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Bio-Briquetting Process: An Overview

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Abstract: *The world's energy demand is currently rising as a result of the expanding population. Because of the rising worry about climate change brought on by the greenhouse gas emissions created by fossil and coal fuel, bio-briquette, especially those made from agricultural waste, are a sustainable energy source that have a great chance of becoming alternative energy sources. Hence, this review paper provides overview on the principles, processing, densification, storage and economics of Briquetting.*

Keywords: *Biomass, Agriculture Waste, Densification and Briquetting*

I. INTRODUCTION

Biomass energy has been dividing attention as an energy source, due to its zero net carbon dioxide accumulation in atmosphere. Among other biomass, agriculture residues have been most familiar and preferable kind of choice. They are available for almost free of cost and are in abundance existing in our country. It is estimated that around 650-700 million tonnes of agricultural residues were produced in a year. But the difficulty of handling agricultural waste is that it burns so rapidly and it is difficult to maintain a steady fire in a combustion Process. The densification of agricultural left overs into solid fuel pellets or briquettes is one strategy that is being pursued in several regions of the world for improved and efficient exploitation of agricultural residues. By squeezing the large mass together and then the size is reduced. They are appealing for use at home and in industry due to the simplicity of storing and transporting such improved solid fuel briquettes (often in log shape) of high specific weight. Briquette combustion has the potential to be more even than that of the loose and bulky form. This would allow briquetted materials to be used directly as fuel in a way that is somewhat comparable to how wood and coal are burned in residential (perhaps modified) stoves and ovens. These problems in handling and transport of biomass can be rectified by briquetting technology. This process involves reducing the size by pressing immense mass together and makes it ease of storing and transporting such fuel briquettes. This also increases the fuel values of the residue, hence makes it more efficient than unprocessed ones unlike immense forms, briquettes combustion is more uniform and can be used in perfect fuel burning, briquetting makes residues, low density, high volume and burns as good as coal, leaves less Ash content, emit less or no smoke and have low ignition point.

II. PRINCIPLES AND TECHNOLOGY

Briquetting is a mechanical process that transforms loose biomass into a homogeneous, high-density fuel with a higher energy content and less moisture than the raw material. It stands for a group of technologies for turning biomass into fuel. When a Biomass is subjected to high pressure and temperature, the cellular structures inside the substance release lignin, which bonds the individual particles into a compact unit called a briquette. The purpose of briquetting is to compress materials that would not otherwise be used because of their lack of density into solid fuel that can be burned like wood or charcoal. A variety of wastes, including plastic, milled paper, and other flammable wastes, can be employed.

Different binding techniques are employed depending on the type of material, the pressure applied and the binder used. Interlocking bonds, adhesion and cohesion forces, and attraction interactions between solid particles make up the binding mechanism of biomass under high pressure. When high pressure is applied to biomass, the solid particles mechanically interlock and exhibit higher adhesion/cohesion (molecular forces like van der Waal's forces), forming intermolecular connections in the contact area. Briquetting presses are used to do this out. Based on the types of presses employed, briquetting can be divided into five primary categories, according to FAO (1990): Piston Presses, Screw Presses, Roller Presses, Pelletizing, Manual Presses and Low Pressure Briquetting. Briquetting technologies can be categorised into three groups based on the pressure that is used: High Pressure Compaction, Medium Pressure Compaction assisted by a heating device, and Low Pressure Compaction with a binding agent.

2.1 Biobrequetting Process

Figure 1: Briquette production process.

2.2 Collection of Raw Materials

Waste from forestry and agriculture is used to make biomass briquettes. Rice husk, Mustard stalks, sawdust and coffee are the main raw materials used to make biomass briquettes. Groundnut shell, cotton stalks, husk, coir pitch, jute sticks, sugarcane bagasse caster seed and shells, stalks from maize, wood chips, bamboo dust, tobacco, tea waste, bamboo dust Cobs, Arhar stalks, Paddy, Wheat, Sunflower, Palm Soya Bean Husk, Veneer remnants, straws and barks, leaves, pine needles, seed cases, etc.

Biomass briquettes are widely used for any type of thermal application, including the production of steam in boilers, in furnaces and foundries (where it can be used for metal heating and melting where the melting point is less than 1000˚C and for heating purposes (residential and commercial heating for winter, hotels, canteens, cafeterias, and household cooking equipment, among other places, have heating in cold locations. Substituting traditional solid fuels like coal and oil through a drying process and gasification. There are two phases of the process one with the binding agent present and one without binding agent. In Without a binding agent, the wood's inherent lignin ties the wood fibres together. Combining to create a solid. It is far more effective to burn Sawdust Briquettes than it is to burn firewood. Briquettes can contain as little as 4% moisture, whereas firewood can contain up to 60% moisture.

