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Thermal and Mechanical Analysis on Palm Briquettes

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***Abstract* - Now we are getting more solid municipal and agricultural wastes. If we can utilize these solid wastes into useful energy resources, then the utilization of these resources along with renewable resources may increase the extinct period of non renewable resources. In this paper the wastes from the palm plantation are converted into briquettes by mixing them with screw pine powder, coconut coir, Indian bdellium powder and saw dust in different proportions. The mechanical and thermal analyses were conducted. Calorific value is calculated by both theoretically and experimentally.**
***Key words:* - palm plantation, screw pine, coconut coir, Indian Bdellium, saw dust, thermal analysis**

I. INTRODUCTION

Resources of energy are classified into renewable and non renewable. . At present we are depending mainly on non renewable resources for power generation. As we continuing this usage they may extinct in future. So we need to go for alternate energy sources.. If we can substitute the renewable resources to non-renewable at present for smaller applications we may increase the exhaust period of non-renewable resources. In developing countries we are obtaining more agricultural and municipal wastage which causes a lot of problem in dumping and in rural areas they burnt loose solid wastes cause a lot of pollution. Apart from the problems of transportation, storage, and handling, the direct burning of loose biomass in conventional grates is associated with very low thermal efficiency and widespread air pollution. If we utilize the solid wastes as an alternate or along with fossil fuels we may increase the extinct period or as an alternate to them. And also we may reduce the problem of dumping and pollution in rural areas. Hence the concept of briquettes was introduced.

Briquettes were made by densification of loose solid waste materials to dense compact solid structures. It has higher energy content and less moist content. We have different technologies for making of briquettes such as screw extrusion process, ramming process, hydraulic pressing, roller pressing and by pelton press and piston press [1]. Based on different technologies they are made at elevated temperatures [2]. If the moisture content is more in raw materials then we require more temperature while pressing. In some processes we need to use the binder materials such as starch, Maida flour, wheat flour etc.,[3]. The briquettes are mainly prepared by using rice husk, ground nut shells, saw dust, paper, sugarcane wastes, saw dust, crop wastes, etc. Briquettes also made by mixing those wastes with coal, lignite, seaweeds [4], cotton stalks, textile wastes [5] etc. As they are compressed and all the moisture is squeezed out hence emits less pollution. They will burn for longer time. No heat energy can be wasted, and it is utilized properly. In general, briquettes are of two types irrespective of their shape and size, one is compact solid block and other is concentric centered hole structure. Based on the type of material used they will contain higher heating value which can substitute coal for most of its applications and in boilers.

II. METHOD OF PREPARATION

A. Powder Preparation

Briquettes are prepared by using many wastes such as sawdust, rice husk papers etc., which are having some drawbacks such as if we use rice husk which contains silicon upon combustion produces silicon dioxide causes damages to the boiler shell. The saw dust briquettes are having low calorific value compared to others. Hence in this paper I used Palm branches mixed with coconut coir, sawdust, screw pine, Indian Bdellium tree powder with and without using binder material in different proportions.

Screw pine, Indian Bdellium tree powders are used as they catch fire quickly, while saw dust and coconut nut coir give more density, acts as binding agent to briquettes. The raw materials are palm branches, coconut coir, saw dust, screw pine, Indian Bdellium tree powder. The palm branches are dried and chopped into a fine powder by using paper machine. Then that powder is dried to remove the moisture content for 3-4 days. In the same manner the other ingredients are also dried for 3-4 days.

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Fig.1.Mixed powder of raw materials

B. Equipment Preparation

The die is of cylindrical in shape having dimensions of 15 cm (nearly 6 inches) diameter, 30.5 cm (12inches) height. The interior of die is very smooth. Many techniques are used such as ramming, screw press extrusion technique by preheating die and without preheating die. Other techniques like Peterson press (Daham Shyamalee et al.,, 2015), hydraulic press(C. Supann et al.,,2008). Basing on all the equipment designs I prepared my own set up for briquette preparation. The set up is prepared by using iron channels of 10cm (4 inches) width. Two iron channels of 127 cm (50 inches) long, other two iron channel of 46 cm (18 inches), 61 cm (24 inches) are taken and welded. A 100 ton hydraulic jack is used for compressing the powdered material. A supporting cylindrical rod is used and the total set up is prepared.

