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Design and Fabrication of Biomass Pelleting Machine

[1]Anirudha Tondare, [2]Mr Anay Nadkar, [3]Miss Vishaka Zope, [4]Mohan P Khond
[1,2,3]B.Tech Student, [4]Associate Professor
Department of Mechanical Engineering, College of Engineering, Pune, Maharashtra, India.
Email: [4]mpk.mech@coep.ac.in

Abstract

Many developing countries produce huge amount of agro waste. The disposal of this waste is a major problem. The residues like wheat and rice husk, sawdust from carpentry shops, groundnut shells, and dry leaves from plants are available in a large quantity. Apart from the problems of storage, transportation and easy handling of this waste, burning of biomass in grates poses a greater problem of widespread air pollution. Also, the conversion efficiencies are poor. There is a rising issue of depletion of conventional forms of energy. Energy is a key factor in the development of any country. But due to large scale exploitation of fossil fuels like coal, petrol, diesel, etc. there is a possibility of these fossil fuels fading away. According to the reports, there has been an increase in the use of fossil fuels by 0.6%, which amounts to around 127 million metric tons of consumption. So, renewable energy resources are becoming pertinent by hour. Another global issue faced is waste management. Initiatives to recycle and reuse have recently started. They have provided a right step forward. But recycling of waste in the same form has practical limitations. In the view of above problems, we propose to fabricate a machine which will convert the waste biomass (agro-waste) into a reusable form of briquettes which will be easy to handle, transport and store.

Keywords: *Biomass, Fabricate, Hopper, Rollers*

INTRODUCTION

Biomass, as a source of energy is gaining importance with time. It is replacing coal in certain applications like small scale power plants, heating and many industrial applications. Domestically it can be used in small stoves, which could decrease the effective cost of cooking. Most importantly, this process of producing solid fuel from biomass waste can help in the waste management of these wastes in a productive way.

This project deals with the design and fabrication of a simple and compact machine, which will convert the raw biomass waste in a storable form. Pellets formed are short cylindrical pieces which are produced mechanically by compressing a uniform material that has first passed through a mill to provide homogeneous particle size after which it is pressed through a die with holes of required size. The machine would be designed in such a way that there would be very little manual intervention required during the process. Also the design would be cost effective so as to market it domestically, focusing on the average farmer as a customer.

India is a tropical country thus offers an ideal environment for Biomass production. There is a large quantity of agricultural potential, which makes huge amounts of agro-wastes. With an estimated production of about 460 million tons of agricultural waste per annum, biomass can supplement coal up to 260 million tons; which could save about Rs. 250 billion per annum

The main advantages of biomass densification for combustion are:

1) Simplified mechanical handling
2) Low cost of transportation due to high energy density
3) Uniform combustion in boilers

4) Reduced dust production
5) Reduced possibility of spontaneous combustion in storage

METHODOLOGY

The idea is to fabricate a machine which would have mixing, blending, and compressing chambers. The first section would be comprised of a hopper to feed the input, which would pass to cutting chamber. The cutter would cut the input material into powdered form. A sieve-like plate would be mounted below it to pass this powdered biomass to blending chamber. Here the binder and water would be added to the powdered biomass. Many naturally occurring binders may be used like wheat flour (wastage from mills), wet paper pulp, cow dung etc. The mixing would be done by helical blender, as it is the most efficient blender for handling highly viscous fluids. Due to the helix shape of the blender, the thick viscous mixture would then follow its helix to reach the next chamber.

The next part would be the final stage of the machine. The thick mixture would be passed onto a die. The rollers would be mounted such that there is a clearance between the rollers and the die. The die, being mounted on the central shaft along with the cutting blade and blender, would rotate during the operation. The rollers have their axis perpendicular to the central shaft axis, and the axle that passes through the rollers would be mounted in the casing. The collection of cylindrical shaped briquettes would be done in the chamber under the die from which the briquettes would proceed to drying.

