PERFORMANCE ANALYSIS OF LOOSE BIO MASS BRIQUTTES FROM AGRO AND FORESTRY WASTE

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ABSTRACT

The substitute of this non-renewable source with natural Waste would lesser the larger pollution of the world. The Agricultural and plant scraps converted to valuable biomass briquettes, which is the substitution of coal. The biomass wastes like Banana leaves saw dust, rice shell, coffee shell, Groundnut shell that are collected, pressed and compacted as bio waste briquettes, which can be transported and used to produce heat. Bio waste is the unique form having lower mass density large transportation and storage cost and not able to used as fuel. Densifying biomass wastes by briquetting method helps to minimize the storage handling problems and improved the colorific value of bio waste combustible fuel.

After that calorific value, fixed carbon content, Ash content, moisture content, volatile matter for different composition of biomass briquettes were analyzed and investigated. It was observed that moisture content increases volatile matter also increases it reduce calorific value.

Briquette-2 ash content 3 to 4 times lower than the other briquettes and it has 19MJ/kg. It can reduce the overall pollution when compared the other fossil fuel combustion. Saw dust briquettes easy to dry and better utility among various bio-waste briquettes.

Keywords—*(sawdust waste, rice shell, coffee shell, ash content, volatile matter)*

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I. INTRODUCTION

China is rich in coal, while crude oil and natural gas constitute comparatively little proportions. China is the biggest producer and consumer of coal in the world. More than 70% of the total energy in China is produced from coal combustion. This trend is expected to continue for the next 50 or more years [1,2]. Direct combustion of coal is not only inefficient, and will cause serious pollution . Million people die causing by lung and heart disease each year as a result of heavy emissions of pollutants (such as small particulates, sulfur dioxide, and mercury) by the transportation, storage, and combustion of coal. While the health risks are borne by local residents, the environmental impact of China's air pollution goes beyond its borders. Sulfur emissions from the combustion of coal cause acid rain, which may be carried by wind to fall in neighboring countries such as Japan and Korean, damaging crops, forests and fisheries, harming the ecosystems in the East Asian region. With the enhancement of awareness of environmental protection, people have higher requirement on the environment. Therefore, clean and highly efficient utilization of coal is being an important scientific and technological issue. And clean coal technology has attracted much attention and become one of important themes of energy research. Clean coal technology represents a series of new techniques aiming to decrease the pollutant discharge and improve the energy utilization efficiency as much as possible in the processing, combustion and conversion etc. of coal. Such a series of techniques forms a system of clean and highly efficient utilization of coal [3]. Briquette is one of development direction of clean coal technology. In China, briquette is developed to adjust coal industry structure, increase coal utilization value, improve environment and realize sustainable development of coal industry [4].

The powdered bio waste mixed with binding material for, briquette forming, storage and transportation

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Briquette binder acting a key role in the development of briquette production. The strength, thermal stability, burning performance and cost of briquette depend on the superiority of briquette binder [5].

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In this paper, briquette binder, the procedure of non-binder briquetting mechanism and procedure of briquetting mechanism having binder are reviewed.

The higher heating value is the cost-effective factor that can boost biomass usefulness in energy industry [7]. Biomass, in its unique form has little bulk density values and results in large transportation and storage space costs. Biomass while used as

Combustible fuel gives emissions in the type of particulate matter to the atmosphere. Rising the density of the biomass either by briquetting or by the pelletizing machinery increase bulk density, enhanced ease of handling [8,9] and superior hardness briquettes / pellet. It also improves the combustion efficiency and make the biomass briquettes efficient combustible fuels [8,10]. Densification of biomass transformed into pellets or briquettes is one of the approach, pursued all over the world, towards development and capable utilization of agricultural wastes. Bulk density is one of the most significant property detrimental in making logistic systems handling of biomass.

The wetness content, form, volume, exterior characteristics and element density are the major factors disturbing the bulk density. Biomass is briquetted to easiness handling and boost density of biomass to be used as fuel. Briquetting involve compress biomass with or without binder and extra additives that helps the briquette for efficient burning. Loose packed biomass of lower bulk density 0.1 to 0.2 g/cm^3 increases to 1.2 g/cm^3 during the procedure of briquetting. The direct flaming of free bio waste in conservative grates yields small thermal effectiveness and matter flue gases having suspended particulate lead to air pollution. So far researchers are mainly focused on biomass alteration technologies. The exists scope for Research and development works on biomass densification development [11]. Briquetting methods allow the bio waste to burn long time. This bio waste powder is then pressurized through a high or low-pressure motorized press which heats the powder and forces it throughout a die. Dependent on the require of the end consumer, the briquettes are created into special shapes and sizes. Briquetting can be made by reciprocating ram /piston press or screw press. In process of briquetting, selecting superiority raw material is key factor in determining commercial success. Briquetting process is accomplished with natural material lignin acting as a binder in high pressure press.

