CHAPTER – 01
INTRODUCTION
1.1. Introduction

With growing development of Indian economy, energy consumption is increasing day by day. Energy consumption in household shares 40% of total energy consumption all over India. Moreover about 30% of total population resides in the villages which consider a good sum of 0.36 billion of total population. In the domestic household sector cooking is the largest end user accounting for almost 90 percent of the total domestic energy use. The rural masses mostly depend on biomass or kerosene for their energy needs. Gradual price hike in crude oil in international market has greatly affected the rural India. In order to cushion fuel price hike, the rural masses are shifting more to biomass. Deforestation for fuel wood has graven the problem of climate change and global warming. The seriousness of the problem can be sensed by seeing depleting forest reserves. This trend needs to be checked from environment point of view. Development of renewable energy sources helps to reduce the degree of dependence on energy imports as well as it can be a tool for curbing carbon emission. So, emphasis is given to the renewable energy program. The energy requirement in rural household is mainly for cooking and sometimes heating in colder regions. So there is enormous demand for fuel wood. The one option could be the densification or briquetting to counter this problem. It has a great scope in rural India as India produces large amounts of bio waste material every year. This includes rice straw, leaf wastes, wheat straw, coconut shells and fibres, rice husks, stalks of legumes and sawdust. Some of this biomass is just burnt in air; some like rice husk are mostly dumped into huge mountains of waste. Open-field burning has been used traditionally to dispose of crop residues and sanitize agricultural fields against pests and diseases. Instead of burning down these wastes or letting to decompose in open air which raises the problem, it can be converted to bio fuels to produce power either by direct combustion or transforming these loose biomass to solid fuels. Biomass briquetting is the densification of loose biomass material to produce compact solid composites of different sizes with the application of pressure. Three different types of densification technologies are currently in use. The first, called pyrolizing technology relies on partial pyrolysis of biomass, which is mixed with binder and then made into briquettes by casting and pressing. The second technology is direct extrusion type, where the biomass is dried and directly compacted with high heat and pressure. The last type is called wet briquetting in which decomposition is used in order to breakdown the fibres.
On pressing and drying, briquettes are ready for direct burning or gasification. Some of the advantages of briquettes are given below.

- This is one of the alternative methods to save the consumption and dependency on fuel wood.
- Densities fuels are easy to handle, transport and store.
- They are uniform in size and quality.
- The process helps to solve the residual disposal problem.
- The process assists the reduction of fuel wood and deforestation.
- Indoor air pollution is minimized.
- Briquettes are cheaper than COAL, OIL or LIGNITE.
- There is no sulphur in briquettes.
- There is no fly ash when burning briquettes.
- Briquettes have a consistent quality, have high burning efficiency, and are ideally sized for complete combustion.
- Combustion is more uniform compared to coal.
- Unlike coal, lignite or oil, briquettes are produced from renewable source of energy, biomass.
- Loading/unloading and transportation costs are much less and storage requirement is drastically reduced.
- Briquettes are clean to handle & can be packed in bags for ease of handling & storage.
- Briquettes are usually produced near the consumption centres and supplies do not depend on erratic transport from long distances.
- The technology is pollution free and Eco-friendly.
- The briquette is easy to ignite.
CHAPTER – 02
PROBLEM STATEMENT
2.1. Present state of art

In the present state of art no such machine is available in the market that makes the briquettes from the dry leaves. The machines which are available in the market makes briquettes either from agriculture waste or from wood dust and these machines are too costly and bulky which are not affordable by small scale manufacturers and farmers. At present the leaves which falls from the trees adds nothing to the environment but making the surrounding dirty. Even Nagpur Municipal Corporation collects these dry leaves at one place and burns it with traditional style. Burning like this causes pollution. Keeping this point in view, study was undertaken to develop the machine which is able to make briquettes from agricultural waste, wood dust and from dry leaves.

Fig.2.1 Present state of art
2.2. Available machines in the market

Various machines are available in the market for making biomass briquettes. The machines are of various types like hydraulic type, screw pressed type and piston pressed type. Though these machines are available they are not affordable by the poor farmers and small scale manufacturer. The price of this machine is high because it uses high power motor and engines. These machines are difficult to operate by unskilled labour in small areas. So there is a need to develop a machine which is ease in operation and also of lesser price than the machine available in market.

2.3. Comparison between machines available in the market

<table>
<thead>
<tr>
<th>Model name</th>
<th>Jumbo 90 (hydraulic type)</th>
<th>GEMCO screw type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Bulky</td>
<td>Bulky</td>
</tr>
<tr>
<td>Power consumption</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Vibration</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Cost</td>
<td>High cost</td>
<td>High cost</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Log diameter / length</td>
<td>40mm / 50mm</td>
<td>25mm / 40mm</td>
</tr>
</tbody>
</table>

Table 2.1 Comparison between machines available in the market

Fig.2.2 Jumbo 90 (hydraulic type)
2.4. Comparison between available machine and our machine

<table>
<thead>
<tr>
<th>Available machine</th>
<th>Our machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of available machine in the market is large.</td>
<td>Size of machine is small</td>
</tr>
<tr>
<td>Moving these machines is difficult job</td>
<td>This machine can easily move from one place to another.</td>
</tr>
<tr>
<td>Cost of the machines available in the market is high.</td>
<td>Cost of this machine is affordable by small scale manufacturer and farmers.</td>
</tr>
<tr>
<td>Require more maintenance</td>
<td>Require less maintenance</td>
</tr>
<tr>
<td>Require more electricity and power</td>
<td>Require less power and electricity</td>
</tr>
</tbody>
</table>

Table 2.2 Comparison between available machine and our machine
2.5. Problem statement

Solid waste management is one of the major problems. This is not only found in the urban areas but also at the rural areas. The major waste generated at the rural areas is agricultural waste or residue i.e. crop by-product. Despite this level of waste generation fuel for heating, cooking and other purposes is a huge problem. Hence they rely on wood fuel and charcoal.