Fig.2. Experimental set up

C. Binder Material and Briquette Preparation

After the set up preparation the binder material is to be prepared from Maida flour poured in boiling water and the boiled starch are mixed with each other in the ratio of 1:1 until we get a paste. The saw dust, coconut coir powder, screw pine powder and bdellium powder are mixed in the ratio of 1:2:2:1. This mixture is again mixed with palm in different ratios of 100:0 with and without binder, 100:50 with binder, 100:20 with and without binder, 0:100(only additives). The binder is mixed in the ratio of 10:1. And that mixture is dried for 2 hrs. Then the mixture is taken in the die and placed in the set up. Then by using the hydraulic jack compress the mixture with its maximum power of 100 ton. We can get the briquette and it is kept under that pressure for a period of 12hrs then releases the pressure and takes out the briquette from the die.

Table:-1

Briquette composition and its ratio

BRIQUETTE MATERIAL RATIO	COMPOSITION
100:0 P_{W100}	Pure palm powder with binder
100:0 P_{WO100}	Pure palm powder without binder
50:50 P_{W50}	Palm powder mixed with 50%additives with binder

80:20 P_{W20}	Palm powder mixed with 20%additives with binder
80:20 P_{WO20}	Palm powder mixed with 20%additives without binder
0:100 A_{W100}	Pure additives only with binder

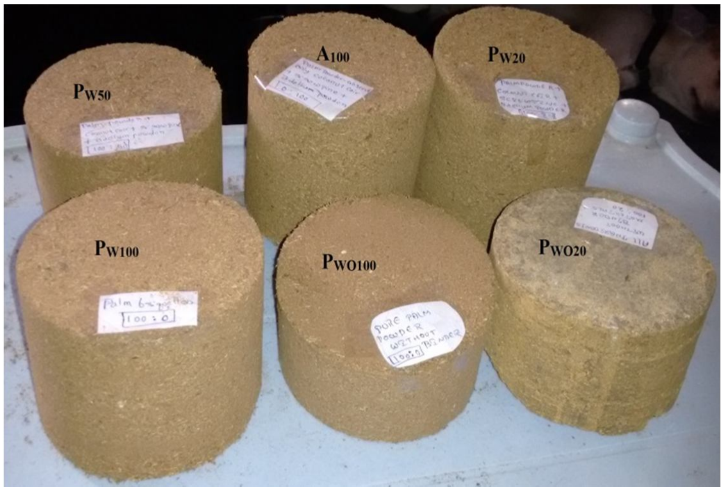

Fig.3. Prepared briquettes

III. RESULTS AND DISCUSSION

The prepared briquettes are carried out for mechanical, proximate and thermal analyses

A. *Mechanical analysis*

1) *Density:* After taking the briquettes from the mould they are weighed in a digital weighing balance, and the volume of briquette is calculated for obtaining density. The highest density obtained is 0.91g/cm^3 for P_{WO20}.

$$density = \frac{mass}{volume}$$

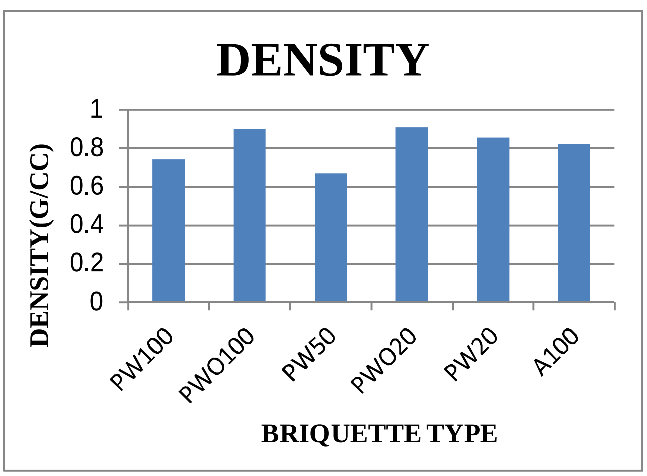

Fig.4 variation of density with briquette type

2) *Compression strength:* The acceptable compressive strength for briquettes is 0.38 MPa. The compressive strengths are used for storing and handling the briquettes. The highest compression value obtained is 1.45 MPa for P_{WO20}.

