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Design and Development of Biomass Briquetting Machine

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Abstract: *Human waste, agricultural waste and animal waste will always be available in abundance as long as living upon the surface of the earth is permissible. This will certainly constitute some form of nuisance if not effectively managed and utilized. Briquetting is one useful way to manage the rubbish generated by human and their activities on the earth surface, especially in this generation where the desire for energy is ever in geometric progression.*

Briquetting is a method of compacting the wastes into a single solid rod or brick with the use of briquetting machine. These briquettes are utilized as alternative source of energy for cooking and general thermal energy supplement. Consequently, a manually operated simple briquetting machine was designed and fabricated. The machine is made from locally available materials. The assembling was done through welding and machining processes. The simplicity and performance evaluation of this machine justify its efficiency, ease of operation as well as suitability for small scale production of briquettes.

Keywords: Briquettes, Briquetting machine, Alternative energy, Small scale briquetting

I. INTRODUCTION

Briquettes are made from waste. Materials such as old newspapers, partially decomposed plant, wood etc. are made to function as alternative fuel to charcoal and fire wood. Briquetting is a process where some type of material is compressed under high pressure (Grove, 1995).Depending on the materials, methods and procedure of making these briquettes; they can burn cleaner than coal. Turning useless materials into a fuel source is attractive because it is a sustainable process (Denham, 2007). Many different methods and technologies exist for pressing briquettes. Though each method has its own unique advantages and disadvantages, the method, technology or the machine used plays a significant role in the quality of the briquette produced. This paper describes the development of a briquetting machine for small scale application. The machine can be used by small scale entrepreneurs for small entrepreneurial community groups and business people. Compaction of the products from the machine was aided by using starch as binding agent for fastening its particles.

II. THE BRIQUETTING SYSTEM

Utilization of agricultural residues is often difficult due to their uneven and troublesome characteristics. The process of compaction of residues into a product of higher density than the original raw material is known as densification or briquetting. Densification has aroused a great deal of interest in developing countries all over the world lately as a technique for upgrading of residues as energy sources. Converting residues into a dandified form has the following advantages:

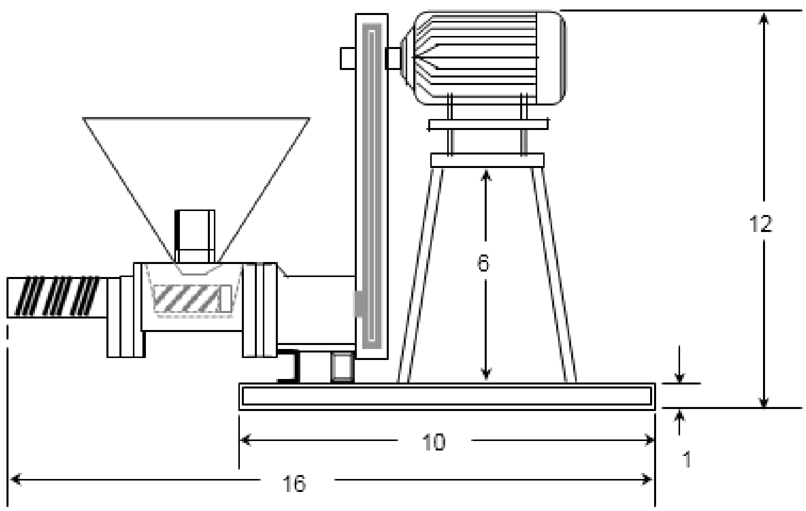
- The process increases the net calorific value per unit volume
- Dandified product is easy to transport and store
- The process helps to solve the problem of residue disposal
- The fuel produced is uniform in size and quality

The process also helps to reduce deforestation by providing a substitute for fuel wood.

There are several methods available for dandifying biomass. Screw press briquetting is a popular densification method suitable for small-scale applications in developing countries. The raw material from the hopper is conveyed and compressed by a screw in screw press briquetting. This process can produce denser and stronger briquettes compared with piston presses. There are basically two types of screw presses: conical screw press and screw press with heated die.

