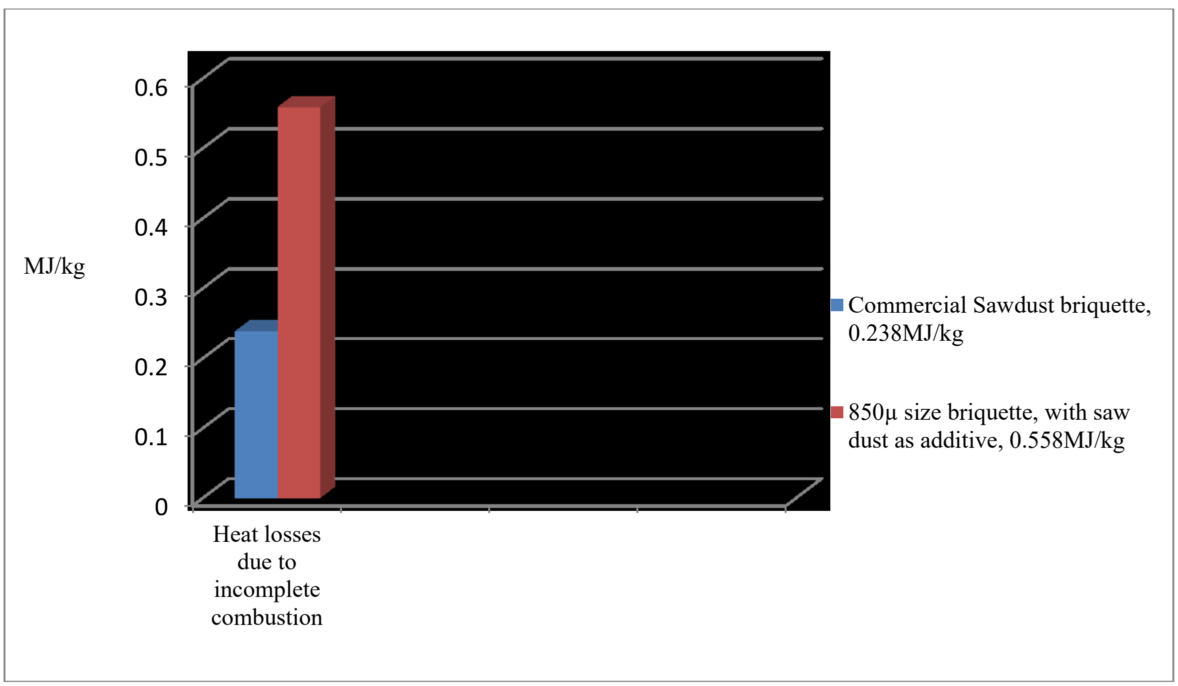

FIGURE 9: Heat losses due to incomplete combustion (L_5)