Agricultural residues are, in principle, one of the major sources. They arise in large volumes and in the rural areas which are often subject to some of the worst pressures of wood shortage. Main agricultural residues that are produced are Rice straw, wheat stalks, maize stalks, cotton stalks, and leaf wastes.

There is also bio waste as wood dust. This wood dust is produced in big scale. Beside the problem of transportation, storage and operation, open burning of this bio waste with traditional style without control can cause critical air pollution. The impact of agricultural waste on the environment depends not only on the amounts generated but also on the disposal methods used. Some of the disposal practices pollute the environment.

The potential threat posed by climate change, due to high emission levels of greenhouse gases (CO2 being the most important one), has become a major stimulus for renewable energy sources in general. When produced by sustainable means, biomass emits roughly the same amount of carbon during conversion as is taken up during plant growth. The use of biomass therefore does not contribute to a buildup of CO2 in the atmosphere. Hence there is the need of an appropriate briquetting machine to make biomass a significant impact as fuel.
CHAPTER – 03
LITERATURE REVIEW
3.0. Literature review

3.1. History of briquetting

Briquetting is the densification of loose biomass material. Fuel briquettes emerged as a significant business enterprise in the 20th century. In the 1950s, several economic methods were developed to make briquettes without a binder where multitude of factories throughout the world produced literally tens of millions of tons of usable and economic material that met the household and industrial energy needs. During the two World Wars, households in many European countries made their own briquettes from soaked waste paper and other combustible domestic waste using simple lever-operated presses.

Today’s industrial briquetting machines, although much larger and more complex, operate on the same principle. Briquetting could be categorized into five main types depending on the types of equipment used; piston presses, screw presses, roller press, pelletizing, manual presses and low pressure briquetting.

Biomass is acquiring increasing importance because of the growing domestic and industrial applications for heating, combined heat and power (CHP) and electricity generation in many countries.

There have been briquetting projects in many African countries such as Zimbabwe, Tanzania, Uganda, Kenya, Sudan, Rwanda, Niger, Gambia, Ethiopia and Senegal, though not all of these are still functional. The raw materials most commonly briquetted in Africa are coffee husks and groundnut shells while sawdust and cotton stalks are also used.

The history of residue briquetting in Africa is largely one of single projects in various countries which have usually not been successful (FAO, 1990). A survey carried by FAO, (1990) showed that many briquetting plants in East Africa have been faced by outright failures while others have had their operations marred by problems. According to this survey, it was difficult to find a single agency-funded briquetting project which had been commissioned and was operating fully satisfactorily. The reasons that seemed to explain this failure includes:
1. Inappropriate ordering of briquetting machinery.
2. Non-availability and high cost of the briquetting machines.
3. Poor projects.
4. Low local prices of firewood and charcoal which inhibited the marketing of briquettes and unacceptability of briquettes in the household sector.

3.2. The residual base

The potential agro-residues which do not pose any collection and drying problems, normally associated with biomass are Rice straw, rice husk, wheat stalks, coffee husk maize stalks, cotton stalks, and leaf wastes.

There are many factors to consider before a biomass qualifies for use as feedstock for briquetting. Apart from its availability in large quantities, it should have the following characteristics:

3.2.1. Low moisture content

Moisture content should be as low as possible, generally in the range of 10-15 percent. High moisture content will pose problems in grinding and excessive energy is required for drying.

3.2.2. Ash content and composition

Biomass residues normally have much lower ash content (except for rice husk with 20% ash) but their ashes have a higher percentage of alkaline minerals, especially potash. The ash content of different types of biomass is an indicator of slagging behavior of the biomass. Generally, the greater the ash content the greater the slagging behavior. But this does not mean that biomass with lower ash content will not show any slagging behavior. The temperature of operation, the mineral compositions of ash and their percentage combined, determine the slagging behavior. If conditions are favorable, then the degree of slagging will be greater. Minerals like SiO2 Na2O and K2O are more troublesome. Many authors have tried to determine the slagging temperature of ash but they have not been successful because of the complexity involved. Usually slagging takes place with biomass fuels containing more than 4% ash and non-slagging fuels with ash content less than 4%. According to the melting compositions, they can be termed as fuels with a severe or moderate degree of slagging.
3.2.3. Flow characteristics

The material should be granular and uniform so that it can flow easily in bunkers and storage silos. Some of the appropriate agro-residues are:

1. **Rice husk:** When compared to sawdust, agro-residues have a higher ash content, higher potash content and have poor flow characteristics. However, rice husk is an exceptional biomass. It has good flow ability, normally available with 10 percent moisture and the ash contains fewer alkaline minerals, thereby it has a high ash sintering temperature. In fact, it makes an excellent fuel although its calorific value is less than wood and other agro-residues.

2. **Groundnut shell:** Because of low ash (2-3%) and moisture content less than 10%, it is also an excellent material for briquetting.

3. **Cotton sticks:** This material is required to be chopped and then stored in dry form. It has a tendency to degrade during storage. Also, it has a higher content of alkaline minerals and needs to be used with caution.

4. **Coffee husk:** An excellent material for briquetting having low ash and available with 10% moisture content. The material is available in the coffee growing areas.

5. **Mustard stalks:** Like cotton sticks, it is also an appropriate material for briquetting.

