Design and Analysis of Disc & Hoper for Pellet making machine

(Pellet making machine and its problems in manufacturing: An Reseach Case Study)

Nilesh C Kanojiya[1], Rahul ojha[2], Shubham Singh[3], Prashant Kondhalkar[4], Pushpak Pawankar[5], Akshay Kotiyan[6], Raj Harsh[7]

[1]*Assistant Professor, Mechanical Engineering Department, G H Raisoni Academy of Engineering & Technology Nagpur*

[2,3,4,5,6,7] *B.E Final Year Students, Mechanical Engineering Department, G H Raisoni Academy of Engineering & Technology Nagpur, Maharashtra, India*

Abstract- **The assembly line setup was in proper which caused the issue of delay in work and creating problems for the firm. By group format of assembly process it was proved that the assembly process can be done soon The group process includes two members in each group working on a same machine to assemble it and had completed the assembling of two machine within two days Large surface area of hopper created a problem in the quality of the product this was due to irregular portion of raw material entering into the machine and getting converting into pallets with inferior quality The design of new hopper with rectangular shape and less area of passage proved that slow moving of raw material into the machine can make the machining process very good with superior product quality Engineering over the last decades there have been two major factors that have been driving the growth of the pellet fuel market. The first is the consistent rise in cost of fossil fuel and price instability, and the second is the increased attention given to the effect of using fossil fuels such as oil and gas on the environment. Other factors that support the case for pellet is that they are a fuel that can be produced locally form local wood and biomass materials. Local pellet production and distribution can produce an affordable fuel, while creating local jobs and keeping the carbon footprint to a minimum. Biomass pellets are the most common type of pellet fuel. It includes wooden pellets which are generally made from compacted sawdust and related industrial wastes from milling of lumber, manufacture of wood products and furniture and construction.**

I. INTRODUCTION

Pellet Making Machine is a manufacturer of machinery devoted to environmental protection, conservation and green energy. Its facility is located in a "High and New Technology Industrialization Zone" in Nagpur. The company's exports include a range of machinery for producing biomass energy, briquetting and oil presses. Pellet Making Machine's machinery is designed for its functionality and easy maintenance. The usable life of its key parts is twice that of its peers. The company has good standing in the domestic market and has exported its machines around the world. As global supplies of traditional energy sources are depleted, and as the need to protect the environment has become more urgent, biomass energy has moved to the forefront of the alternative energy movement due to its carbon neutrality. Pellet Making Machine seeks to increase the availability of machinery used to harness the power of biomass energy to ensure environmental protection and sustainable development. The process for manufacturing wood pellets for fuel involves placing clean wooden biomass normally between 0-5 mm under high pressure through a small round holes called a die. Eco energy used ring die machines. The manufacturing process must have the correct conditions for the natural lignin in the wood to be released and bind the wood pellets together, we don't use any glues or binding agents in our production or product, when the biomass fuses together, forming a solid mass. This process is called extrusion. Eco energy's manufacturing process forms high quality fuel wood pellets, while other type of biomass may need additives to serve as a binder that have to hold the pellets together. Creating wood pellets is a small part in the overall process of manufacturing wood fuel pellets.

II. PROBLEMS FOUND IN PELLET MAKING MACHINE

- Pellet machine encounter problems such as pressure irregularities and choke at the initial start for different kinds of biomass feed stock.
- One of the problem encounters in the pellet making machine is damaging of internal parts in the machine.
- The problem includes assembly line setup for the manufacturing of the machine in the company.
- The problem we also encounter is feeding system in the machine through the hopper.
- Fabrication of Solar operated biomass pelletizing machine.

A. Problem Statement :

Pellet machine encounter problems such as pressure irregularities and choke at the initial start for different kind of feedstock:

- Disc springs are integrated into a vertical axis pellet machine for a pressure regulation and design optimization force deformation and stress deformation relations of disc spring are investigated using analytical and finite element method (FEM). Pelletizing pressure were calculated based on disc spring force values using hertzian stress formula. Utilized disc spring ensured the pressure regulation, production efficiency increase and damage prevention on the die roller mechanism.

One of the problem encounters in the pellet making machine is damaging of internal parts in the machine:

- Optimum condition for pellet production are obtain while after the first start specially the die and related components reach a particular temperature this is because the friction between biomass and die lowers and inter regular region at high temperature future more component in internal structure of biomass activate with high temperature with bonding mechanism the moisture extracted from biomass at high temperature reduces the friction between biomass and die also lignin a main constituent of woody/herbaceous biomass, gains flow ability above the glass-transition temperature thus maintain bond for mechanically durable pellet. It is know that lignin polymer glass-transition temperature is 65-75 degree Celsius at 8% moisture ratio after this temperature, lignin in biomass softens and binding effect increases.

