Design and Development of Biomass Briquetting Machine with Grinding and Blending Unit

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Abstract — India is a developing nation and its GDP is dependent mostly on agriculture. And due to agriculture tonnes of biomass waste is being produce, which is mainly used for making manure and also for cooking in some rural area but still most of it goes into waste. But nowadays these biomass is been transformed into briquettes by compressing the biomass with some binder as 100kg/m² which increases its density and also calorific value. This research paper focuses on modification of the existing design of briquetting machine which includes modifying mixing and blending unit and extrusion unit which is screw type to make a low cost machine. This biomass residue is first turned into small particles of 5mm size in a mixer drum which is powered by a 1/4HP AC single phase motor running at 1440 r.p.m. Then this grinded biomass was blended with binder in another drum in same unit by manually using a blending arm. After that the blended biomass is fed into extrusion unit where it was compressed by screw which was running at 300r.p.m powered by 0.5H.P motor through attachable a nozzle with cylindrical hole and then cut into equal pieces manually. The capacity of machine measured was 20kg/hrs.

Keywords - Biomass waste, Mixer and blender unit, Screw press machine, briquette

I. INTRODUCTION

India is a developing and also an agricultural nation whose GDP is largely dependent on agriculture. Also India is having the second largest population in world which is increasing day by day and so the people requirements such as food, electricity and other important things. Due to which the agriculture production is also increased and with it the biomass residue is also increasing. And these biomass residue is mostly used for making manure and also directly for cooking but still a large amount of it goes into waste. And these biomass which is mostly fluffy and having moisture generate smoke when burnt so it’s not healthy and environment friendly way to use it. There are many way to use biomass residue but among them the best one which is much beneficial is briquetting. So nowadays these biomass residue is been converted into briquettes by mixing with certain binder and additives to increase their calorific value and density. Briquettes are nothing but compressed biomass residue as 100 kg/m³ and this is being done from ancient time but not at industrial level as now is being done. These biomass briquettes which is much denser and having more calorific value than the biomass residue produces lesser smoke as compared to biomass itself and burn at a constant rate. These biomass briquettes are now widely used in industrial furnaces, in small thermal power plants for electricity production and also rural area since it is cheaper and having more calorific value than coal and biomass itself. The briquette are also having more oxygen and less carbon than coal are environment friendly. They can be use in decentralized power generation and also they are easy to transport and store. Also these conversion of biomass into briquettes will produce an earning source for people in rural area plus it will help in reduction of CO² emission since it produce less CO² than LPG, coal and other fossil fuel. And it is a renewable source of energy so its production won’t end like fossil fuel.

II MATERIAL USED AND METHOLOGY

The study was conducted with an overall objective of design and fabrication of a low cost screw press type briquetting machine along with a low cost Mixing and blending unit and more calorific value briquette composition.

Procurement of Materials

2.1 Following materials were purchased and used for fabrication of the screw press type briquetting machine

Table-2.1.:—Procurement of material for screw type briquetting machine

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric motor</td>
<td>1</td>
<td>0.5 H.P. with 1440 R.P.M ,AC</td>
</tr>
<tr>
<td>Power screw</td>
<td>1</td>
<td>Dimension: 4 Inch outer dia.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>And 1.5 Inch inner dia. &amp; 16 Inch length ,Pitch=</td>
</tr>
<tr>
<td>Extruder barrel</td>
<td>1</td>
<td>5 Inch dia. and 16 Inches length</td>
</tr>
<tr>
<td>Pulley</td>
<td>2</td>
<td>1st pulley:- 2 inch outer dia.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade-A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd pulley:- 6inch outer dia.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade-A</td>
</tr>
<tr>
<td>V-belt</td>
<td>3</td>
<td>Grade-A</td>
</tr>
<tr>
<td>Bearing</td>
<td>2</td>
<td>6200 series - 6206</td>
</tr>
<tr>
<td>Hopper</td>
<td>1</td>
<td>made up of tin sheet material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diversion to bottom to feed stuff into the extruder screw.</td>
</tr>
<tr>
<td>Angle bar frame</td>
<td>12</td>
<td>The stand for the machine is made from the angle bar</td>
</tr>
<tr>
<td>Nut and bolts</td>
<td>5</td>
<td>10 mm diameter and 1 inch length bolts.</td>
</tr>
</tbody>
</table>
2.2 Procurement of Material purchased for mixing and blending unit:

<table>
<thead>
<tr>
<th>Material Purchased</th>
<th>Number</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Motor</td>
<td>1</td>
<td>1440 R.P.M., 230 Volt, Single Phase, AC Only</td>
</tr>
<tr>
<td>Bevel Gear &amp; Pinion</td>
<td>2</td>
<td>Gear: Pinion:</td>
</tr>
<tr>
<td>Mixer blade and drum</td>
<td>1</td>
<td>Stainless steel blade &amp; drum: 9Inches length, 4Inch dia.</td>
</tr>
<tr>
<td>Blender arm &amp; drum</td>
<td>1</td>
<td>Arm shaft length: 5Inches, Arm: 3Inches</td>
</tr>
<tr>
<td>Ball Bearing</td>
<td>2</td>
<td>6205 &amp; 6202 series</td>
</tr>
<tr>
<td>Hollow Shaft</td>
<td>1</td>
<td>1st shaft: 2Inches dia, 28Inches length, 2nd: 1Inches dia, 8Inches length</td>
</tr>
<tr>
<td>Nut and bolts</td>
<td>8</td>
<td>10mm diameter and 4 inches length</td>
</tr>
<tr>
<td>Plywood Sheet</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Angle bar frame</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table-2.2.1: Procurement of material for Grinding and Blending Unit

III METHOD OF OPERATING THE MACHINE

Grinder unit:
Grinder unit consists of a food processor blade, Drum, AC motor, and Base supports. The blade rotates at very high speed due to which it achieves the ability to cut any agro waste in small particles the edges of the blade is finished with the rough pattern which make high impression over the stuff to be grind.

The motor is connected to ac current supply and rotated to high speed and the waste stuff is delivered inside the drum the stuff comes in contact with the high speed rotating blades which gets cuts into the small particles after the drum is filled with agro stuff the drum is covered with the cover to prevent the particles to escape from the drum due to impact.

Blender unit:
The function of the blender is to mix the agro waste stuff homogeneously with the binder to make the dense stuff. After the agro stuff is ground properly then shifted to the blender drum in blender the blender arm is dipped fully inside the stuff and rotated by means of the gears provided to the arm the agro stuff get rotated to the edges of the blender arm and get mixed with the binder and forms the bonded structure of some density. The mixture us blended enough to make the stuff viscous so that it can take shape from the outlet of the extruder.

Extruder unit: The extruder unit contains the barrel, extruder screw, AC motor, pulley and belt. The extruder screw rotates inside the barrel by means of motor and pullet arrangement. The blended agro stuff is delivered from hopper inside the barrel and screw arrangement. The screw rotates and forces the stuff out from in barrel due to the force from screw the stuff is transferred to the outlet of the extruder. The outlet of extruder contains compact shape which makes compression effect over agro stuff due to which the stuff take the form of the outlet pipe and the cylindrical briquette is formed and get out from the extruder as output.

The cylindrical shaped briquettes are wet due to binder so their moisture is soaked by treating them with the smoke created from the fire which can evaporate the moisture from the briquettes so that they can become dry and can be used for fire purpose.