3.3. Characteristics of briquettes

Briquettes must be consistent or otherwise cracks, scratches could appear, and fine elements would separate, which is not acceptable. Briquettes with higher density have a longer burning time. The standard DIN 51731 defines the interval of briquette density values from 1 to 1.4 kg/dm$^3$ (g/cm$^3$). The standard DIN 52182 (additional standard DIN 51731) also describes the testing method for briquette density. A piece of briquette has to be weighed and its diameter and length measured. Briquette density has to be evaluated according to the following ratio.

$$ \rho_N = \frac{m_N}{V_N} \text{ (g/cm}^3\text{)}$$

Where,
• $m_N$ = briquette weight (g)
• $V_N$ = briquette volume (cm$^3$)

3.4. Briquetting technology
The briquetting technologies can be divided into:

• High pressure compaction,
• Medium pressure compaction assisted by a heating device,
• Low pressure compaction with a binding agent.

Depending on the type of material, the pressure applied and the binder used, different binding methods are used. The physical properties (moisture content, bulk density, void volume and thermal properties) of the biomass are the most important factors in the binding process of biomass densification. The densification of biomass under high pressure results in mechanical interlocking and increased adhesion/cohesion (molecular forces like van der Waal’s forces) of the solid particles, which form intermolecular bonds in the contact area. Additives of high viscous bonding media (binders), such as tar, molasses and other molecular weight organic liquid can form bonds very similar to solid bridges. Adhesive forces at the solid/liquid interface and cohesion forces within the solid are used for binding. Lignin of biomass/wood which is deliberated under high pressure and/or temperature can also be assumed to help binding in this way.

3.4.1. High and medium pressure compaction
High and medium pressure compaction normally does not use any additional binder. Normally, the briquetting process bases either on screw press or piston press technology. For the Screw Press Compress, the Biomass is extruded nonstop by the screw through a hot and taper block. For Piston Press Compress method, the hardness at the touch part like at the compress and block part is less compare with screw and block for Screw Press type. At the pass, the energy using is less compare at this time. From quality aspect, the briquetting and production procedure for Screw Press is more good compare with Piston Press type. The centre of pore that is associated with briquetting process from Screw Pressure help in achieving the perfect and flat burning. So, this briquette can be carbonized.
### 3.4.2. Difference between piston press and screw press

<table>
<thead>
<tr>
<th></th>
<th>Piston Press</th>
<th>Screw Press</th>
</tr>
</thead>
<tbody>
<tr>
<td>The optimum of raw material Moisture Contain</td>
<td>10-15%</td>
<td>8-9%</td>
</tr>
<tr>
<td>Output of machine production</td>
<td>Level by level</td>
<td>Nonstop</td>
</tr>
<tr>
<td>Energy using</td>
<td>50 kWh/tone</td>
<td>60 kWh/tone</td>
</tr>
<tr>
<td>Briquette Density</td>
<td>1-1.2 gm/cm³</td>
<td>1-1.4 gm/cm³</td>
</tr>
<tr>
<td>Maintenances</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Briquette burning Performance</td>
<td>Not so good</td>
<td>Very good</td>
</tr>
<tr>
<td>Carbonization to the coal</td>
<td>Impossible</td>
<td>Produce the good coal</td>
</tr>
<tr>
<td>Homogeneity in the briquette</td>
<td>Non-homogeneous</td>
<td>Homogeneous</td>
</tr>
</tbody>
</table>

**Table 3.1 Difference between piston press and screw press**

### 3.4.3. Low pressure compaction

Low pressure briquetting needs a binding agent to assist the formation of bonds between the biomass particles. There are various binding agents in use which can be divided into two main groups:

- **Organic binders**
  - Molasses
  - Coal tar
  - Bitumen
  - Starch
  - Resin

- **Inorganic binders**
  - Clay
  - Cement
CHAPTER – 04

SOLUTION ON PROBLEM
4.1. Solution on problem

The solution for the above problem was to develop a machine. So we took some initiative and carried out market survey for availability of such kinds of machines in the market. After surveying we found that the machines available were either too bulky or too costly. It was not affordable by small scale manufacturer and farmers. So the concept we thought was totally new, that would not only solve the previous problems but also the cost of machine in the market will be low and affordable. Below is some conceptual drawing which we suggest as solution for the problem statement.

Fig.4.1 First conceptual model of leaf log maker machine
4.2. Different parts are as follows

1. Hydraulic cylinder
2. Gear pump
3. Engine
4. Feeding section
5. Removable head
6. Handel
7. Frame
8. Wheels
4.2.1. Hydraulic cylinder

A hydraulic cylinder is a mechanical actuator that is used to give a unidirectional force through a unidirectional stroke. Hydraulic cylinder gets their power from pressurised hydraulic fluid, which is typically oil. The hydraulic cylinder consists of a cylinder barrel, in which a piston is connected to a piston rod moves back and forth. In this machine it is used to compress the material into the cavity for desired shape & size of waste leaves.

4.2.2. Gear pump

A gear pump uses the meshing of gears to pump fluid by displacement.

4.2.3. Engine

An engine is a machine designed to convert one form of energy into mechanical energy. It uses fuel to create heat which is then used to create a force.

4.2.4. Feeding section

The feeding section is nothing but the hopper which has the arrangement to control the flow of material into the cavity where it is compressed into desired shape and size.

4.2.5. Removable head

It is the output area from which the briquette of desired shape and size comes out from compression chamber.

4.2.6. Frame

Frame is assembling and positioning all the parts and elements together. It must be rigid and strong enough to bear the shock and vibration.

4.2.7. Wheels

Wheels are used to move the machine from one place to another.
After doing market survey we found that this two conceptual models based on hydraulic system are not suitable because of the following reasons:

- It uses the hydraulic system which is too costly.
- It requires more electricity and power.
- The machine becomes too bulky.
- The overall cost of the machine increases due to the hydraulic system, engine and gear pump.
- Handling of hydraulic oils which can be quite messy. It is also very difficult to completely eliminate leakage in a hydraulic system.
- Most hydraulic fluids have a tendency to catch fire in the event of leakage, especially in hot regions.