Extra obligatory substance is avoided as lignin is unconfined on purpose of more pressure. Biomasses missing plenty flexibility possibly will must beginning of binder to shape briquette, Holding briquette in concert throughout storage and carrying. The value and charge of the briquettes depends on binders in addition to additives use in briquetting. Biomass kind contains extremely extensive series of biomass resources such as farming residues, herbaceous and wooded biomasses, nut shells, stem, husks and pulps. These biomass have extensive range of physical properties i.e., fixed carbon, ash content, moisture and volatile matter.

Therefore increasing Technique as well as experiential equations to expect the upper heat values (HHV) is a substance of interest to several. In India rice manufacture accounts for 14% of world's rice production [12] and therefore a huge quantity of residue rice shell is generate. Rice shell, an agro-based residue is generate at the rate of roughly 0.046 tons per ton of rice produced [13]. India is formally forecast to gather an evidence of 163.3 million tons (108.9 million tons, milled basis) in 2016 [14]. Some researchers are trying to discover the chances of convert the biomass addicted to rate added & valuable income-generating products [15]. In the current work, first trials were conducted for locally obtainable biomass and binder. Dissimilar biomass/binder ratio was tried and a suitable range of biomass/ binder ratios were chosen. During testing wet process by means of starch (organic) binders have adopted. The briquettes shaped were tested for durability and bulk density. A mathematical bond to estimation/expect calorific value based on contiguous analysis be developed and validate.

PROBLEM STATEMENT

- Solid waste management is one of the major problem. The major waste generated at the rural areas is agricultural waste (crop by product).
- Besides the problem of transportation, storage and operation, open burning of the bio waste can cause critical air pollution.
- Existing machines are larger in size and due to over cost not reach the farmers.
- National assets share its edge with the states of Haryana and Uttar Pradesh. Increasing air pollution in Delhi is yield flaming through the farmers.

OBJECTIVES

The main objectives of this project to analyze and Investigation are conduct for nearby accessible biomass waste and binders. There has been a current push to substitute the flaming of fossil fuel with biomass. The substitute of these non-renewable fuels by means of manufactured goods of organic waste would lesser taken as a whole pollution in world. The agricultural waste like saw dust, rice shell, coffee shell etc. are gathered and compacted into briquette, these briquettes used to produce heat. These briquettes are substitute for liquid fuel and coal and as well give extra energy per kg.

II. MATERIALS AND METHODS

Raw materials for Briquette

Bio waste is a fuel alternate to coal and charcoal. Biomass briquettes are through farming and forestry waste. The loose biomass is changed into bio waste briquettes by means of briquetting device with or without binder, here the organic binding material. The most important material for bio waste briquette be, Mustard stalks, Saw powder, Rice husk, Coffee husk, Coir pitch, Jute sticks, Sugarcane bagasse, Groundnut shell, Cotton stalks, Caster seed shell/ stalk, Wood chips, Bamboo dust, Tobacco waste, Tea waste, , Wheat straw, Sunflower stalk, Palm husk, soya bean husk, Veneer residues, Barks & Straw, etc. The Briquettes are widely to steam generation in boilers, in furnace & foundries for heating (housing & business Heating for winder, heat in Cold area and Hotels, canteen, cafeteria and residence hold kitchen appliances etc.), drying development and in gasification plant replaces diesel, Kerosene, Furnace oil (FO), into conservative solid fuels similar to coal and wood

Here produced briquettes raw material ratios and structures is shown below.