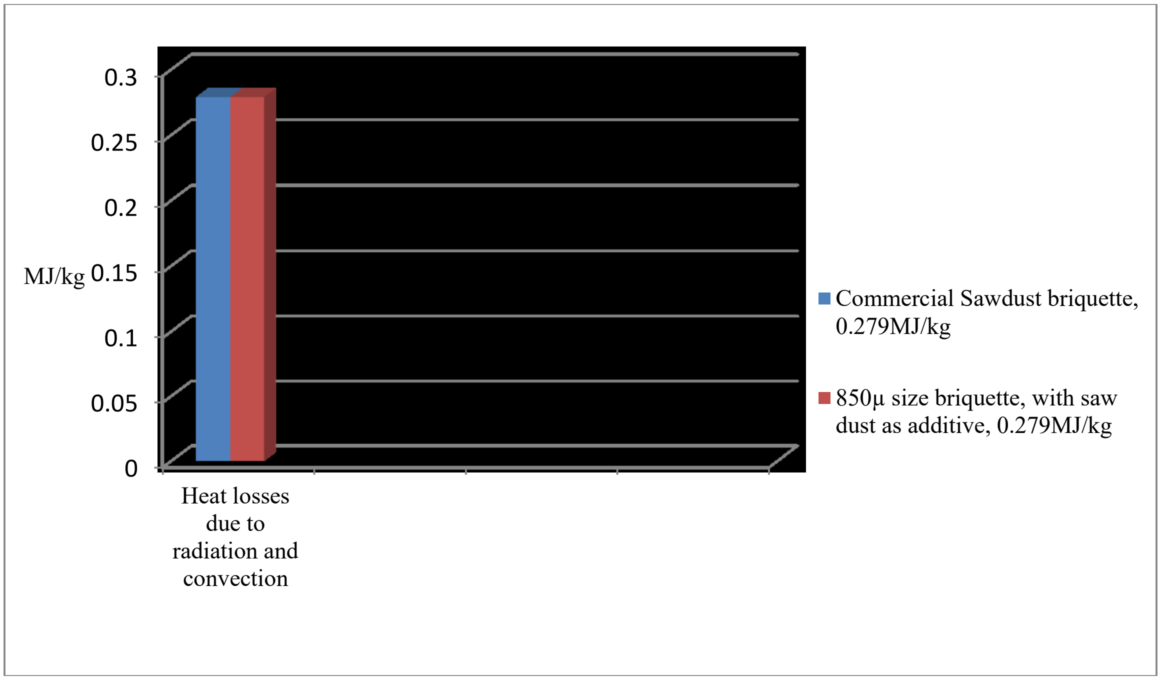

FIGURE 10: Heat losses due to radiation and convection (L_6)

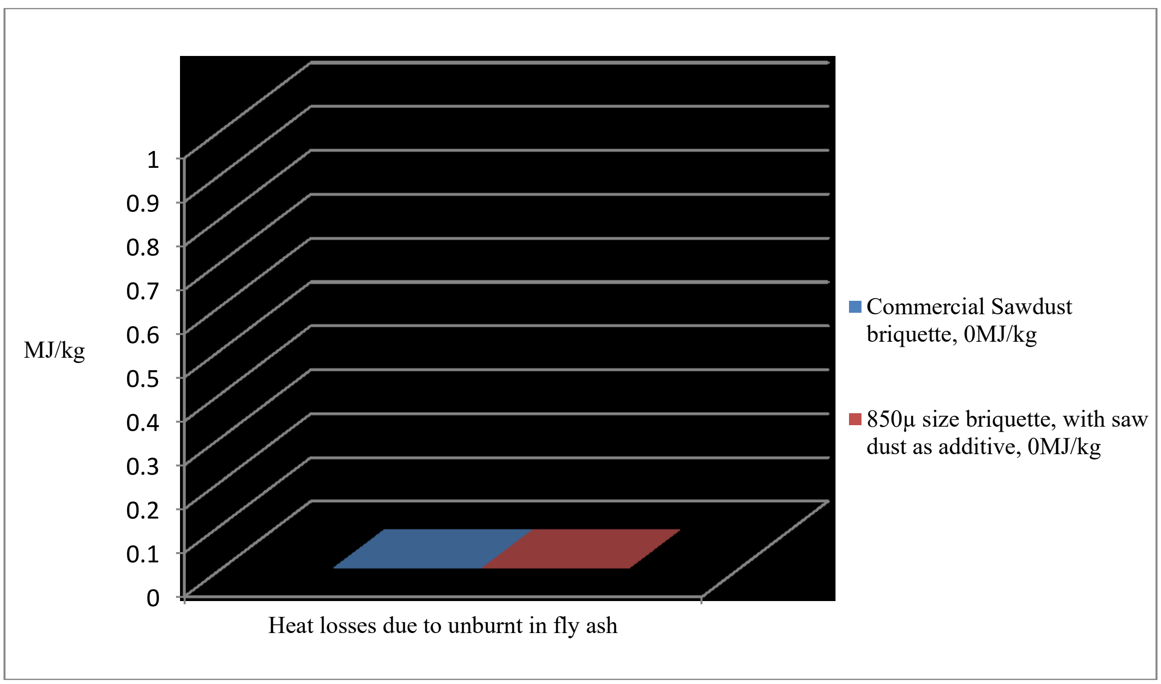

FIGURE 11: Heat losses due to unburnt in fly ash (L_7)