2.3 Preparation

- **Cleaning:** To eliminate impurities from the biomass, such as metal, plastic strings, dirt, and soil, sifting or the use of screening equipment and magnetic conveyors is used, followed by the collection of the wastes, cleaning, and sorting. Both the quality of the product and how well machines work during processing are impacted by foreign elements.
- **Storage:** Proper biomass storage is crucial to allowing for natural drying and minimising the need to dry the material for an extended period of time in order to obtain the necessary moisture content for the densification process. To prevent mixing with sand, stone, and other pollutants, the heaped raw material can be stored in building sheds or covered with geotextile.

2.4 Drying

In order to start the densification process, it is necessary to reduce the moisture content (MC) of the biomass to the minimal level necessary. The recommended range for moisture content is 5–15%. Both natural and forced drying methods are available for drying. Natural drying is a process that exposes biomass to the sun's rays and the wind to allow material to dry naturally without extra heating. The quantity of moisture in the product, as well as the ambient temperature and humidity, all affect the number of hours and days needed for natural drying.

The ideal level needed for densification should be reached for material moisture content. However, forced drying is an industrial technique that lowers the moisture content of biomass fuel to a predetermined range (5–15%) that is sufficient to begin densification. Forcibly drying equipment includes direct dryers (pneumatic), where biomass is spun inside a heated, revolving cylinder, and indirect dryers (rotary drum or trommel), where biomass is circulated throughout an exterior tunnel and dried by hot, dry air in direct contact with the wood.

By coming into touch with the hot interior surface of the cylinder, biomass is dried. When the biomass has a moisture level of over 50%, indirect dryers are typically used. Sun drying (natural drying) is easier and less expensive than mechanical drying (forced drying), but it is more weather dependent. Several agricultural wastes have a moisture content higher than green wood, which has a moisture content of 50–55%, so they require the most energy to be dried.

2.5 Size Reduction

Agricultural wastes are chopped into smaller bits for simple handling, transportation, and combustion. Size reduction can be categorised as chopped (50-250 mm), chipped (8-50 mm), or ground (8mm) depending on the kind of biomass. Bulky biomass, such as groundnut waste, bagasse, wheat straw, barley, maize straw, cobs, and others, are chopped into small pieces to improve their workability and compactness. Straw and Stalk types are chopped by chaff cutters into granular, and sticks are shredded. Others are ground into smaller particles, such as those that are less than 0.1 mm for bamboo fibre and sugarcane skin using a cutting mill, and that are between 2 and 5 mm and 7 to 10 mm for hazelnut husks and sunflower leftovers, respectively.

Choosing the right particle size for briquette manufacture should result in both high-quality briquettes and economical production. Hammermills, knife mills, linear knife grids, and disc attrition are common pieces of equipment used in size reduction, with hammer mills being the most effective and cutting mills the second.

2.6 Binding Agent

To stop the compressed material from eventually springing back and taking its former shape, a binding agent is required. When compressing ligneous material, this agent can either be a part of the material itself in the form of lignin, or it can be introduced to the process. Most agricultural leftovers contain lignin, also called sulfuric lignin. It fits the definition of a thermoplastic polymer since it starts to soften and flow at temperatures over 100°C. The important step in high pressure briquetting is the lignin softening and subsequent cooling of the material while it is still under pressure. Organic binders: Molasses, Coal tar, Bitumen, Starch, and Resin. Inorganic binders: Clay, Cement, Lime, Sulphite liquor.

2.7 Processing: Biomass Pre-Heating Technique

A shell and tube heat exchanger is essentially what a biomass pre-heater is. Hot flue gases from a biomass gasifier pass through the "shell," while a motor-driven screw feeder feeds biomass via the "tube." By combining cold air with the hot gases, it is possible to regulate the temperature of the flue gases. Once the gas temperature reached around 650°C, rice husk was added to the pre-heater. The pre-heater heated the raw material using hot flue gas from the combustion chamber that had been diluted or cooled by mixing it with fresh air, as needed. Charcoal served as the fuel for the downdraft type gasifier. It stood 1.4 metres tall and could hold 15 kilogramme of charcoal to run for around 10 hours nonstop in one batch. A hopper for storing fuel, a reactor zone, a grate, and an ash pit made up the gasifier. To burn the production gas, a combustion chamber was placed between the gasifier and pre-heater. Fire clay served as the interior insulation while ceramic fibre served as the exterior insulation. There was a sight glass available to observe the combustion. A blower provided air to the combustion chamber where it burned the producing gas. The producing gas was ignited using an electrical heater that was put within the combustion chamber. If necessary, the flue gas was cooled down in a mixing chamber before entering the pre-heater. This was accomplished in this chamber by combining fresh air and the heated flue gas. A blower brought fresh air into the mixing chamber.