Fig. 1-Briquette-1

Fig. 2-Briquette-2

Fig. 3-Briquette-3

Fig. 4-Briquette-4


Fig. 5 -Briquette-5 Fig. 6- Briquette-6


Fig. 7- Briquette-7 Fig. 8-Briquette-8

Properties of Biomass

Agro Wastes	Cal/ kg	Ash content
Babool Wood	470	0.90%
Bagasse	470	1.80%
Bamboo dust	370	8.00%
Barks Wood	390	4.40%
Castor Seed Shells	386	8.00%
Coffee Husk	420	5.30%
Coir Pitch	414	13.60
Cotton Stalks/ Chips	420	3.01%
Forestry Waste	300	7.00%
Groundnut Shell	450	3.80%
Jute Waste	480	3.00%
Mustard Shell	430	3.70%
Paddy Straw	346	15.50
Palm Husk	390	4.90%
Rice Husks	320	22.20
Saw Dust	440	1.20%
Soya bean Husk	417	4.10%
Sugarcane Waste	370	10.00
Sunflower Stalk	430	4.30%
Tea waste	400	6.70%
Tobacco Waste	110	49.40
Wheat Straw	400	8.00%
Wood Chips	430	1.20%
Mustard Stalk	420	3.40%

Binders

Starch

Starch is the a large amount ordinary binder although it is actually expensive. It doesn't need to be a food grade. In general, about 4.8% of starch is required to construct the briquettes. Starch sources may be Wheat starch, Maize flour, Rice flour, Cassava flour, Potato starch, etc. To utilize the starch as a binder, you must initially gelatinize the starch, which is blended in with water and heated to form a clingy consistency, at that point then adding up to the mixer to be mixed with the charcoal powder.

Clay

Clay or soil is commonly obtainable at nearly no cost in several areas. Clay do not add to anything the heating rate of the briquette. If more clay is used to the briquette will catch fire and burn slowly . Besides, clay will be converted into ash after burning, which restricts the passage of radiant heat, the heating rate of the charcoal is reduced.

Gum Arabic

Gum Arabic, well- known as acacia gum, is a natural gum obtained from acacia tree, which is especially familiar in Africa Sahel, particularly Sudan, Senegal, Somalia, etc. Gum Arabic is effectively used as suitable binder material to charcoal briquette. It do not produce serious smoke, nor is thermal needed.

Molasses

Molasses is a one of the product of the sugarcane production. One thousand kilogram of briquettes needs about 21 - 25.2% molasses. Briquettes binded when the molasses burn well enough, but have an unpleasant smell at the time of combustion. To over come this problem , thermal treatment is applied previous to using the briquette, which is also known as “curing”.

Wood Tar and Pitch

timber tar comes from the carbonization process and is improved from stationary kilns and retorts. Pitch is one of the viscous liquid that remains later than the distillation of coal tar. Tar is liquid in form while pitch is solid in form. Both of them need re-carbonization to overcome the emission of serious smoke which may create unfavorable health.

Beside, cow fertilizer and paper pulp one of the binding material for briquettes. Cow dung is available mostly in countryside areas. Waste paper is tom to small piece and mix with water to form a gelatinized paste.

By referring several journals we came to conclusion that by using starch as binder has many advantages than binders. Even through cost of the flour required to make starch is costly, the smallest amount of starch usage as a binder makes it an inexpensive.

Table 2.1 Properties of the inorganic binder

Classification	**Performance**	**Material**	**Advantage**	**Disadvantage**
Industrial Briquette inorganic binder	• Good sulfur retention • Low ash content • Good waterproof • Wide source	• Limestone • Clay • Bentonite • cement	• Good thermal stability • Good hydrophilicity • Wide source • Low price	• High ash content • Low heat • Poor water proofing
Civilian briquette inorganic binder	• Wide source • Low price • Pollution-free	• Limestone • Clay • Compound binder	• Good thermal stability • Good hydrophilicity	• High ash content • Low heat
Environmental protection briquette inorganic binder	• Good sulfur retention • Pollution-free	• Limestone • Iron oxide • Magnesium oxide	• Wide source • Good surface	• High price • High ash content

Table 2.2 Properties of the organic binder

Classification	Forming condition	Material	Advantage	Disadvantage
Biomass binder	• Cold Briquetting waste • Water content (2-3%)	• Agricultural waste • Aquatic plant • Forestry biomass • Aquatic plant	• High mechanical strength • Wide source • Low price • High heat value	• Low thermal stability • Poor water repellency • Low ignition temperature
Tar pitch and petroleum bitumen binder	• Hot/ cold briquetting process	• Coal tar pitch • Petroleum bitumen • Coal tar • Tar residue	• Good cohesiveness • High wetting capacity	• Serious pollution
Lignosulphonate binder	• Cold briquetting process	• Paper mill • Lignin derivative • Lignin liquour	• Strong adhesive strength • Low cost • Low ash content • Pollution-free	• Poor thermal stability • Low thermal stability
Polymer binder	• Cold briquetting process	• Starch • PVA	• Good cohesiveness	• High cost • Low waterproofing • Low coking property

Bulk density and compressive strength

Biomass briquettes bulk density is attained by geometric method. Geometric size of cylindrical briquettes was measured by using vernier caliper and the volume was calculated by (P _ Diameter of cylindrical briquette) _ height. Briquette was weighed and bulk density was determined by the relation:

Bulk Density = (mass of briquette)/(volume of briquette).