Based on the above reasons we move towards the pneumatic system because:

- Like hydraulics, pneumatics is a type of fluid power application where instead of an incompressible liquid, pneumatics employ gas in their system.
- The air used in pneumatics devices is dried and free from moisture so that it does not create any problem to the internal part of the system.
- Initial cost is less; hydraulics equipment costs as much as twice the price of pneumatic equipment.
- Air availability
- Ease of transfer through piping.
- Ease of use.
- Ease of maintenance.
- Safe, explosion proof.
- Works in wide range of temperature.
4.3. Model based on pneumatic system

![3D model of leaf log maker machine (Pneumatic type)](image)

**Fig.4.3 3D model of leaf log maker machine (Pneumatic type)**

4.4. Different parts are as follows

1. Main frame
2. Pneumatic cylinder
3. Feeding section
4. Screw conveyer
5. Control unit
6. Power transmission unit

4.4.1. Main frame

The supporting structure of machine is a frame, which supports the whole assembly of the machine like motor, feed mechanism, sprockets, hopper, compression chamber etc. The frame was made heavy to have better balance and stability.
4.4.2. Pneumatic cylinder

Pneumatic cylinder is a mechanical device which uses the power of the compressed gas to produce a force in a reciprocating linear motion. Pneumatic cylinder is used to compress material into the cavity for desired shape & size of waste leaves.

4.4.3. Feeding section

The feeding section is nothing but the hopper which has the arrangement to control the flow of material into the cavity where it is compressed into desired shape and size.

4.4.4. Screw conveyer

A screw conveyer is a mechanism that uses a rotating helical screw blade usually within a tube, to move granular materials. It is used for feeding the leaves from hopper to compression chamber. It also partially crushes the leaves.

4.4.5. Power transmission unit

The power is transmitted to the main shaft with the help of motor at specific rpm.
CHAPTER – 05
DESIGN METHODOLOGY
Design Methodology

5.1. Power required to drive the machine

The power required to drive the leaf log maker machine should be such that:

1. It must carry variable load during constant running of machine.
2. The frame must sustain the weight of motor.

So keeping this objective in mind the power required to drive the load according to the requirement of the machine. It must be 0.5 HP to 1 HP. So, on being safer side we selected 1HP motor.

5.2. Design of chain drive

Rated power, $P_R = 1 \text{ HP} = 0.7457 \text{ KW}$

$N_1 = 950 \text{ rpm}$

1. Design power

$P_d = P_R \times K_1$

$K_1 =$ load factor

Taking $K_1 = 1.4$ (moderate shock for 24 hrs/day)

$P_d = 0.7457 \times 1.4 = 1.04398 \text{ KW}$

2. Pitch and no. Of strands for smaller sprocket

$N_1 = 950 \text{ rpm}$ \hspace{1cm} $P_d = 1.04398 \text{ KW} = 1.4 \text{ HP}$

From design data book page no. 152 fig. 14.1

For single strand selecting chain no. 35

Therefore, pitch, $p = 9.525 \text{ mm}$

Tooth range (15 to 25)

Selecting $T_1 = 17$
Pitch diameter of smaller sprocket, \( D_{p1} = \frac{p}{\sin(\frac{180}{T_1})} \)

\( D_{p1} = \frac{9.525}{\sin(\frac{180}{17})} = 51.836 \text{ mm} \)

Velocity, \( V_{p1} = \frac{\pi \times D_{p1} \times N_1}{1000} = \frac{(\pi \times 51.836 \times 950)}{1000} = 154.705 \text{ m/min} \)

\( V_{p1} = 154.705 \text{ m/min} = 2.578 \text{ m/s} \)

From design data book page no. 151 Table XIV-3

Recommended velocity is in between 150 – 450 m/min

Therefore, design is safe

3. Power capacity per strand

\[
P/\text{strand} = p^2 \left[ \frac{V}{104} - \frac{V^{1.41}}{526} \right] \left( \frac{26 - 25\cos\frac{180}{T}}{1} \right) \times K_c
\]

\( K_c = \text{capacity factor} = 1 \) (for single strand)

\[
P/\text{strand} = 9.525 \left[ \frac{2.578}{104} - \frac{2.578^{1.41}}{526} \left( \frac{26 - 25\cos\frac{180}{17}}{1} \right) \right]
\]

\( P/\text{strand} = 1.3136 \text{ KW} = 1.76 \text{ HP} \)

4. No. Of strand

No. Of strand, \( n = \frac{P_d}{(P/\text{strand})} = \frac{1.04398}{1.3136} = 0.79 \)

So, selecting \( n = 1 \)

5. Total power

\( TP = P/\text{strand} \times n = 1.76 \text{ HP} \)

So, \( TP > P_d \)

Therefore, design is safe
6. **Recommended wear load, \( F_W \)**

\[
F_W = 0.35 \times p^2 = 0.35 \times 9.525^2 = 31.75 \text{ N}
\]

7. **Tooth load, \( F_T \)**

\[
F_T = \frac{P_d}{V_p} = \frac{1043.98}{2.578} = 404.95 \text{ N}
\]

8. **Maximum permissible bore diameter, \( d \)**

\[
d = \frac{(T_1 - 5) \times p}{4} = \frac{(17 - 5) \times 9.525}{4} = 28.575 \text{ mm}
\]