The raw material was heated In the pre-heater before being fed to the briquetting machine. The pre-heater had an outer shell and an inner pipe, measuring 2.3 m long and 40 cm wide (feeder drum). A conveyor screw was used to move the raw material through the feeder drum while preheating it. A variable-speed motor turned the pre-heater screw. The area between the feeder drum and the shell is where the hot flue gas from the combustion chamber is released into the atmosphere.

III. HEATED - DIE SCREW PRESS - BREQUETTING MACHINE:

The single extrusion heated-die screw-press briquetting machine employed in this study was of this type. The drive motor, screw, die, die heaters, and power transfer system are the machine's main components. The power was transferred from the engine to the screw using a pulley and belts. The exterior surface of the die was fastened with an electrical coil heater, which was used to heat it to roughly 300˚C. This temperature is necessary to soften the lignin, which serves as a binder in the biomass. The temperature was always maintained by an electrical heater that was thermostatically controlled. Raw material is crushed and extruded through the die as soon as the motor is turned on and fed to the screw.

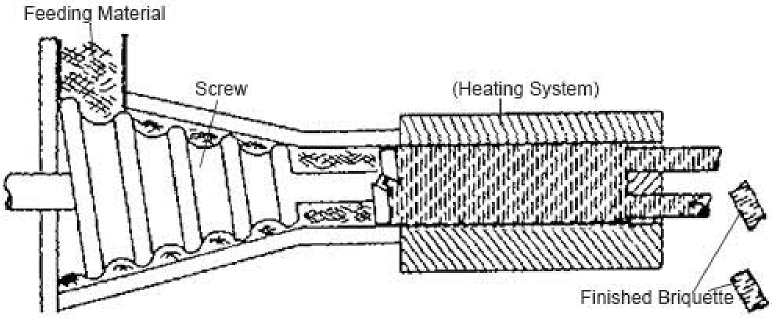

Figure 2a: Screw Pressing briquette machine.

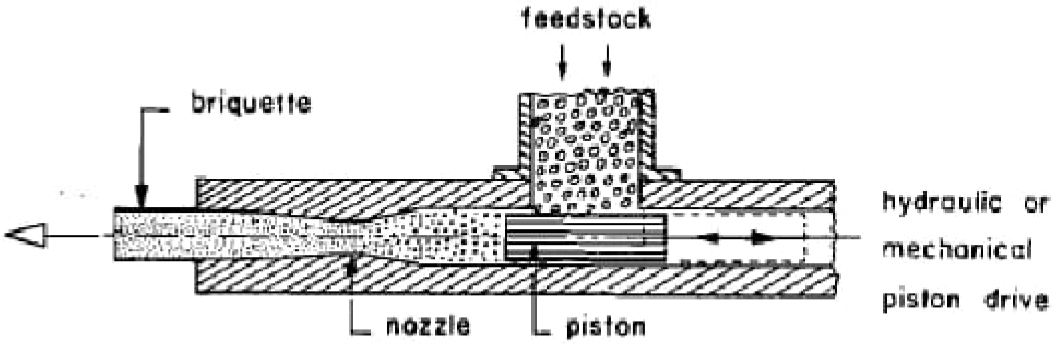

Figure 2b: Piston Pressing briquette machine.

Five longitudinal grooves on the inside surface of the cylindrical die serve to keep the densified material from spinning with the screw. During briquetting, the briquettes frequently partially pyrolyze at the surface and produce a lot of smoke. The screw's construction leaves a central, round hole in the briquette, which serves as a vent for steam produced during briquetting.

The briquetting machine had a 20 HP electrical motor and could produce about 90 kg per hour. The wear of the screw is the primary cause of this briquetting machine's maintenance issues.

IV. BIOMASS DIE – HEATING STOVE

Around 25% of the total electricity used by the briquetting machine is used for die heating, which accounts for a sizeable percentage. Therefore, it is anticipated that replacing the electrical die heaters with a biomass-fired stove will lower briquette production costs by lowering power costs.