It has been reported that pre-heating the raw materials reduce the power required for the briquetting, allow higher quality briquettes for given energy input, lower wear on dies or a combination of these (Joseph et al., 1985, Reed et al. 1980). Reed et al. (1980) found that the work and pressure of compression or extrusion can be reduced by a factor of two by preheating the raw material to 200-250°C before densification.

Joseph and Hislop (1985) reported the results of briquetting preheated papyrus by the Intermediate Technology Development Group (ITDG). Papyrus briquettes were produced at pressure between 25-30 MPa with preheat, compared to a pressure of approximately 180 MPa without preheat. The authors concluded that existing briquetting plants modified for preheat should operate at lower pressures, wear rates and power requirements. Aqa and Bhattacharya (1992) studied the effect of varying the die temperature and the raw material (sawdust) preheats temperature on the energy consumption for sawdust using a heateddie screw press. Densifying sawdust preheated to a suitable temperature could save significant amount of energy. The energy input to the briquetting machine motor, die heaters and the overall system were reduced by 54.0, 30.6 and 40.2% respectively, in case of sawdust preheated to 130°C.



Performance test of a SHIMADA (Europe) briquetting machine in India showed that raising the feed temperature to 80-90°C before briquetting increases screw life to 44 hours from 17 hours without pre- heating (Mishra, 1996). Also, the production rate was found to increase from 340 to 360 kg/hr and the power consumption was reduced by 15-20 percent. hot flue gases from a biomass gasifier pass through the 'shell'. Temperature of the flue gases could be controlled by mixing cold air with the hot gases. Ricehusk was fed to the pre-heater when the gas temperature reached about 650°C.

The raw material pre-heating system consisted of a gasifier, a gas combustion chamber, an airflue gas mixing chamber and the pre-heater. The gas from the gasifier was burned in the combustion chamber. The hot flue gas from the combustion chamber, diluted/cooled by mixing with fresh air if necessary, was used to heat the raw material in the pre-heater.

The gasifier was of downdraft type and used charcoal as fuel. It was 1.4 meter tall and around 15 kg charcoal could be loaded for one batch which could run for about 10 hours continuously. The gasifier consisted of a hopper for fuel storage, a reactor zone, a grate and an ash pit. The reactor part of the gasifier was made of stainless steel and was insulated by ceramic fiber insulation to reduce heat loss. A blower was used to supply air to the gasifier. A suction blower was connected to the outlet side of the gasifier for start-up. The producer gas leaves the gasifier through a pipe connected below the grate. The producer gas and air were supplied to a combustion chamber. The combustion chamber was located between the gasifier and pre-heater to burn the producer gas. It was insulated internally by fire clay and externally by ceramic fiber insulation. A sight glass was provided to watch the combustion process. Air was supplied to the combustion chamber by a blower to burn the producer gas. An electrical heater placed inside the combustion

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chamber was used to ignite the producer gas. A mixing chamber was used to cool down the flue gas if necessary before its entrance to the pre- heater. This was achieved by mixing fresh air with the hot flue gas in this chamber. Fresh air was supplied to the mixing chamber by a blower.

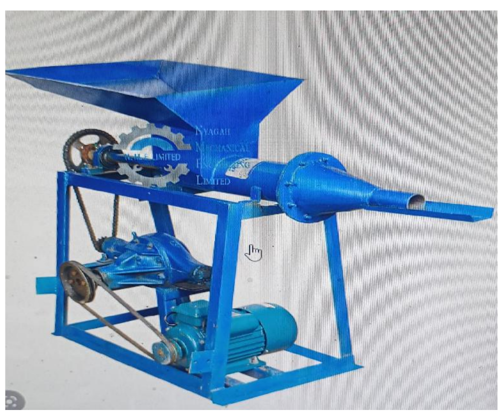
The pre-heater was designed and constructed to heat the raw material before feeding to the briquetting machine. The pre-heater (Figure 2) was 2.3 m long and 40 cm wide and consisted of an outer shell and an inner pipe (feeder drum). The raw material was preheated while being conveyed through the feeder drum by means of a conveyor screw. The pre-heater screw was rotated by a variable-speed motor. The hot flue gas from the combustion chamber was passed through the space between the feeder drum and the shell and discharged to the atmosphere. Thus, the feeder drum was heated by the flue gas at the bottom. The outer shell was insulated by a 5 cm thick layer of Rockwool to reduce heat loss to the surroundings. The pre-heater exit point was adjusted such that raw material was fed directly to the briquetting machine.