From design data book page no. 119 Table XII-3

Shaft diameter for 0.7457KW & speed \( N_1 = 950 \text{ rpm} \) is 24 mm

So calculated diameter > 24 mm

Therefore, design is safe

9. **RPM of larger sprocket**

Selecting \( T_2 = 25 \) for larger sprocket

Now, \( N_1 T_1 = N_2 T_2 \)

\[
N_2 = \frac{N_1 T_1}{T_2} = \frac{950 \times 17}{25} = 646 \text{ rpm} = 650 \text{ rpm}
\]

10. **Pitch diameter of larger sprocket, \( D_{p2} \)**

\[
D_{p2} = \frac{p}{\sin \left( \frac{180}{T_2} \right)} = \frac{9.525}{\sin \left( \frac{180}{25} \right)} = 75.99 \text{ mm}
\]

11. **Length of chain, \( L_p \)**

Assuming centre distance, \( C = 310 \text{ mm} \)

\[
L_p = \frac{T_1 + T_2 + 2C + \frac{p(T_2 - T_1)^2}{40C}}{2} = \frac{17 + 25 + 2 \times 310 + 9.525(25 - 17)^2}{9.525} \]

\[
= \frac{2 \times 9.525}{40 \times 310}
\]
LP = 86.14 mm

12. Approximate dimensions for roller chains
- Roller diameter, \(dr = \frac{5p}{8} = \frac{5 \times 9.525}{8} = 5.95\) mm
- Chain width, \(W = \frac{5p}{8} = \frac{5 \times 9.525}{8} = 5.95\) mm
- Pin diameter, \(dp = \frac{5p}{16} = \frac{5 \times 9.525}{16} = 2.976\) mm
- Thickness of link plate = \(p / 8 = 9.525 / 8 = 1.190\) mm
- Max. Height of pin link plates, \(Hp = 0.82p = 0.82 \times 9.525 = 7.8105\) mm
- Max. Height of roller link plate, \(Hp = 0.95p = 0.95 \times 9.525 = 9.0487\) mm

![Approximate dimensions for roller chains](image)

13. Standard roller chain sprocket dimensions
- Width of sprocket teeth, \(t_0 = 0.58p – 0.15 = (0.58 \times 9.525) – 0.15 = 5.3745\) mm
- Corner relief, \(e = 0.125p = 1.190\) mm
- Chamfer radius, \(r = 0.54p = 5.1435\) mm
- Outside diameter for smaller sprocket, \(D_{O1} = p [0.6 + \cot (180 / T_1)]\)
  
  \[D_{O1} = 9.525 [0.6 + \cot (180 / 17)] = 56.669\) mm

- Outside diameter for larger sprocket, \(D_{O2} = p [0.6 + \cot (180 / T_2)]\)
  
  \[D_{O2} = 9.525 [0.6 + \cot (180 / 25)] = 81.113\) mm
• Root or bottom diameter for smaller sprocket, \( D_{r1} = D_P - 0.625p \)
\[ 0.625p \ D_{r1} = 51.836 - (0.625 \times 9.525) = 45.882 \text{ mm} \]

• Root or bottom diameter for larger sprocket, \( D_{r2} = D_P - 0.625p \)
\[ 0.625p \ D_{r2} = 75.99 - (0.625 \times 9.525) = 70.036 \text{ mm} \]
5.3. Design of pneumatic system

1. Cylinder calculation

Pressure Required = Force/Area

Fig. 5.2 Pneumatic compressor actuator

2. Force calculation:

Total force, \( F = F_G + F_A \)

Where,

\( F_G \) = Force used to balance the load or Resisting force

\( F_A \) = Force needed to accelerate the material

I. \( F_G \) Calculation:

Height of material which we want to be compress in the cylinder = 60 mm

Diameter of cylinder, \( D = 20 \) mm

Now, Volume of material which we want to compress in cylinder, \( V = \pi X R^2 X h \)

\( V = \pi X (0.01)^2 X 0.06 = 10884 \times 10^{-5} \ m^3 \)

Mass of Material (Leaf), \( m = Volume \times Density \)

(Assume Density of leaf=750 kg/m\(^3\))
m = 1.884 \times 10^{-5} \times 750 = \textbf{0.01413 \text{ kg or 14.13 gm}}

But by practical calculation it is found nearly to be = 50 gm

So, \( F_G = \text{Mass} \times \text{Acceleration due to gravity} \)

\( F_G = 0.05 \times 9.81 = \textbf{0.4905 N = 0.5 N} \)

II. \( F_A \) Calculation:

Work, \( W = \text{Force} \times \text{Displacement} \)

\( W = \text{Kinetic Energy} \)

\( W = F_A \times S = (mv^2) / 2 \)

Where,

\( S = \text{Stroke Length} = 100 \text{ mm} \)

\( m = \text{Mass of leaf} = 50 \text{ gm} \)

\( v = \text{Speed of Actuator} = 1 \text{ m/s} \quad \text{…… (Assumption)} \)

Therefore, \( F_A \times 0.1 = (0.05 \times 1^2) / 2 \)

\( F_A = \textbf{0.25 N} \)

Total Force, \( F = F_A + F_G \)

\( F = 0.25 + 0.5 = \textbf{0.75 N} \)

3. \textbf{Pressure Required, P}

\( P = \text{Force} / \text{Area} \)

\( \text{Area} = (\pi \times D^2) / 4 = 3.14 \times 10^{-4} \text{ m}^2 \)

\( P = 0.75 / 3.14 \times 10^{-4} \)

\( P = \textbf{2388.5 N/m}^2 = \textbf{0.3463 \text{ Psi}} \)
4. Slider calculation

Mass of slider, $m_S = 1.5$ kg

Force, $F_S = m_S \times$ acceleration due to gravity

$F_S = 1.5 \times 9.81 = 14.715$ N

Therefore,

Pressure required for slider, $P_S = \frac{F_S}{\text{Area}}$

Area = $\left(\pi \times D^2\right) / 4 = 3.14 \times 10^{-4} \text{ m}^2$

$P_S = 14.75 / (3.14 \times 10^{-4})$

$P_S = \frac{46863 \text{ N/m}^2}{6.79 \text{ Psi}}$

From the above calculation, maximum pressure is 6.79 Psi. So we will design the compressor pressure according to the required slider pressure.