Briquette samples is experienced for compressive strength were dried and the measurement of length and diameter were measured by vernier caliper. The bearing exterior of the compression testing machine was well cleaned. Specimen was positioned at the centre of the base plate of the compression testing machine. Load was applied to opposite sides of specimen casting direction. The top movable portion is rotated untill it touches the top surface of the specimen. The load is applied slowly and continuously at the rate of 140 kg/cm2/min till the specimen fail and greatest load is recorded. Compressive strength is determined from the obtained failure load.

Proximate analysis

(a) Moisture content

About 1 g of sample was taken in a petri dish (W_1) and kept inside the oven at a temperature between 104°C – 110°C. The sample has to be dried 5 to 6hrs, until the weight of the hydro char with Petridis becomes constant (W_2). The formula is given below.

$$\textbf{Moisture content (db. \%)} = \frac{W_1 - W_2}{W_2} \times 100 \qquad \textbf{A}$$

Where,

W_1 - Initial weight of the hydro char sample before placing in the drying oven (g)

W_2 - Final constant weight of the hydro char sample after drying(g)

(b) Volatile matter

To measure the volatile matter, about 1 g of dried samples were placed in an alumina crucible with a closed fitting cover and kept inside the muffle furnace at 950 ± 20°C for seven minutes. Then, the samples were cooled and reweighed. The loss in weight of the biomass sample was found out and the per cent of volatile matter was calculated as,

$$\textbf{Volatile matter (\%)} = \frac{V_1 - V_2}{V_1} \times 100 \qquad \textbf{B}$$

Where,

V_1 - Initial weight of the hydro char sample (sample + crucible + lid) before placing inside the furnace (g)

V_2 - Final constant weight of the hydro char sample (sample + crucible + lid) after cooling and removal of volatiles (g)

(c) Ash content

About 1 g of sample was placed in the muffle furnace at the temperature of 950°C for 3- 4 h with cap removed (open crucible). The crucible was then cooled properly in the desiccator and reweighed. The material left in the crucible is the amount of ash present in the hydro char samples.

$$\text{Ash content (\%)} = \frac{A_1 - A_2}{A_1} \times 100$$

Where,

A_1 =Initial weight of the hydro char (sample + crucible) before placing inside the furnace (g)

A_2 = Final constant weight of the hydro char (sample + crucible) after cooling and removal of fixed carbons (g)

(d) Fixed carbon

Fixed carbon is the prime element for the burning of any material during combustion process. The fixed carbon content of biomass samples was calculated by taking the sum of ash content (%) and volatile matter (%) and by subtracting from 100%. (On dry basis, %).

Fixed carbon (%) = 100 - (Volatile matter (%) + Ash content(%))

Fuel Properties

Determination of calorific value by correlation analysis

The calorific value of the samples were also calculated using the correlation formulae with various standard equations and formulae using the values determined from proximate and ultimate analysis. All the correlation formulae were used to develop a model and compared with predicted and measured values.

Calorific value by ash and volatile matter

The calorific value of the sample (dry basis) was calculated using ash and volatile matter and found that this empirical equation are excellent in predicting the HHV of the samples.

$$\textbf{HHV (MJ kg}^{-1}\textbf{) = 26.601 – 0.304*A – 0.082*VM}$$

Where,

A and VM – Weight (%) of ash content and volatile content in the sample

III. RESULT AND DISCUSSIONS

Analysis of Proximate and calorific value

The sample briquettes calorific values were calculated by applying (Contech Microsystem) bomb calorimeter. Also summarizes the biomass briquette samples calorific values. It was calculated that carbonization of the rice shell resulted in raise in the fixed carbon and reduce in volatile matter and also an raise in calorific value. It was also calculated the briquette samples calorific value is reduced with moisture content, volatile matter and ash, whereas calorific value raise with fixed carbon.