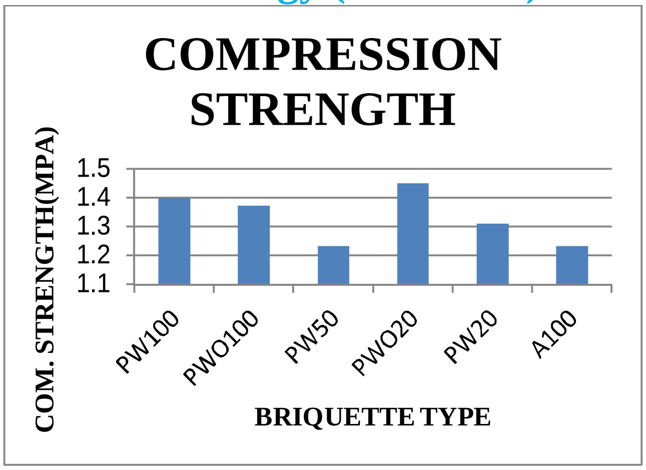

Fig.5 variation of compression strength with briquette type

B. Proximate analysis

1) The moisture content, volatile content, ash content and fixed carbon and calorific value for the briquettes are obtained experimentally is shown in the following charts.

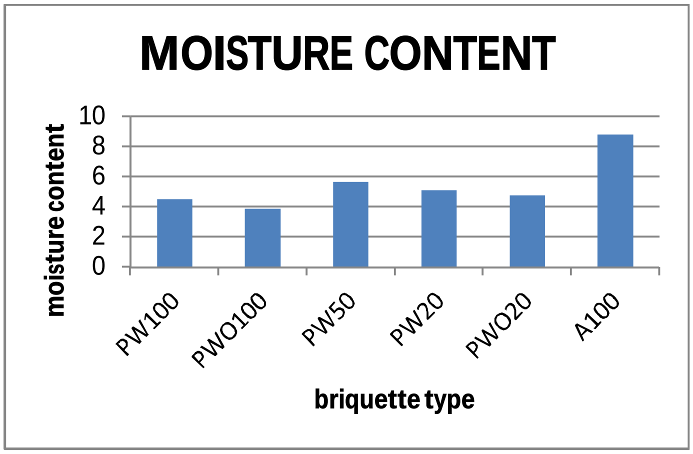

Fig.6 variation of moisture content with briquette type

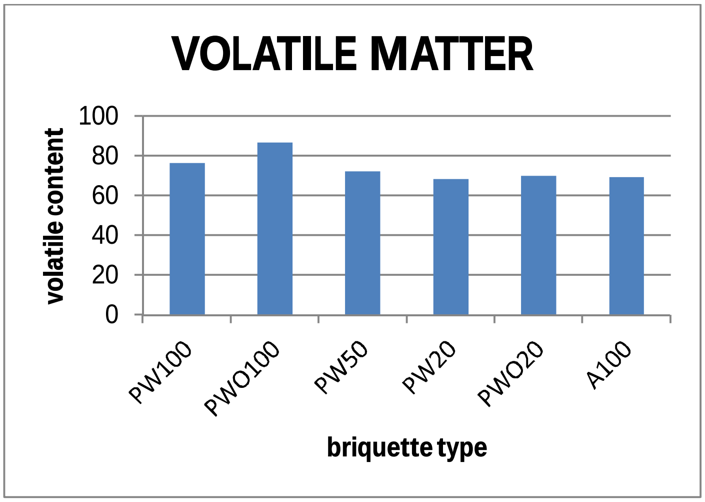

Fig.7 variation of volatile matter with briquette type

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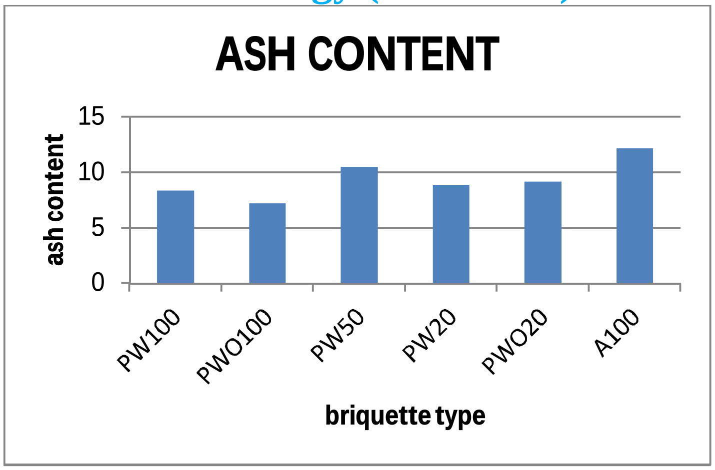