5. Air consumption calculation

Air consumption = $A \times S \times C$

Where,

$A = \text{area of cylinder} = \left(\pi \times D^2\right) / 4 = 3.14 \times 10^{-4} \text{ m}^2$

$S = \text{stroke length of cylinder}$

$C = \text{log per minute} \quad \quad \quad \quad \quad \quad \text{(We produce 4 log per minute)}$
For compression of material,

Stroke length, \( S = 100 \text{ mm} \)

Air required = \( 3.14 \times 10^{-4} \times 0.1 \times 4 = 1.256 \times 10^{-4} \)

**For slider,**

Stroke length, \( S = 70 \text{ mm} \)

Air required = \( 3.14 \times 10^{-4} \times 0.7 \times 4 = 8.792 \times 10^{-5} \)

Total air consumed, \( T_A = \text{air required for compression of material} + \text{air required for slider} \)

\( T_A = 1.256 \times 10^{-4} + 8.792 \times 10^{-5} \)

\( T_A = 2.135 \times 10^{-4} \text{ m}^3 / \text{minute} \)

\( T_A = 0.2135 \text{ liter/minute} \)
5.4. Design of screw conveyer

We consider several factors for designing. As we have freedom in taking brick dimensions. Consider cylindrical briquette of diameter 20 mm and height 20 mm.

Assuming delay time due to pneumatic system to be 15 sec. we consider total time to make a briquette to be 20 sec.

Therefore we have 5 seconds for conveying the material to compression chamber.

1. **Volume, V**

\[
V = \left(\pi \times D^2 \times L\right) / 4
\]

\[
V = \left(\pi \times 0.020^2 \times 0.020\right) / 4 = 6.28 \times 10^{-6} \text{ m}^2
\]

Assuming density of dry leaf to be, \(\rho = 0.41 \text{ gm/cm}^3 = 410 \text{ kg/m}^3\)

2. **Mass, M**

\[
M = \rho \times V
\]

\[
M = 410 \times 6.28 \times 10^{-6} = 2.5748 \times 10^{-3} \text{ kg}
\]

3. **Frictional force, F**

Assuming coefficient of friction to be 0.3 between additives and pipe

\[
F = (\mu \times M \times g) + \text{bearing}
\]

\[
F = (0.3 \times 2.5748 \times 10^{-3} \times 9.81) + 0.15 = 0.1575 \text{ N}
\]

4. **Helix angle, \(\alpha\)**

Assuming major diameter of screw conveyer, \(D_M = 20 \text{ mm} = 0.02 \text{ m}\) and pitch, \(p = 15 \text{ mm} = 0.015 \text{ m}\)

\[
\alpha = \tan^{-1}\left(\frac{p}{\pi \times D_M}\right)
\]

\[
\alpha = \tan^{-1}\left(\frac{0.015}{\pi \times 0.02}\right) = 13.42 \text{ degree} = 14 \text{ degree}
\]

From machine design textbook by Khurmi Gupta page no. 630 table 17.4
For $D_M = 20\, \text{mm}$, minor diameter, $d_M = 15.5\, \text{mm}$

5. Efficiency, $\eta$

$\eta = \frac{[W \times \tan (\alpha)]}{[W \times \tan (\alpha + \phi)]} = \frac{[\tan (\alpha)]}{[\tan (\alpha + \phi)]}$

$\alpha = 14\, \text{degree}$

$\phi = \tan^{-1}(0.3) = 16.69\, \text{degree} = 17\, \text{degree}$

$\eta = \frac{[\tan (14)]}{[\tan (14 + 17)]} = 0.415 = 41.5\%$

6. Effort required, $F_E$

$F_E = F / \sin \alpha = 0.1575 / \sin 14$

$F_E = 1.6525\, \text{N}$

7. Torque, $T$

$T = F_E \times r = 1.6525 \times 10 \times 10^{-3}$

$T = 0.01652\, \text{Nm}$

8. Feed rate, $f$

$f = \text{rpm} \times \text{pitch}$

$f = 650 \times 15 = 9750\, \text{mm/min}$
CHAPTER – 06
MODELLING OF MACHINE
6.0. MODELLING OF MACHINE

6.1. CAD

CAD should be defined as the use of computer system to assist in the creation, modification, analysis or optimization of a design. The computer system consists of the hardware and the software to perform the specialized design functions required by the particular user firm. The CAD hardware typically includes the computer, one or more graphics terminal, keyboards and other peripheral equipment. The CAD software consists of the computer programs to implement computer graphics on the system plus application programme to facilitate the engineering function of the user company.

6.2. THE DESIGN PROCEDURE

The general process of design is characterised by Shingley as an interactive process consisting of six phase:

1. **Recognition of need**: - It involves the realization by someone that a problem exists for which a corrective action should be taken in the form of design solution.

2. **Problem identification**: - Involves a through specification of the item to be designed. This includes physical characteristics, function, cost etc.

3. **Synthesis**: - Each subsystem of the product is to be conceptualized by the designer.

4. **Analysis**: - All the subsystem of the product has to be analysed, improve through this process and it can redesign and analysed again. The synthesis and analysis are closely related to each other.

5. **Evaluation**: - It is concerned with measuring the design against the specification established in the problem definition phase.