Model to predict calorific value

From proximate analysis on the briquette samples, a mathematical equation to calculate the calorific value using regression analysis and is given as:

$$HHV\ (MJ/kg) = a1 + (a2 \times FC) - (a3 \times VM) - (a4 \times MC)$$

Parameters	Rise husk, Coffee husk	Saw dust, Coffee husk, Binder	Saw dust, Nut shell	Saw dust, Bagasse, Binder	Nut shell, Coffee husk, Binder	Saw dust, Rice husk, Binder	Nut husk, Banana leaf, Binder	Nut husk, Bagasse, Binder
Moisture content (%)	5.0	6.2	5.4	5.1	7.0	5.0	6.8	6.9
Volatile matter (%)	76	81	80.8	84	86	81	79	82
Ash content (%)	3.5	0.9	2.8	0.85	1.5	3.4	2.4	1.7
Organic carbon (%)	8.8	11.9	11	10.05	5.5	10.6	11.8	9.4
Calorific value (kcal/kg)	4611	4701	4568	4647	4560	4520	4632	4624

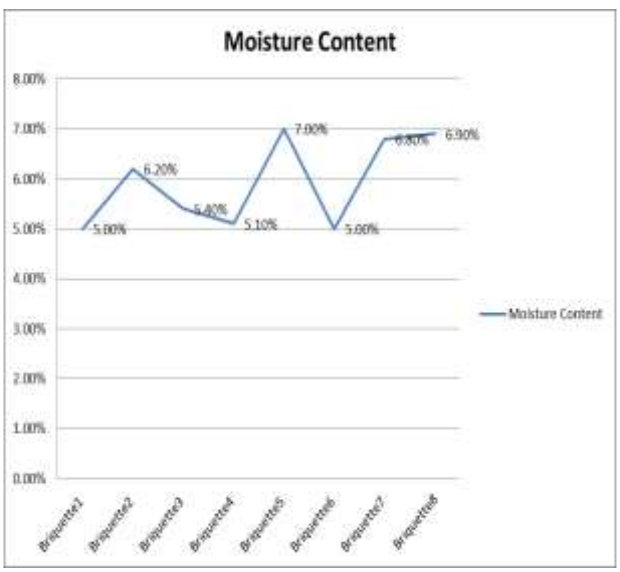

Figure 9

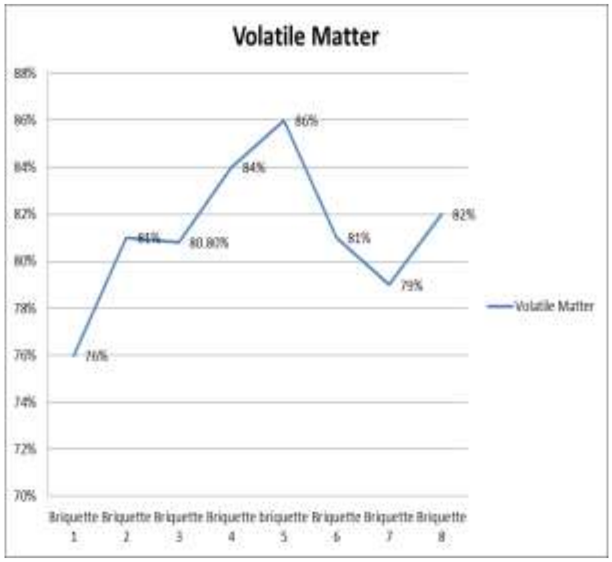

Figure 10

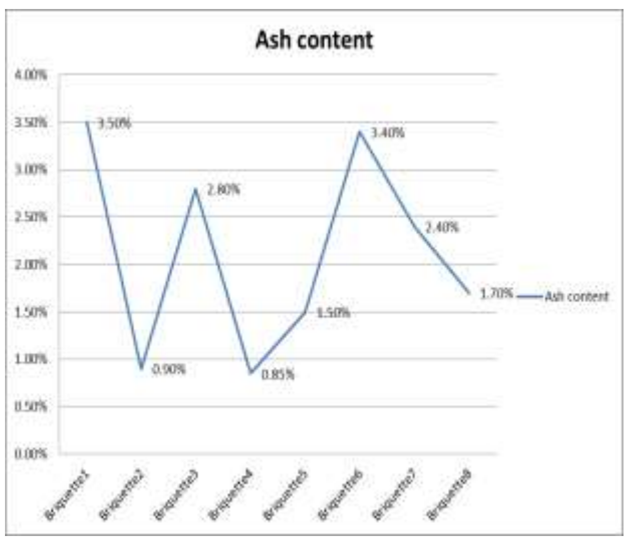

Figure 11

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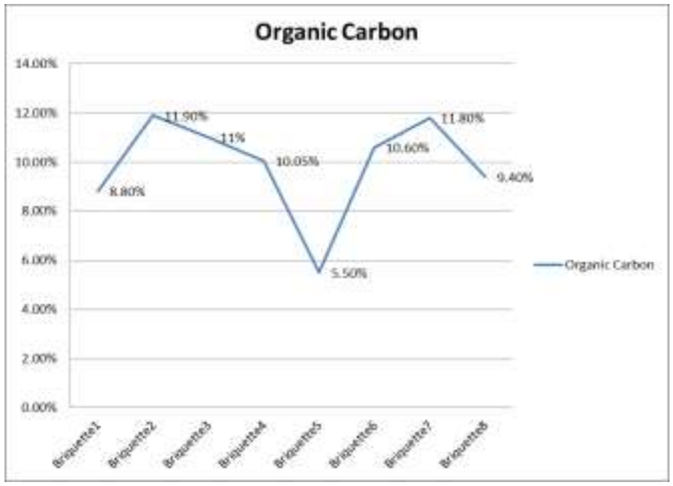

Figure 12

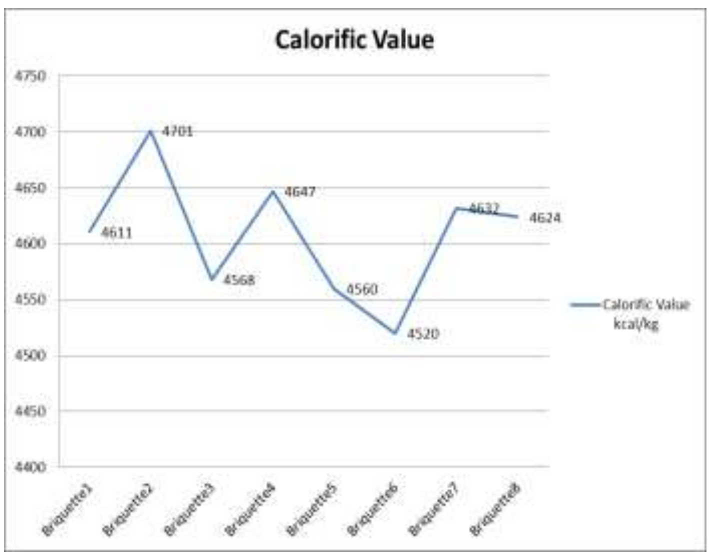

Figure 13

MERITS OF BIOMASS BRIQUETTING

Briquettes formed from agro waste are quite good alternate for coal, lignite, Firewood has several advantages

- This is one of the most important methods to save the utilization and dependence on fuel wood.
- Briquettes are simple to handle, stock up and move

- They are homogeneous in size.
- The Briquetting method help to resolve the residual disposal problem.