Fig.8 variation of ash content with briquette type

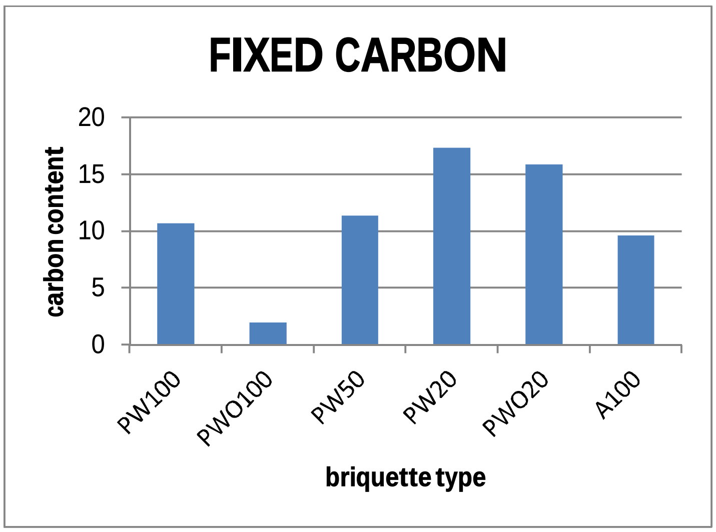

Fig.9 variation of fixed carbon with briquette type

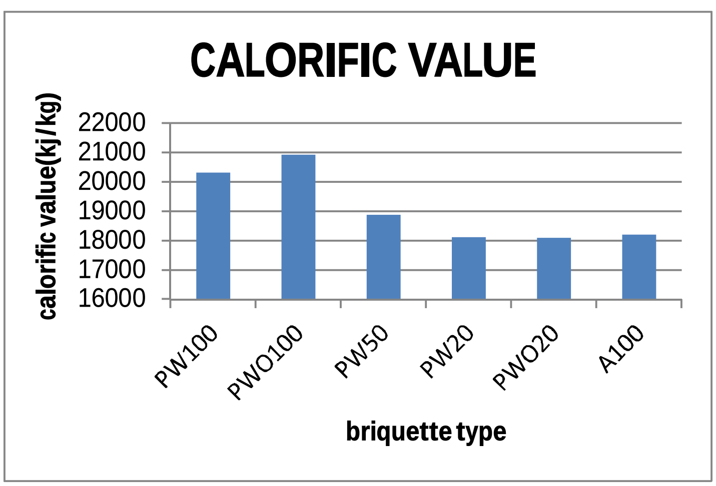

Fig.10 variation of calorific value with briquette type

2) Calculated calorific values: The calorific values are calculated by using Dulung formulae

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$$CV=14600\times C+(H-1/8O)\times 62100-(9H+X)\times 1120$$

C= Carbon, H= hydrogen, O= oxygen, X= moisture.