6. **Presentation**: - It is concerned with the documenting the design by means of drawing, material specification and assembly list.
6.3. CONVENTIONAL DESIGN PROCEDURE

Fig. 6.1 Flow chart of design procedure of CAD
6.4. MODIFIED DESIGN PROCEDURE BY THE CAD

Recognition of need

Problem definition

Synthesis

Analysis and optimization

Evaluation

Presentation

Geometric Modelling

Engineering Analysis

Design Review and Evaluation

Automated Drafting

Fig. 6.2 Flow chart of modified CAD procedure
6.5. CREATION OF GEOMETRIC MODELLING WITH CAD SOFTWARE

Computer aided design (CAD) can be defined as the use of computer to assist in creation, modification, analysis or optimization of design. Thus computer system also uses hardware and software to perform the specialized design function required by the particular user firm.

In this work CATIA parametric is used for modelling and simulation of leaf log maker machine.

This CATIA parametric is used due to following reasons
❖ Faster drafting capture with solid modelling.
❖ Faster drafting with solid modelling. It is almost automatic when the user is working on CATIA parametric.

CATIA Parametric
❖ Better visualization with three dimensional views. Three dimensional view modelling reduces the design errors also reduces and eliminates physical prototypes.
❖ You are creating a soft prototype of your product on computer. Major work is done through this software,
6.6. FOLLOWING ARE THE OPERATIONS PERFORMED IN SOFTWARE

CATIA PARAMETRIC FOR MODELLING

6.6.1. Sketching

In this modelling component sketching is done in fully constrained condition when certain change in part, it will permit up to certain limit. There is no necessity to sketch again all entities again. In this module circle, line, rectangle, hexagon, trimmed, extend, mirror command etc are used.

6.6.2. Part modelling

In this model extrude, chamfer, fillet, revolve, loft, shell, pattern etc are used to generate 3-d model on screen.

6.6.3. Assembling of all components

In this model of software all 3-d as well as geometric part are called one by one as per sequence of fitting of machine. In this module all parts are assembled by applying various command like mate, rectangular, place component and replace component etc commands are used for generating final view of machine.

6.6.4. Drafting

In this module all views of machine are generated on drawing sheet as per conventional drawing. In this module front view, side view and top view are generated. This gives a detailed idea of our machine. In this module base view, projected view, sectional view, auxiliary view, etc commands are used. Another side in drawing annotation tool bar are used to give dimensions of all parts as well as to apply various symbols like welding, surface finish, fit etc.

6.6.5. Simulation

A powerful feature of CAD is simulation. It helps the designer in knowing kinematics, robotics assembly and FMS design. Simulation helps in the performance of the product before making prototype and identifies the modification needed.
The technique of simulation has been used by designer and analysts in physical science and it promises to become an important tool for tackling and complicated problem of dynamic mechanism. The range of simulation varies from simple probe to problem of multi degree freedom complex mechanism.

6.6.6. Advantages of simulation

1. Simulation technique when compared with experimental and standard probability analysis, after number of advantages over this technique.
2. Simulation model are comparatively flexible and can be modified to accommodate the changing environment of real situation.
3. The simulation technique gives the real idea about motion of mechanisms.
4. It reduces the experimental time, expenditure so it directly reduces the lead time.
5. Simulation has the advantage of being relatively free from mathematics and thus can be easily understood by operating personnel and non-technical manager. This help in getting the proposed plans accepted and implemented.
### 6.7. CAD Modelling of the Machine

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Part Name</th>
<th>CAD Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hopper</td>
<td>![Hopper CAD Model]</td>
</tr>
<tr>
<td>2.</td>
<td>Pneumatic cylinder</td>
<td>![Pneumatic Cylinder CAD Model]</td>
</tr>
<tr>
<td>3.</td>
<td>Compression chamber</td>
<td>![Compression Chamber CAD Model]</td>
</tr>
<tr>
<td>4.</td>
<td>Screw conveyer</td>
<td>![Screw Conveyor CAD Model]</td>
</tr>
<tr>
<td>5.</td>
<td>Control unit</td>
<td>![Control Unit CAD Model]</td>
</tr>
</tbody>
</table>

**Table.6.1 Different parts of machine generated in CAD**
6.8. Generated 3D CAD Model

Fig.6.3 Final 3D model of leaf log maker machine
CHAPTER – 07

DEVELOPMENT OF MACHINE
7.0. DEVELOPMENT OF MACHINE

The machine developed was considered of different parts and the specification of the parts are given and are explained under following headings:

7.1. Main frame

The supporting structure of machine is frame which supports the whole assembly of machine like motor, feed mechanism, sprockets, hopper, and compression chamber. The material used for making the frame was iron angle L-channel. The frame was fabricated with overall dimensions (l x b x h) (52 x 35 x 35) mm. The frame was made heavy to have better balance and stability.

![Fig.7.1 Main frame](image)

7.2. Feeding section (Hopper)

The feeding section is nothing but the hopper which has the arrangement to control the flow of material into the cavity where it is compressed into desired shape and size. The hopper was made conical in shape. The upper diameter is 100 mm and that of lower is 30 mm. The height of the hopper is 114 mm.
7.3. Power transmission

Power is transmitted to the screw conveyer by the motor of 1 HP and 950 rpm. This power is kept constant and the rpm is reduced with the help of chain and sprocket arrangement and it reduce up to required rpm.

7.4. Screw conveyer

A screw conveyor is used for feeding the leaves from hopper to compression chamber. It also partially crushes the leaves. The length of the screw conveyer is 115 mm and the pitch is 15 mm. The major diameter is 20 mm and the minor diameter is 15.5 mm.
7.5. Chain drive

The chain drive is used to transmit the power and motion from the main shaft to the screw conveyer. The number of tooth on smaller sprocket is 17 and that of larger is 25. The centre distance between two sprockets is kept as 310 mm.