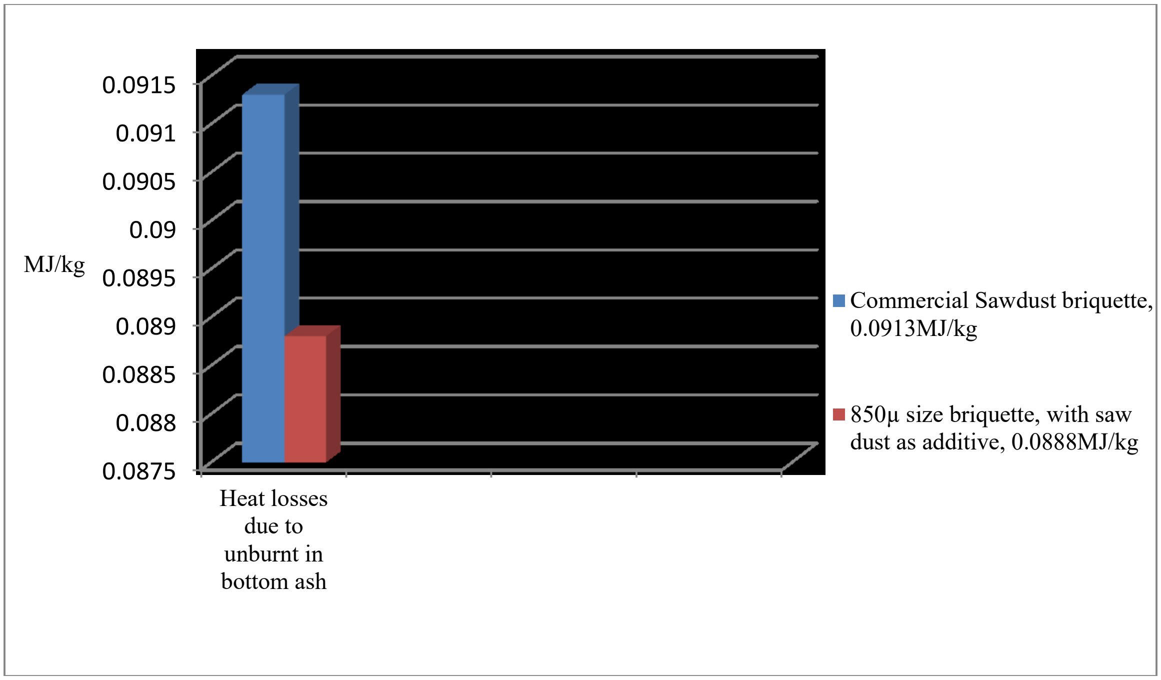

FIGURE 12: Heat losses due to unburnt in bottom ash (L_8)

From the comparison graphs drawn it can be concluded that results obtained depicts that the boiler efficiency by indirect method for commercial sawdust briquette is 70.01%, while that of briquettes made from coconut leaf of 850µ size with sawdust as binder is 61.76%.

Thus, it can be easily realized that even though commercial sawdust briquettes have higher efficiency compared with coconut leaves based briquettes, the boiler efficiency can be increased by increasing its calorific value, reducing heat loss in the dry flue gas, and heat loss due to evaporation of water formed because of H_2.

The reason for higher boiler efficiency of commercial sawdust briquette is owing to its elevated calorific value (18.63MJ/kg) when compared with briquettes prepared using coconut leaf of 850µ size by means of sawdust as a binder (15.37MJ/kg). The outcome from proximate and ultimate investigation shows that there was decline in moisture contentand ash content percentage and raise in volatile matter percentage, whilst compared with commercial sawdust briquette, which is of considerable importance. Additional properties like percentage of fixed carbon, hydrogen, nitrogen, sulphur, and oxygen were roughly the same as that of the commercial sawdust briquette. For the two materials, i.e. coconut leaf briquettes prepared using 850µ and commercially available sawdust briquette used in boilers, coconut leaves with sawdust as binder exhibited more positive attributes as it is more abundantly and easily available, thus making it more economically viable.

CONCLUSION

Thus, it can be found that coconut leaf briquettes can be a potential candidate for alternative biomass fuel. Furthermore, the fuel efficiency and combustion characteristics can be enhanced by means of optimal binders and additive to the raw materials. The study and result of these experiments have proved that briquettes produced from 850µ size coconut leaves using sawdust as an additive and wheat flour as binder can make good biomass fuels.

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