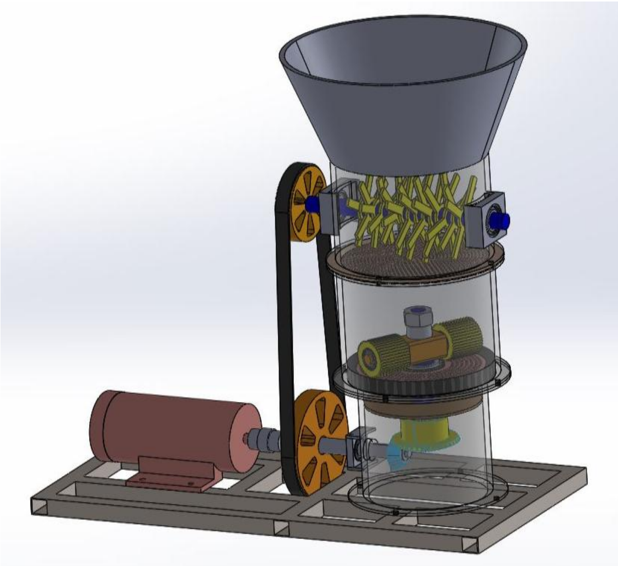

Fig: 1. *The pellet mill*

The pellet mill as schematically shown in Figure 1 consisted of the following parts:

1. Feed hopper: This is where the feeds were fed and extruded by the two pellet rolls to the die plate as pellets. It has outer and inner diameters of 280 mm and 220 mm, respectively, with a height of 150 mm. A stainless steel can be used to prevent sticking of feeds to the feed hopper and to allow easy cleaning. The outer diameter will be welding to eliminate any sharp edges that may be caused by the stainless steel sheet.
2. Cutting chamber: This is where leaves or another biomass material will cut by sharp edge cutter. This cutter will cover diameter around 250 mm. hence all the material which we are feeding will cut effectively and according our

size requirement. Speed reduction can be given to the cutter for varying size of particle.

3. Pelleting chamber: After the material is properly mixed it will introduce in pellet chamber. This is where mixing and extruding of feeds was performed prior to being pushed through by the pellet rolls into the holes of the die plate. This part was made from mild steel (MS) plate with dimensions of 30 cm diameter x 12 cm high in order to withstand the rigorous force created by the rotating die plate and pellet rolls.
4. Pellet rollers: This part was responsible in compressing the formulated feeds before it was extruded in the die plate. The two corrugated pellet rolls will be put in with two bearings each and were inserted in a 4 cm cold rolled steel (CRS) shafting to allow them to freely rotate once the shaft rotated also. The pellet rolls, each with a dimension of 70mm diameter x 60 mm length
5. Die plate: It is the part that converted the formulated feeds into cylindrical-shaped solid materials or into pellets. The die plate will be fixed with help of casing. It can be made from a metal plate with 220mm diameter with 20 mm thickness in order to bear the weight and force created by the rotating pellet rolls. It has 440 holes each with a diameter of 5 mm.
6. Discharge chute: This is where the pelletized feeds were discharged for collection. It was made from 2mm thick MS plate with dimensions of 13 cm wide x 45 cm long.
7. Electric motor: It is used to rotate main shaft which contains mainly cutter, blender and pellet roll. This is responsible in driving the pellet roll to an appropriate speed that led to the conversion of mashed formulated feeds into pellets. A single-phase 1 HP electric motor can be used in order to drive the needed speed for operation of 1380 rpm and at the same time is able to bear overload should it happen.

WORKING PRINCIPLE

The machine works on the principle that it uses a roll-type extrusion press. The formulated feeds are fed into the pelleting chamber by the pellet rolls. As the pellet rolls rotate, force is applied creating rearrangement of the particles in order to fill the voids or holes of the die plate. The pressure is increased in compression step, causing brittle particles to break and malleable particles to deform forcing them to be fed in the die and come out as pellets. The pellets then fall naturally due to impact created by the rotating die plate, hence, no need for a cutter.