The calculated calorific value is highest for P_{w20} is 25554.4kj/kg

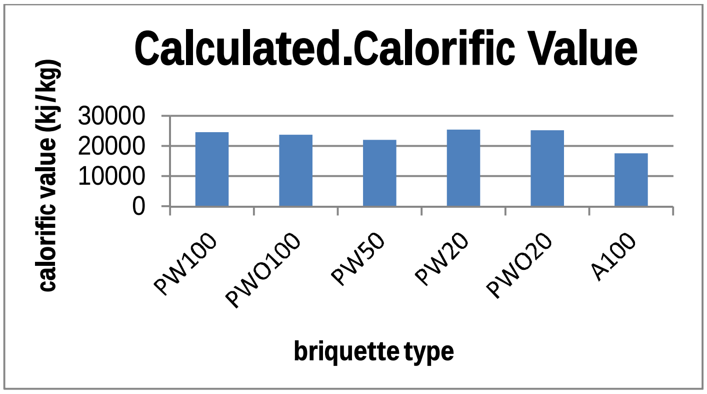

Fig.11 variation of calculated calorific value with briquette type

3) *Comparison of calorific values:* The calculated and experimentally determined calorific values are compared with each type.

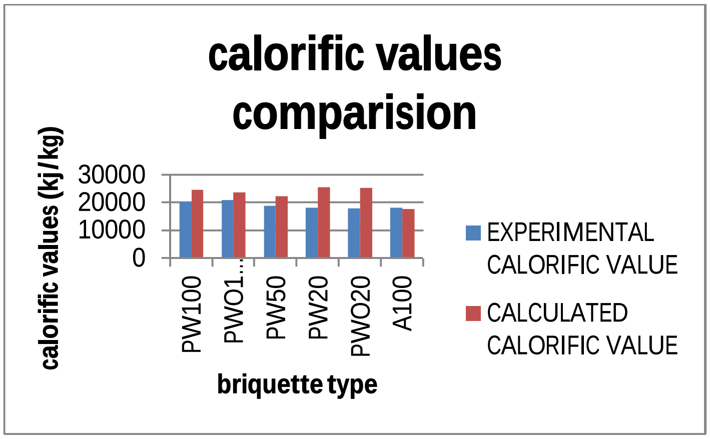

Fig.12 comparison of calorific values

C. Thermal analysis

1) *Ignition time:* As briquettes do not ignite quickly, hence 4ml of kerosene is poured on the briquettes to ignite quickly. The less ignition time is for P_{W50} is 44sec

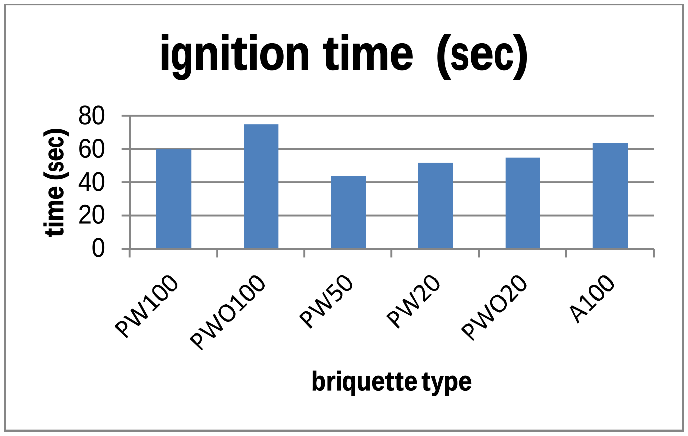

Fig.13 variation of ignition time with briquette type

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2) *Total burning time:* It is the total time taken for complete conversion of briquettes to ash form. It is high for p_{W50} is 27 min.

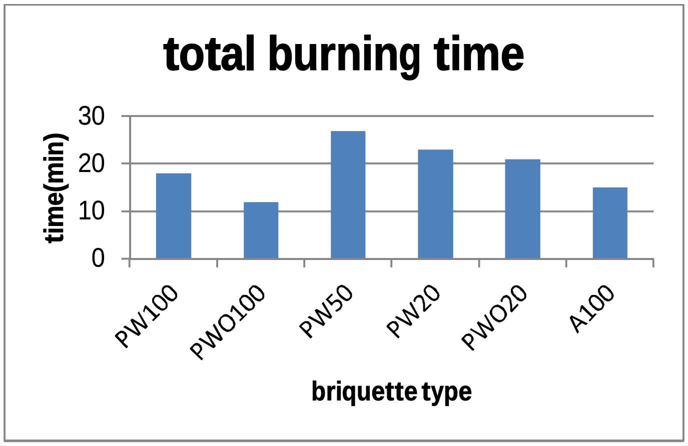

Fig.14 variation of total burning time with briquette type

3) *Maximum temperature:* It is the highest temperature attained by the briquettes while burning. And the maximum temperature is 248^0c for P_{wO50}, A_{100}.