IV DESIGN AND CALCULATION
The speed of motor selected was 1440r.p.m. and so the design was made according to it:

<table>
<thead>
<tr>
<th>Briquette Specifications</th>
<th>Cylindrical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of Briquettes</td>
<td>Cylindrical</td>
</tr>
<tr>
<td>Outer diameter of Briquette</td>
<td>50mm</td>
</tr>
<tr>
<td>Hole diameter of Briquette</td>
<td>10mm</td>
</tr>
<tr>
<td>Length of Briquette</td>
<td>100mm</td>
</tr>
<tr>
<td>Machine Capacity</td>
<td>50Kg/hrs</td>
</tr>
<tr>
<td>Biomass Material Density</td>
<td>100Kg/m³</td>
</tr>
</tbody>
</table>

Table-4.1: Assumed Briquette and Machine Specifications
Design of Grinder:-
Mixing capacity:-
Volume of grinding chamber= \( \frac{\pi}{4} \times d^2 \times L = \text{mm}^3 \)
Grinding power:-
Power of motor= 0.25 HP = 196.25 Watt
Blade velocity = \( V = \frac{\pi \times d \times N}{60} = \text{m/s} \)
Where, \( d \) = diameter of blade.
\( N \) = rotation per minute of blade.

Design of Blender:-
Blending capacity:-
Volume of blending drum= \( \frac{\pi}{4} \times d^2 \times L = \text{m}^3 \)
Gear ratio= \( \frac{\text{T1}}{\text{T2}} = \)

Design of Extruder:
- Shape of Briquette = Cylindrical
- diameter of briquette = mm
- Length of Briquette = mm
- Compaction ratio = 14 (standard)
- Diameter of screw shaft = mm
- Volume at entry (Ve) = \( \frac{\pi}{4} \times (d^2) \times x \times L = \text{mm}^3 \)
- Volume at compression zone (Ve) = \( \frac{\pi}{4} \times (d^2) \times x \times L \times p = \text{mm}^3 \)
  Assume that compression ratio is 10
  \[ 10 = \frac{\text{Ve}}{\text{Ve}_c} \]
  \[ p = \text{mm}^3 \]
- Density of material = kg/m³
- Mass of material conveyed
  \( m = \text{kg} \)
  The efficiency of screw conveyor is 50 %
  \( m = x 0.5 = \text{kg} \)
- Density of compact briquette (\( \rho \)) assumed= 1000 kg/m³
- Volume of briquette = \( \frac{\pi}{4} \times d^2 \times L = \text{mm}^3 \)

Design of Pulley and V-Belt drive:-
Data: - Motor power = 0.5 HP
\( P_r = \text{Watt} \)
Design power
\( P_d = P_r \times k_l \) Load factor \( k_l = 1.15 \)
\( P_d = \text{Watt} \)
D.D.B [T-XV 2]
Selecting the section of the belt on the basis of design power i.e. kw
From D.D.B [T-XV-8]
For designation A: - \( W=13, \) t=18, \( D_{min}=75 \text{ mm}, \) kc=2.52
[Centrifugal tension factor]
- Peripheral velocity (\( V_p \))
Selecting smaller diameter of pulley as mm

\[ V_p = \frac{\pi D_1 N_1}{60 \times 1000} = \text{m/min} \]
- Ratio of tensions
  \( N_1 D_1 = N_2 D_2 \)
  \[ N_2 = \text{rpm of extruder screw} \]
  So, \( D_2 = \text{mm} \)
  Where, \( D_2 = \text{diameter of bigger pulley} \)
- Centre distance
  \( C = D_1 + D_2 = \text{mm} \)
- Length of belt
  \[ L = \frac{\pi}{2} \times (D_1 + D_2) + 2C + \frac{(D_1 - D_2)^2}{4C} \]
  \( L = \text{mm} \)

By taking the briquette manufactured by the industry and the briquette manufactured by our machine the calorific value have been calculated and are compared as follows. Formulae for water equivalent of calorimeter

\[ W = \frac{H \times M}{T} \times (CV_T + CV_F) \]
Formulae for Calorific value of fuel sample
\( CV_s = T \times W - (CV_T + CV_F) \)

Specifications:-
- \( T \) - Final temperature rise of water in degree Celsius
- \( M \) - Mass of the sample in grams
- \( H \) - Known calorific value of benzoic acid in Cal / gm = 6464 Cal/gm
- \( W \) - Water equivalent of the Calorimeter in Cal / deg
- \( CV_T \) - Calorific value of fresh
- \( CV_F \) - Calorific value of fuel sample
- \( CV_V \) - Calorific value of Fuse wire = 2.33 Cal/cm
- \( CV_T \) - Calorific value of the Thread wire = 2.1 Cal/cm

V EXPERIMENTATION AND TESTING ON MACHINE
We have taken observations. By varying the composition of a briquette made from Saw dust, Dried leaves, coconut husk and binder as a corn starch.