7.6. Ease of operation

As per our observation we found that the leaf log maker machine has excellent performance because of following features,

- Feeding is easy because of specific size, shape and slope provided to the perforated screen and also to the frame.
- Portable chassis can be used at any destination.
- Semi-automatic machine that lead to ease of operation.
- Variable size can be obtained with the help of electronic circuit.
- Because of easy operation of machine, we can continue the work for longer time.
7.7. Working of machine

Before the start of briquetting process the machine needs to be setup properly at place where sufficient space is available at the site. Check that the connection is done properly. A proper timing is set with the help of electronic circuit for feeding the material into the compression chamber. After setting the time the motor starts and the input is given to the hopper. From hopper the feed goes to the compression chamber via screw conveyer. In the compression chamber the feed is compressed by the pneumatic cylinder up to 6 – 7 bars and the log is created.

![Fig.7.5 Final developed machine](image)
CHAPTER – 08
LIVE TESTING
8.0. Live Testing of Machine

Fig. 8.1 Live testing of machine

Fig. 8.2 Dry leaves

Fig. 8.3 Powdered form of dry leaves

Fig. 8.4 Leaf briquettes
Fig. 8.5 Burning of leaf briquette
CHAPTER – 09
RESULT
9.0. Result

9.1 Efficiency of machine

For making 1 briquette the time required for machine is 15 sec.

Therefore, number of briquettes made by machine in 60 sec

\[ N = \frac{60}{15} = 4 \text{briquette} \]

Also, number of briquette made by machine in 1 hour

\[ N = \frac{3600}{15} = 240 \text{ briquettes} \]

Mass of 1 briquette is 30 gram

Therefore, mass of 240 briquettes

\[ M = 30 \times 240 = 7200 \text{ gram} = 7.2 \text{ kg} \]

So, the machine is producing 7.2 kg of briquettes in 1 hour.

The input (in terms of raw material) required to machine in 1 hour is 8 kg

Therefore, efficiency of machine

\[ \eta = \frac{\text{output produced by machine}}{\text{input given to machine}} \]

\[ \eta = \frac{7.2}{8} = 0.9 = 90\% \]

9.2 Cost analysis

The power of compressor and motor is 360 watt and 250 watt resp.

So the total power is 610 watt = 0.61 kW

Therefore number of unit of electricity required is 0.61 unit and cost associated with 0.61 unit is Rs 2.98.

Consider cost of 1 kg of dry leaves = Rs 3

Therefore coast of 8 kg of dry leaves = 8 x 3 = Rs 24
Therefore total cost = 24 + 2.98 = Rs 26.98 = 2698 paisa

Cost of 1 briquette = 2698 / 240 = **11.24 paisa**

### 9.3 Cost analysis by productivity

The mass of 1 briquette = 30 gm.

Therefore number of briquette produced in 1 hour from 1 kg of raw material N = 1000 / 30 = 33.33 briquette

Therefore cost of 1 kg of briquette = 33.33 x 11.24 = **Rs 3.74**

Market value of 1 kg of briquette is Rs 5.

### 9.4 Comparison of coal and fuel briquette properties

<table>
<thead>
<tr>
<th>Combustion gas properties</th>
<th>Coal</th>
<th>Briquette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross calorific values</td>
<td>25.9</td>
<td>22</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>0.86</td>
<td>0.71</td>
</tr>
<tr>
<td>Carbon w/w%</td>
<td>61.2</td>
<td>22.5</td>
</tr>
<tr>
<td>Hydrogen w/w%</td>
<td>4.3</td>
<td>0.71</td>
</tr>
<tr>
<td>Oxygen ratio w/w%</td>
<td>7.4</td>
<td>43.8</td>
</tr>
<tr>
<td>Sulphur w/w%</td>
<td>3.9</td>
<td>0.0020</td>
</tr>
<tr>
<td>Nitrogen w/w%</td>
<td>1.2</td>
<td>0.0010</td>
</tr>
<tr>
<td>Ash w/w%</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Water w/w%</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Carbon dioxide volume%</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Oxygen volume%</td>
<td>3.7</td>
<td>13.4</td>
</tr>
<tr>
<td>% Excess air</td>
<td>20</td>
<td>18</td>
</tr>
</tbody>
</table>

**Table 9.1 Comparison of coal and fuel briquette properties**
Fig. 9.1 Graph representing Comparison of coal and fuel briquette properties
CHAPTER – 10
CONCLUSION
10.0. Conclusion

10.1. Following are some important conclusion, which are summarized as follows:

1. The leaf log maker machine is suitable for making briquettes without any damage. The difficulties that come across the small manufacturing units and farmers can be overcome by this machine.

2. The machines available in market are either too bulky or too costly compared to our machine.

3. The briquettes can be made without adding any binder. Only 7 – 10 % of moisture is required for binding.

4. The leaf briquettes made by our machine is long lasting, burn for longer time with minimum pollution.

5. The cost of 1 kg of briquettes produced by our machine is Rs. 3.74 which is less than the briquettes available in market i.e. Rs. 5 per kg.
CHAPTER - 11

FUTURE SCOPE
11.0. FUTURE SCOPE

11.1. Following are some recommendations and modifications which can be made in future:

1. The machine is in process of patent.
2. The machine can be commercialized in future and can be bought into market for benefit of farmers and small units of manufacturers.
3. In future the machine can be installed in parks, institutes and the places where the agro waste products are available.
4. Even Nagpur Municipal Corporation can make use of this machine in future for making leaf briquettes.
5. In future we can install crushing mechanism so that the dry leaves can be converted into powdered form and the output of crushing unit can be given as input to hopper.
CHAPTER – 12
BIBLIOGRAPHY
12.0. BIBLIOGRAPHY

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