Fig. 1. Roller die

The problem includes assembly line setup for the manufacturing of the machine in the company:

The company imports the various parts of machine from different parts of state and also across the country. The parts once brought in the company the assembly work gets starts this includes a single worker is assigned with a single machine, a single worker takes around 3 days to assemble single machine which is very slow and not good for the growth of company. There are in total 25-26 workers from which assembly work is given only to 16-17 workers, this shows that to assemble 16-17 machine it takes around 45-48 days.

Fig. 2.Internal Parts (Pellet Machine)

- Fabrication of Solar operated biomass pelletizing machine:

The pelletizing machine is mainly found in production firms, railway/coal Corporation and steel industry. The design and optimization of pelletizing machine which will operate on solar energy for the production of pellet from the mixture of biomass. The process of producing pellets for the purpose of strength measurement of powder agglomerates for good handling of waste material for usage. The machine consist of a mixer as this machine will operate on solar energy the cost will be reduced. The project is of benefit and as a teaching aid consequently from this benefit the machine is recommended to manufacturers for usage.

- The problem we also encounter is feeding system in the machine through the hopper:

Hopper problem was also a very big problem the raw material which is poured in hopper which as the diameter of 12 cm on its base. The raw material direct goes in the machine through high speed which causes the improper crushing of raw material and also the quality of pellets produced was of inferior quality. The poor quality of pellets is not accepted by the firm as well as customer.

Fig. 3.Old and New Hoper Design of Pellet Machine

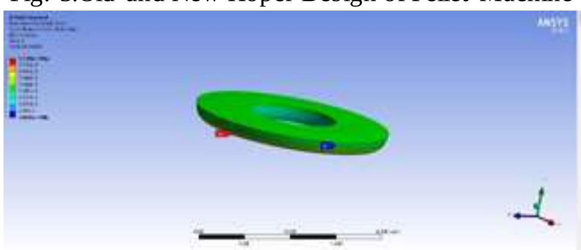

Fig. 4. Design of Disc

III CALCULATIONS

- Pellet machine encounter problems such as pressure irregularities and choke at the initial start for different kinds of biomass feed stock:

Depending on temperature, every kind of biomass forms its own pelletizing characteristic in a frictional material-machine relation. This is shown in Figure 1, the effective forces F1, F2, and F3 on the biomass under pelletizing pressure in a cylindrical channel. Kovacova have derived pressure relation equations of a pressed biomass through a cylindrical die channel based on the force equation in Figure

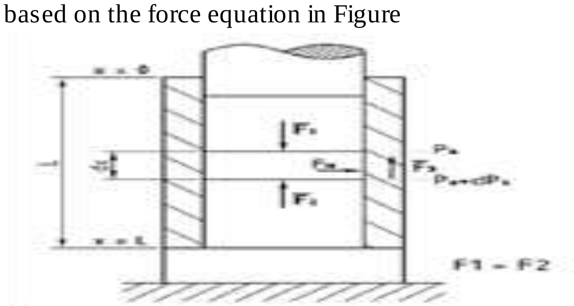

Fig. 5. Effective forces on biomass in die channel [1]

$p_a(L) = P_{ap}\dot{e}^{-4\frac{\mu\lambda}{d}}L$ ……………(1)

$p_{a_P}(L) = p_a e^{\frac{4\mu\lambda}{d}L}$ ………………..(2)

In equations (1) and (2), symbols are defined as

μ — friction coefficient between the biomass and die,

λ — radial/axial pressure ratio on biomass,

d — hole diameter

L — die length,

Pa — outlet pressure,

Pap— internal pressure.

Disc springs' outer diameters may vary between 8–600mm according to the DIN 2093 standard. Custom disc springs can be manufactured in desired dimensions when needed. In this study, in accordance with press dimensions, a standard sized disc spring with 125mm outer diameter and 71mm inner diameter is used. In Table 1, all parameters of the disc spring are demonstrated. Depending on the operating conditions, disc springs may be used as a single piece, combined in parallel or in series .When stacked in series, the total deformation of springs increase and the load carrying capacity remains constant. Accordingly, the deformation of springs remains constant, load carrying capacity is positively proportional with the spring number.