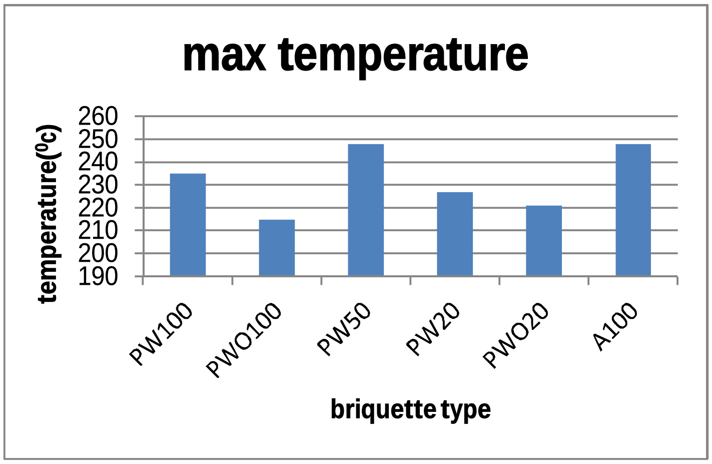

Fig.15 variation of maximum temperature with briquette type

4) *Time for maximum temperature:* The time taken for attaining maximum temperature is less for A_{100} is 326^0c.

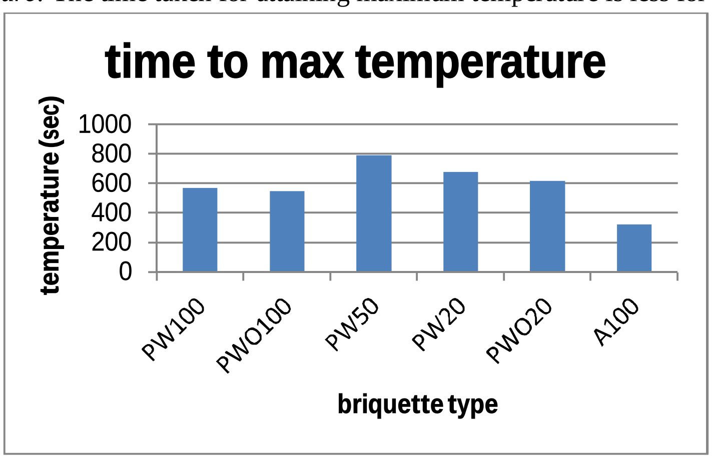

Fig.16 variation of time of max.temperature with briquette type

5) *Burning rate:* The burning rate is the rate at which burning of briquettes will takes place. This is highest for P_{WO100} is 3.4 g/min.

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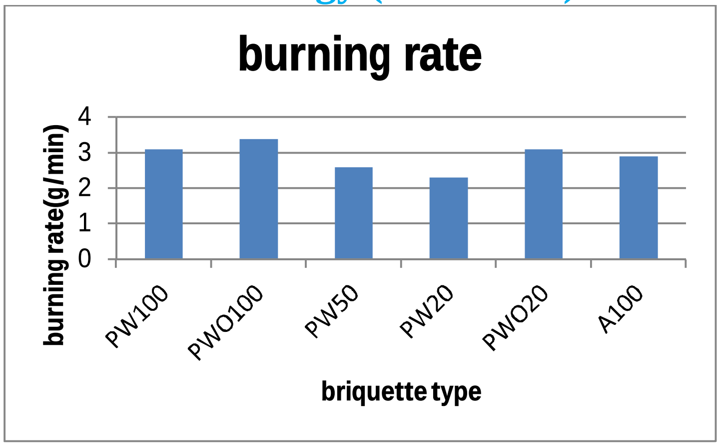