- The method used to the decrease of wood utilization and deforestation.
- It gives extra profits to farmers and more employment..
- During burning of briquettes there is no fly ash.
- Briquettes are made from agro wastes.
- Since briquettes can be domestically made from plants and animal wastes, they are consequently less expensive to produce, and thereby sold at lower prices.

Boilers	(Sugar mills, Paper mills, chemical plants, Cement, food processing units, oil extraction units etc.) using fuel for steam
Forges &Foundries	For metal heating and melting.
Brick kilns and ceramic	For firing of furnaces.
Residenti al Hearing	For winter heating in cold areas and in restaurants, canteens etc.
Gasificat ion	The gas can be used to generate power, and eventually replace coal based producer gas systems and oil firing in
Agricult ure	Heating Green houses, Nurseries and Chicken coops.

IV. Conclusions

In this paper investigate how the briquettes were shaped by agro-residue and analysed that carbonization of the rice shell eliminate a large amount of the unstable matter and raise in amount of fixed carbon content also the calorific value.

- The Briquette-2 has good calorific value 4701kcal/kg
- Briquette-3 has low Ash content as 0.85%.
- When compared Eight Briquettes, Briquette-2 better than other briquettes.

Saw dust composition Briquettes has low moisture content than the other composition Briquettes, delivered a result it easy to dry.

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