The first and still-used calculation method for disc springs was developed in 1936 by Almen and Laszlo Including DIN 2093 standard, among many manufacturers and users, the Almen–Laszlo (A-L) =algorithm for disc springs is widely used. The force deformation relation for a disc spring according to A-L algorithm is formulated as

$F = \frac{4E}{1-v^2}\cdot\frac{\delta}{mD^2}(h-\delta)\left(h-{\delta}/{_2}\right)S^3_{+S}.$ (3)

$F = \frac{4E}{1-v^2}\cdot\frac{hs^{\wedge}3}{mD^2}$ *(4)*

$\sigma c = \frac{4E}{1-v^2}\cdot\frac{\delta}{mD^2}(m1)\left(h-{\delta}/{_2}\right)S^3_{+m2S}.$ (5)

Tension stress at the outer edge of spring is

$\sigma t = \frac{4E}{1-v^2}\frac{hs^3}{mD^2}\left(m_1\left(h-{s}/{_2}\right)-m_2 s\right)$ *(6)*

Where

$m = \frac{6}{\pi \ln^{D}/_{d}}\left(\frac{D/d-1}{^{D}/_{d}}\right)^2$ *(7)*

$m1 = \frac{6}{\pi \ln^{D}/_{d}}\left(\frac{D/d-1}{^{D}/_{d}}\right)$ *(7)*

$m2 = \frac{6}{\pi \ln^{D}/_{d}}\left(\frac{D/d-1}{^{D}/_{d}}\right)$ *(7)*

Calculations based on given formulae are compared with Finite Element Analysis (FEA), results of disc springs will be given in tables in the next chapter. Calculations were made for deformations of 0.25, 0.5, 0.75, and 1 fold of cone heights and presented in Table 2.Practically, the disc spring deformation should not exceed 0.75 of cone height. In our study, it is assumed that this value will not be exceeded. Parallel-stacked two disc springs were used to maintain sufficient pelletizing pressure on the die. Calculations and analysis were made based on parallel disc springs. FEA analysis was made on the scanned CAD data of disc springs. Material is modelled as a spring steel with 206 GPa Young's Modulus and 0.3 poisson ratio. Meshing was made using 20-node hexahedrons, constituent of 5695 nodes and 938 elements. Two disc springs stacked in parallel, defining contact region. between one spring's convex surface and other's concave surface. Friction coefficient (μ) is defined as 0.4 between spring surfaces [21]. As boundary conditions, displacement of the bottom circle of the lower spring is restricted in the vertical axis and set free in the table horizontal axis. Deformations of 0.25, 0.5, 0.75, and 1 fold of cone height is given at the top circle of the upper disc. Force reactions at the top circle and maximum equivalent von-Mises stress values are analysed

Pressures occurring when a cylindrical surface contacts a planar surface can be calculated with Hertzian stress calculations. As seen in Figure 8, a contacting cylinder-plane model is considered for the roller-die relation. Hertzian stress calculation is made based on material properties and dimensions of contacting surfaces and the applied force.

Hertzian stress calculation is made based on material properties and dimensions of contacting surfaces and the applied force .

Hertzian stress is calculated by the follow

$$b = \sqrt{\frac{2F\,(1-v1^2)/E1)+(1-v2^2)/E2)}{\pi l\,(\frac{1}{d1}+\frac{1}{d2})}} \qquad (7)$$

$$Pmax. = \frac{2F}{\pi bl} \qquad (7)$$

Material properties are:

E1= E2= 210GPa

v1= v2= 0.3

Roller dimensions are:

d1= 145mm

L= 110mm

Eq.(1) => $Pmax. = 2.146\sqrt{F}$

Disc springs work in the interval of 0.25h–0.75h deformation. There are two rollers employed in the pelletizing system. Thus, the force applied by disc deformation intervals are calculated as

Pmax = 444.33MPa for 0.25h, (13)

Pmax = 779.74MPa for 0.75h. (14)

The calculated pressure is the maximum value of stress formed in between the die and roller. The pelletizing pressure of biomass may be considered as a half of this value as a practical and easy-applicable approach.Thus, the pelletizing pressure is between 220–390MPa in the operating range of disc springs.

- Fabrication of Solar operated biomass pelletizing machine:

Selecting the single phase induction motor with a speed of 1000 rpm, having a power of 5.5hp.

Since, 1hp = 745.7W

Therefore, 5.5hp = 5.5 * 745.7 = 4101.35W = 4.101KW

IV. TORQUE CALCULATION

Dimensions of the mild steel bar

Height (h) = 260 mm

Radius(r) = 25 mm

Density = 7850 kg/m³

Selected motor speed (n) = 34 rpm

Acceleration due to gravity (g) = 9.8 m/s^2

1) Volume of cylinder = π*r^2*h

=3.14*0.02502*0.260

= 5.1025*10-4 m^3

2) Mass of the blade = Density * volume

= 7850 * 5.1025*10^{-4}

= 4.0054 kg

3) Weight of Blade (W) = mg

= 4.0054*9.81

= 39.29 N

4) Angular velocity of the Blade (ω) = 2 π n/60

=2*3.14*32 rad/sec

= 3.34 rad/sec

Power (P) = T*ω

P = 2πNT/60

4101.35=2*3.14*1000*T/60

T=39.165N-m

From this reading we can calculate power ratings output of solar panel, during the experiment Power rating were as follows.