Fig.17 variation of burning rate with briquette type

6) *Boiler efficiency:* The boiler efficiency can be calculated in this paper is by indirect method. The losses are calculated and then they are subtracted from 100.

$$\boxed{\text{Boiler efficiency}=100-(L1+L2+L3+L4+L5+L6+L7+L8)}$$

L_1 = loss due to dry flue gas.

$$= \frac{m \times c_P \times (T_f - T_a) \times 100}{\text{GCV of fuel}}$$

M = mass of dry flue gas (kg/kg of fuel)

T_f, T_a = flue gas and ambient temperatures respectively (^{0}c)

GCV = gross calorific value

L_2 = loss due to hydrogen in fuel.

$$= \frac{9 \times H_2 \times \{584 + C_p \times (T_f - T_a)\} \times 100}{\text{GCV of fuel}}$$

L_3 = loss due to moisture in fuel.

$$= \frac{M \times \{584 + C_p \times (T_f - T_a)\} \times 100}{\text{GCV of fuel}}$$

M = moisture in fuel

L_4 = loss due to moisture in air.

$$= \frac{AAS \times HF \times C_p \times (T_f - T_a) \times 100}{\text{GCV of fuel}}$$

AAS = actual mass of air supplied per of fuel

HF = humidity factor kg of water/kg of dry air

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L_5 = loss due to carbon monoxide.

$$= \frac{\%CO \times C}{\%CO + \%CO_2} \times \frac{5744 \times 100}{\text{GCV of fuel}}$$

L_6 = loss due to surface radiation, convection.

$$= 0.584\{(T_S/55.55)^4 - (T_a/55.55)^4\} + 1.957\ (T_S - T_a)^{1.25}\ \text{sq.rtof}\ [(196.85V_m+68.9)/68.9]$$

V_m = wind velocity in m/s
T_S = surface temperature (k)
T_a = ambient temperature (k)

L_7 = loss due to unburnt fly ash.

$$= \frac{\text{total ash collected/kg of fuel burnt} \times \text{GCV of fly ash} \times 100}{\text{GCV of fuel}}$$

L_8 = loss due to unburnt bottom ash.

$$= \frac{\text{total ash collected/kg of fuel burnt} \times \text{GCV of bottom ash} \times 100}{\text{GCV of fuel}}$$

By calculating the boiler efficiency from the above formulas we get the highest boiler efficiency is for P_{WO20} is 80.79%

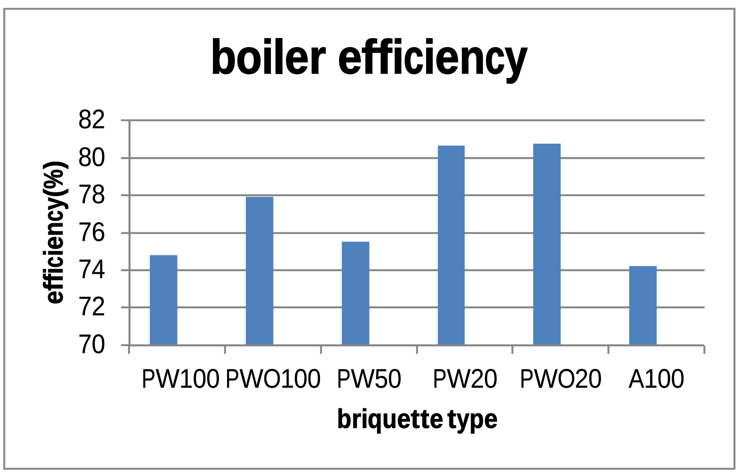

Fig.18 variation of calculated boiler efficiency with briquette type

IV. CONCLUSION

In this paper I used palm branch powder for along with saw dust, Indian Bdellium powder, screw pine, coconut coir with and without using binder for making briquettes. They are carried for mechanical and thermal analysis. In the mechanical analysis and in thermal analysis these briquettes give the better results. As the compressive strength is more compared with the acceptable value these can be stored for a longer period of time. From the boiler efficiency calculations and total burning time we can say that these can be used for larger industrial applications. From this I may conclude that these briquettes may be used along with fossil fuel which can increase the extinct period of fossil fuels.