III. BIOMASS DIE-HEATING STOVE

The electricity consumption for die heating of the briquetting machine constitutes a significant portion, around 25% of the total electricity consumption (Aqa, 1990). Substitution of the electrical die heaters by a biomass-fired stove is therefore expected to reduce briquette production cost by cutting down electricity cost.

After conducting extensive studies with a biomass gasifier stove and a simple stove, the later was found to perform better, by offering the required and steady die temperature. The stove (Figure 3) was of mild steel (1.5 mm sheet) construction, with a furnace of 20 cm x 35 cm x 40 cm (w x b x h) volume and 2 m long chimney attached to it at the top. The die of the briquetting machine passes through the furnace, exposing its outer surface to the flames inside the furnace. The furnace was insulated with a 30 mm refractory lining at its inner surface. Doors were provided for loading the fuel as well as to remove the ash. An ash scraper was fixed below the grate to remove excess ash from the furnace, which will fall through the grate.

Two steel baffles were fixed just above the die, to converge the flames towards the die surface. They were insulated at both sides using refractory cement. The baffles were found to improve the heat transfer from the flames to the die considerably.



IV. RESULTS

The heated-die screw-press briquetting machine, with an average production capacity of 90 kg/hr, used a 20 HP motor for driving the screw, and the screw was driven at 385 rpm. Three numbers of 2000 W electrical coil heaters were used to heat the die. Ricehusk, with a moisture content of about 8% (wet basis) was used as raw material for briquetting. Briquetting experiments were carried out during several days, with and without pre-heating the ricehusk. Quality of briquettes produced, with and without pre-heating, was more or less similar, with the outer surface slightly charred.

Major electrical energy consumption in the briquetting process was by the motor, at about 62% of the total consumption, without pre-heating. Consumption by the electrical coil heaters was nevertheless high, at 68 kWh per ton of briquettes produced. Energy consumption by the motor driving the screw feeder in the biomass pre-heater was found to be insignificant, and hence neglected. The results of the experiments are presented in Tables 2 and is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by

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V. CONCLUSIONS

Experiments were conducted on a heated-die screw-press briquetting machine. The following observations were made:

• Average savings in the electrical energy consumption due to pre-heating were 23.5% at heater and 10.8% at motor respectively. The average total energy saving was about 10.2%.

• The lowest electrical energy consumption for rice-husk was 0.172 and 0.150 kWh/kg of briquettes produced, without and with pre-heating respectively.

TABLE I. Briquette without biomass preheating

Run No.	Average die temperature °C	Briquette Production rate kg/hr	Heater	Motor	Total
1	390	96.1	0.606	0.112	0.712
2	390	87	0.71	0.112	0.184
3	365	85	0.71	0.113	0.181
4	380	88	0.70	0.113	0.181
average		88.38	0.068	0.111	0.179

TABLE II. Briquette with biomass preheating

Run No.	Average die temperature: °C	Avg. biomass temp: °C	Heater	Motor	Total
1	390	100	0.50	0.094	0.168
2	390	101	0.71	0.098	0.184
3	365	100	0.71	0.096	0.181
4	380	98	0.70	0.097	0.181
average		99.9	0.068	0.094	0.179

Average electrical energy savings at the heater, motor and overall system were 23.5%, 10.8%, and 10.2% respectively. The production capacity was about 88 kg/hr.

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