A basic stove performed better than a biomass gasifier stove after thorough testing, providing the necessary and consistent die temperature. The stove had a 2 m long chimney attached to it at the top and was made of mild steel (1.5 mm sheet). Its furnace measured 20 cm by 35 cm by 40 cm (w x b x h). When the briquetting machine's die goes through the furnace, its exterior is exposed to the flames there. A 30 mm refractory lining was used as insulation for the furnaces inside surface. Doors were available for both loading the fuel and removing the ash. Below the grate, there was a permanent ash scraper and falls through grate

To direct the flames toward the die surface, two steel baffles were attached just above the die. They had refractory cement used to insulate them on both sides. The heat transfer from the flames to the die was found to be significantly improved by the baffles. Fuel (briquette pieces measuring 40 x 40 mm) is loaded through the side doors all the way to the bottom of the die, where it is lit with kerosene and some wood chips. The briquetting machine is initiated whenever the die temperature reaches 350°C. The temperature dips to 320–330°C during production, but it can be kept there by periodically (every 5 minutes) adding fuel to the burner. The ash pit door, which is left open while in operation, serves as the primary air intake for combustion. Through the fuel doors, which are also maintained partially open, secondary air is drawn in.

V. HAND MOULDED BRIQUETTES

Briquettes can also be manually moulded in small amounts. Due of binders' ability to create hydrogen bonds with the biomass, sun drying or a light heat treatment in a curing furnace are needed in this situation to create robust briquettes. In China, using an automated briquetting press, crushed coal is combined with water and about 20% of a clay binder to create honeycomb briquettes, which are then sun dried. In Kenya and Benin, 20% of (waste) paper pulp is combined with fine-particle biomass (sawdust, rice husks, wood shavings, charcoal dust, etc.) to create briquettes in a manually powered piston press. However, unlike wood, plastic and municipal trash cannot be transformed into briquettes in the same manner. But because they don't include enough biological components like lignin to serve as a natural binder, such as plastic and municipal waste, they cannot be turned into briquettes in the same way. A greater pressing temperature and compacting pressure should be used as a result.

VI. COOLING AND STORAGE

The heated briquettes coming out of the machines have a temperature of more than 200˚C. They require cooling and storage. Biomass waste can be compressed into briquettes to reduce its volume by a factor of ten, making them considerably easier to transport and store than loose biomass waste. Other fuel types are frequently dangerous and challenging to handle. Briquettes have a long shelf life and can be created in a range of sizes.

VII. ECONOMIC DEVELOPMENT AND BRIQUETTING

In Europe, America, and some regions of Asia, biomass briquette is widely used for residential heating applications and power production, but its use in several developing nations, such as Sub-Saharan Africa, has been considerably constrained. Several of The direct burning of wood and other biomass helps rural residents meet their heating energy needs Loose biomass is used in low-efficiency stoves like the three-stone fire. The constrained output Briquette use and a lack of a well-developed supply chain system for Biomass in forestry and agricultural-related industries.

The low use and manufacturing of briquettes may be attributed to the underdevelopment of the biomass supply chain in the agriculture and forestry sector policy and regulatory uncertainty and high investment risk are two crucial challenges that need to be addressed by governments in developing countries.

VIII. BREQUETTING USING LOCALLY AVAILABLE WASTE

Teak leaves, sugarcane scraps, and clothing scraps are gathered. All of the garbage is first properly washed with water to eliminate filth, and then it is dried on an open top for 15 days. The dried sample pieces were divided into tiny pieces (about 2 inch). The samples were immersed for 24 hours in 3 different buckets. The samples were filtered through a mesh after 24 hours and slightly dried for 15 minutes. Maida's binder was taken (wheat flour). While making trails, it is possible to determine how much binder should be added. We discovered that 100 grams of prepared maida will be adequate.

Maida flour is gently poured into the boiling water and vigorously swirled to prevent lumps from forming. Binder will have a sticky quality. The samples are given good strength by maida, which keeps them from collapsing during firing. The binder is combined with the water-filtered sample. Both are well mixed. The mixture is then stored in a mould that is set on a plank of wood. After adding the entire prepared mixture, the mould is covered with a lid, placed in a bench vise, and then tightened to exert pressure. For roughly 24 hours, the pressure is applied. The mould should be gently removed after 24 hours. The result is a rectangular briquette with a high moisture content. Then, it must be sufficiently dried to produce a hard briquette. The Maida layer that would have formed a coating over the particles transforms during drying from a semi-solid to a solid state, binding the particles together.

IX. CONCLUSION

The biomass densification, briquettes, often known as "smokeless fuel," are high calorific value products that are simple to carry and store. Its calorific value is comparable to coal despite being a non-polluting solid fuel. The agro-residues can be briquetted to decrease additional transportation expenses and related pollutants if the plant sites are selected effectively for convenient availability of raw material. This enhances biomass handling qualities as well. The briquettes made in this way make excellent fuel for home and small-scale local industries.

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