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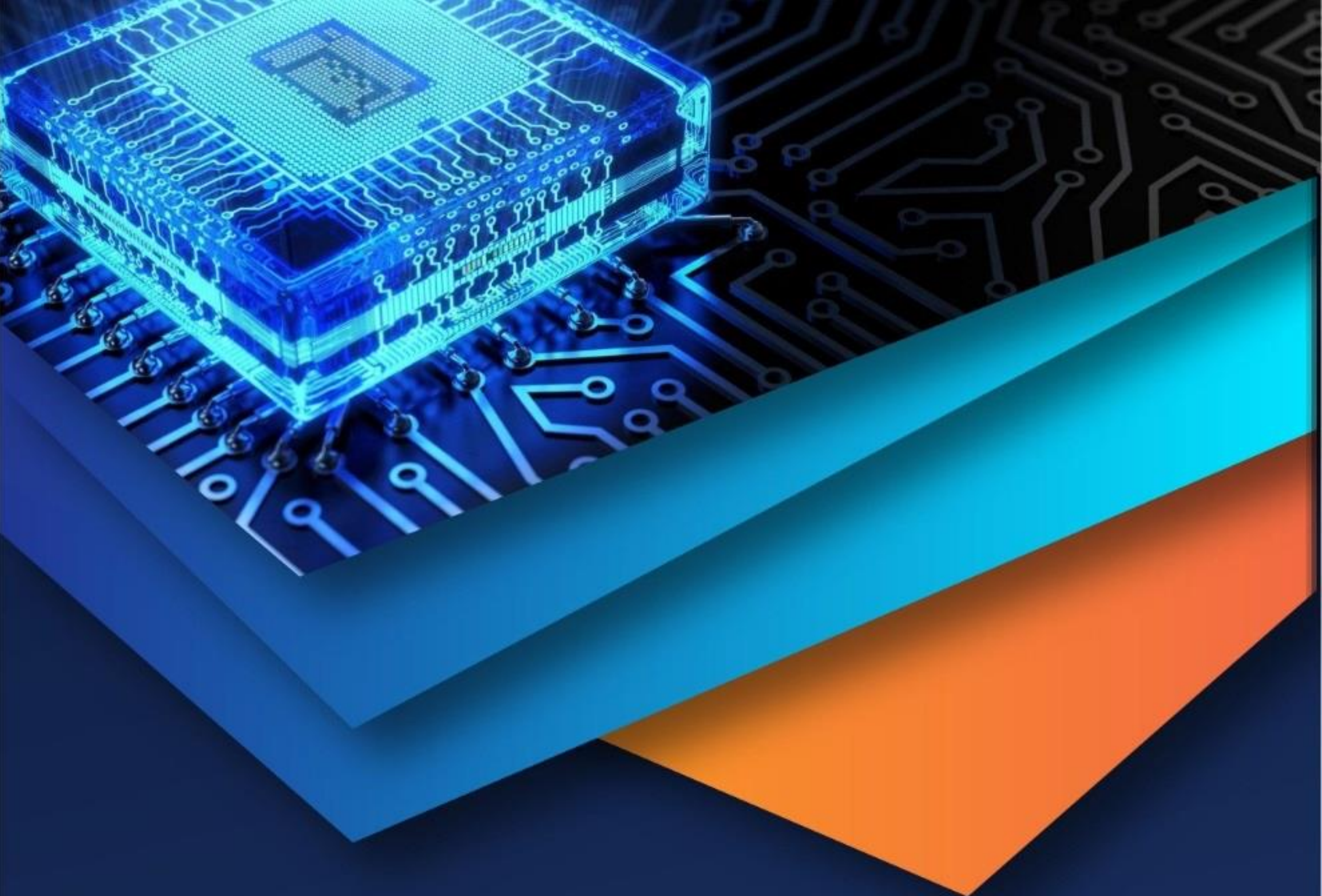

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