Assuming our motor efficiency around 85% so, we need input power around 4.4KW which is greater than the actual power of motor which is 4.101KW. If

the machine runs for 10hrs/day we get power 44KWh. Let us assume efficiency of battery be 95%.
Energy Generation = 44KWh/0.95 = 46.32KWh
No. of solar panel will depend on following factors:
Capacity of each module
Available sunshine where you live
To generate 46.32KW energy if we get hrs. peak sun per day. The following capacity we need is
Output Power = 46.32/5 = 9.26KW
Normally the AC output of a solar PV system is around 80% of rated DC installed capacity
DC Power = 9.26/0.8 = 11.58KW
Let us assume we are using solar panel of 250W DC. Therefore number of panel we required is
No. of panel = 11580W/250 = 46.3 = 47

V. COST CALCULATION OF ENERGY CONSUMPTION

For economic point of view it is necessary to find payback period. Payback period is nothing but time period after which we will get the returns of investment.

By conventional energy resources	By solar energy
Energy charges/ kwh= Rs 7.92	Solar panel cost = Rs3000
Cost =7.92/kwh*409.3kwh/year =3241.65 Rs / year	Battery cost / year =Rs 2000 Maintenance cost =1000 / year
Total = 3241.65 / year	Total = 6000 / year

Payback Time = Total System Cost ÷ Value of Electricity Generated ÷ Annual Electricity Usage = (6000 ÷ 7.92) ÷ 409.3=1.84 years

VI. CONCLUSION

- By the use of disc spring in a pellet fuel machine. Disc springs are integrated into vertical axis pellet machine for pressure regulation and design optimization.
- Pelletizing pressure where calculated based on disc spring force values using hertzian stress formula. Utilized disc spring ensured the pressure regulation production efficiency increases.
- Solar operated biomass palletization machine the energy will saved as we are using renewable energy resources.as we are facing climate change problem and fuel crises problem therefore the use of renewable energy resources is mandatory its need of future. Therefore we are using solar energy which is freely available.
- The assembly line setup was in proper which caused the issue of delay in work and creating problems for the firm. By group format of assembly process it was proved that the assembly process can be done soon
- group process includes two members in each group working on a same machine to assemble it and had completed the assembling of two machine within two days
- Large surface area of hopper created a problem in the quality of the product this was due to irregular portion of raw material entering into the machine and getting converting into pallets with inferior quality
- The design of new hopper with rectangular shape and less area of passage proved that slow moving of raw material into the machine can make the machining process very good with superior product quality

REFERENCE

[1] Stelte, wolfgang; holm, jens k.; sanadi, anand r.; barsberg, søren; ahrenfeldt, jesper; henriksen, ulrik birk “fuel pellets from biomass: the importance of the pelletizing pressure and its dependency on the processing conditions. Published in: fuel link to article, doi: 10.1016/j.fuel.2011.05.011 publication date: 2011.
[2] Vipul J. Shardul, Prof. Arun M. Kulkarni, Prof. Amol S. Dayma, Prof. Anvesh virkunwar “Design, Fabrication of Solar Operated Biomass Pelletizing Machine and Study of Biomass Pellet Samples”. International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 07 | July 2018.
[3] Monica Kovacova, Milous Matus. Pressure Conditions in the Pressing Chamber During Compaction of Powder Materials. International Journal of Mechanical and Production

Engineering (IJMPE), pp. 13-18, Volume-6,Issue-1. Milos Matus ,Monika Kovacova ,Peter Krizan ,Juraj Beniak ,Lubomir Soos , (2018).

[4] E Geethendra Kumar1, Md Ahasan, K Venkatesh, K S B S V S Sastry"Design, fabrication of Powder Compaction Die and Sintered behavior of Copper Matrix Hybrid Composite".International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 04 | Apr-2018.

[5] Tawanda Mushiri Department of Mechanical Engineering University of Johannesburg "Design of a sawdust pelleting machine". Proceedings of the International Conference on Industrial Engineering and Operations Management Rabat, Morocco, April 11-13, 2017.

[6] Sanchit Gaikwad, 2Amol Kalokhe 1,2Department Of Electronics And Telecommunication Engineering, Late G.N Sapkal College of Engineering, " Automatic Paper Plate Making Machine ".International Journal for Research in Engineering Application & Management (IJREAM) ISSN : 2494-9150 Vol-02, Issue 01, APR 2016.

[7] O.M.Akusu1, J.O. Oyejide,J.E. Udumebray. (Dept of Mechanical Engineering, Petroleum Training Institute (PTI), Effurun, Nigeria. "Design and Construction of Dried cassava pellet Grinding" gineering Research .American journal of Engineering Research (AJER) .e-ISSN: 2320-0847. Volume-7, Issue-3, pp-46-55.2018.