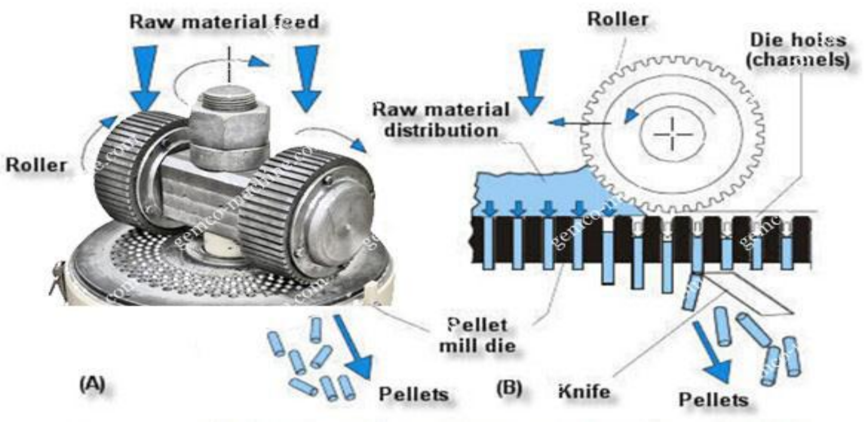

Fig: 2. *Working Principle*

FABRICATED MACHINE

Fig: 3. *Fabricated Machine*

Fig: 4. *Formation of pellets of the required size*

Fig: 5. *Quantity of Pellets formed in one run of the machine*

After design of the machine, according to the required specifications, it was fabricated. The required material was procured and individual parts were manufactured using operations like turning, milling, slotting, drilling, etc. The frame was fabricated using pipes of size 1 inch which were joined using welding. Different parts were joined using bolted joints. The whole assembly is placed on a wooden board to minimize the effect vibration.

Advantages and Limitations

Upshots

- In terms of the product (Pellets):

1) An excellent substitute to conventional fuel at very optimal cost (Only manufacturing and raw material cost)
2) It is a flexible solution to fuel crisis as we can change the composition as per availability of raw material and use it for co-firing with conventional fuels.
3) The fuel pellets is easy to burn and have good calorific value due to compaction.
4) Pellets are easy to store and transport than loose biomass.

- In terms of the machine:

1) Machine is easy to troubleshoot and for maintenance.
2) Design is compact so consumes less floor space.
3) It can be easily operated by any non-technical person
4) The machine is wide open to future modifications and sophistication.

Limitations

1) Due to manufacturing and assembly

anomalies, it didn't yield the results as expected.
2) Proper time for troubleshooting and eliminating all the faults should be given.
3) Machine is quite heavy.
4) Research on material should be done as most of the parts were made from Mild Steel. Other suitable light weight and cheap materials could be explored which could reduce the overall weight and cost of the machine.
5) Wearing of die and rollers could happen.
6) Some arrangement needs to be given to avoid clogging of die or for its cleaning.
7) Efforts can be made in future to improve the productivity of this machine and to improve the calorific value of the pellets by using different proportions of binders.
8) Here, we considered dry leaves, groundnut shells, wheat-rice husk for pelleting, so further work needs to be done for different wastes which can be converted into pellets.
9) Also efforts need to be taken in the direction of commercializing the product so as to manufacture the fuel pellets in mass quantities. This may require incorporation of electronic components to vary the speed of pellet formation as per the loading.

ECONOMICS

- We have considered that a group of 5 farmers, having a medium scale farm, generating waste of the amount 5 kg per day on each farm, will invest in one machine collectively
- For four hours a day, the machine will have to process 6.25 kg of waste per hour
- No. of pellets produced = 440*0.8*45/1.5=10560 pellets
  (Considering 80% of material passes through the holes)
  Effective cycle time =60/(10560/440)= 2.5 minutes
- Simple payback period of the machine:

The various costs for the machine are as follows:

1. Total cost of the machine Co= Rs. 45000
2. Cost per pellet CB= Rs. 0.0071 (Rs 12/kg)
3. Estimated monthly sale SM = 25*20*12 = Rs 6000
4. Estimated annual sale SA= 6000*9 = Rs. 54000
5. Cost of raw material C1= 0.1 kg binder/ kg of pellets*25*4*20*9= Rs. 1800
6. Cost of electricity per year C2= 0.746*4*20*12*2= 720 units/ year*2= Rs. 1440
7. Cost of maintenance per year C3= 200*12 = Rs. 2400

SPP= (Amount to be Invested /Estimated Annual Net Cash Flow)
= Co/ (SA-C1-C2-C3)
= 45000/ (54000-1800-1440-2400)
=0.9302 yrs. i.e. 11.16 months
Hence payback period is around 11 months.
This implies that after the initial period of around one year the customer will be able to breakeven and reach the profit zone which makes it an attractive investment.

CONCLUSION

This machine can be commercialize for domestic use, Agriculture field, Animal feed machine and pellets can be co-fired with coal. The main objective of this project is to fabricate an economical, integrated design, which can be used for pelleting biomass on domestic level. Thus, it solves the problem of waste management and suggests a way to reduce use of fossil fuels as pellets can be used as a fuel substitute.

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