Initial temperature = 30 °C
Rise in temperature = 30.6 °C
Difference in temperature = 0.6 °C
\( L_F \) - Length of the Fuse wire = 10 cm
\( L_T \) - Length of the Thread = 10 cm
\( CF \) - Heat liberated by the Fuse wire in Cal
\( = 2.33 \times L_T \times = 2.33 \times 10 = 23 \text{ Cal} \)
\( CF \) - Heat liberated by Thread in Cal
\( = 2.1 \times L_T \times = 2.1 \times 10 = 21 \text{ Cal} \)

Composition 1:-
- Saw dust =60%, Coconut husk =10%, Dried leaves =25% and Corn starch = 5%
- Initial temperature = 29 °C
- Rise in temperature = 29.5 °C
- Difference in temperature = 0.5 °C.
- \( CV = T \times W - (CV_T + CV_F) \)
- \( CV = 0.5 \times 6699.97 - (21 + 23) \)
- \( = 3305.985 \text{ Kcal} \)

Composition 2:-
- Saw dust = 40%, Dried leaves = 40%, Coconut husk = 15%
and Wheat flour = 5%

Initial temperature = 29 °C
Rise in temperature = 29.6 °C
Difference in temperature = 0.6 °C.
$CV = T \times W - (C_V T + C_V F)$
$CV = 0.6 \times 6699.97 - (21 + 23)$
$= 3975.982 \text{ Kcal}$

Composition 3:-

Saw dust=50%, Dried leaves = 30%, coconut husk = 16%, Corn starch = 4%

Initial temperature = 29 °C
Rise in temperature = 29.55 °C
Difference in temperature = 0.55 °C.
$CV = T \times W - (C_V T + C_V F)$
$CV = 0.55 \times 6699.97 - (21 + 23)$
$= 3640.98 \text{ Kcal}$

Composition 4:-

Saw dust=30%, Dried leaves=50%, Coconut husk = 10%, Wheat flour = 10%

Initial temperature = 29 °C
Rise in temperature = 29.74 °C
Difference in temperature = 0.74 °C.
$CV = T \times W - (C_V T + C_V F)$
$CV = 0.74 \times 6699.97 - (21 + 23)$
$= 4913.97 \text{ Kcal}$

<table>
<thead>
<tr>
<th>Composition %</th>
<th>Mass kg</th>
<th>Calorific value kCal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Saw dust =60%, Coconut husk =10% ,Dried leaves =25% and Corn starch = 5%</td>
<td>0.102</td>
<td>3305.985</td>
</tr>
<tr>
<td>2 Saw dust = 40% , Dried leaves = 40% , Coconut husk = 15% and Wheat flour = 5%</td>
<td>0.110</td>
<td>3975.982</td>
</tr>
<tr>
<td>3 Saw dust=50% , Dried leaves = 30% , coconut husk = 16% , Corn starch = 4%</td>
<td>0.107</td>
<td>3640.98</td>
</tr>
<tr>
<td>4 Saw dust=30% , Dried leaves=50%, Coconut husk = 10% , Wheat flour = 10%</td>
<td>0.100</td>
<td>4913.97</td>
</tr>
</tbody>
</table>

Table 5.1: Observation table of compositions

CONCLUSION:

Hence it is concluded that the Briquette machines can be made at low price along with grinding and blending unit for the rural use and various compositions of briquettes with different shape by using nozzle instead of die can be made from the small capacity machines for rural use and it can be used in small scale for the manufacturing the briquettes.

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