Design of a sawdust pelleting machine

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Abstract

This paper seeks to carry out the design of a pelleting machine with a capacity of 900kg per hour for the Company X. Apparently the boilers at the plant are using wood chips, a by-product from the milling operations as their source of fuel but off late the plant has been experiencing a serious fuel shortage. The fuel crisis emanated from low plant availability caused by old and dilapidated machinery. Major breakdowns that brings the plant to a halt for long hours are abrupt and rampant and during that time no wood chips are produced resulting in a fuel shortage. Following this fuel shortage the boiler operators have resorted to rationing the fuel input into the boiler as it has to run continuously regardless of whether the plant is moving or not. This rationing has resulted in poor boiler performance and low efficiency which has in turn affected the timber drying kilns. The boilers are producing poor quality steam which has had the effect of doubling the timber drying cycles. As a result of doubled timber drying cycles half of the timber produced is sold as wet off sawn at a relatively low price which is a loss to the company. The management and the engineering team in a bid to do away with this problem proposed the use of sawdust as additional boiler fuel. After a consideration of the type of boiler fire grates at the plant it was found that raw sawdust cannot be used as it has a tendency of choking the grates blowing out combustion so it has to be pelletized. With this problem at hand this project zeroed in at the design and development of a pelleting machine that will specifically meet the pellets need at the wattle company. Literature review was done on several types of pelleting machines' operating mechanisms and from this literature three possible concepts were generated. These concepts were evaluated and the best was chosen and developed into a finished design ready for fabrication with all working drawings available for each component. The machine was designed with a constraint budget of USD $10 000 and it will provide a backup and additional boiler fuel to the already being used wood chips.

Keywords
Pelleting, Saw dust, Pelleting machine, Old equipment, Boiler fuel shortage, Maintenance.

1. Introduction

The machinery at the Company Y plant is now old, dilapidated and is operating mainly under corrective maintenance and as a result major breakdowns which halt the plant are abrupt. These downtimes cause serious boiler fuel shortage as the boilers use wood chips which are part of the waste material produced from the milling operations. There is also a scheduled maintenance plan that operates during the weekend and during the effect of this maintenance only one shifts run production instead of the normal two and at times there is no production at all. These factors significantly affect production and there is bound to be a shortage of boiler fuel since the boilers are run continuously regardless whether the plant is operating or not. To solve this problem there is need to convert waste sawdust into useful boiler fuel by pelletizing it since raw sawdust cannot be directly fed into the boiler. Raw sawdust tends to chock the fire grates causing electric motors to trip blowing out the combustion. This paper aims at designing a cheap wood pelletizing machine for making sawdust pellets which are a suitable fuel for the two Babcock and Wilcox boilers at the plant. A wood pelletizing machine grinds wood and sawdust into small fragments moisturizes and compresses it under very high pressure and temperature. The material is then forced through dies of the desired dimensions resulting in pellets.

1.1 Background

The wretched operating conditions of the main milling plant have resulted in the company failing to meet the market's timber demand. In an effort to rectify this problem the management has contracted small mobile bush millers to help the company meet its targets. These millers operate from the company's estates and they incinerate their waste material there bringing only the end product structural timber to the main mill for drying and warehousing purposes. Timber from both the mobile millers and the main mill is dried in Boll man kilns using super-heated steam from the boilers. Timber drying cycles have doubled following the low boiler efficiency caused by the fuel shortage. At the present moment the kilns are only capable of drying half the amount of the timber produced and the other half is sold as wet off sawn timber at a lower price. Fuel shortage has adversely affected the boiler efficiency and currently they are operating at a pressure lying between 50 and 120 bars instead of the optimum 150bars.

Figure 1 mountains of sawdust at Nyanga pine

During the weekdays production is run continuously by two shifts only stopping at break, lunch and hand over take over times. The sawmilling and timber processing operations at the plant produce a significant amount of waste material up to a maximum of 14 tonnes per day. At the present moment the incinerator is malfunctioning resulting in mountains of sawdust being disposed all over the plant. The main objective of this research are to design a cheap wood pelletizing machine not exceeding US$10 000, to design a pelletizing machine with a capacity of 900kg/hour and to design a machine that produces pellets of diameter 4mm and 32mm length.

2. Literature review

Wood pellets are compressed combustible energy carriers that are used as fuel (Justina, 2013). Pellets are already being commonly used worldwide following the rise in the prices of primary fuels and the sudden increase in the concern about the global climate change. The use of pellets has also gained popularity in manufacturing and processing industries. Boilers in many industries globally are using wood pellets for fuel and the Company because of its timber based operations does not want to be left out as they are moving towards that initiative in order to curb the boiler fuel problem. There are two types of pellet mills, one is a flat die mill and the other is a round die pellet mill. First to be designed was the flat die mill; the round die was improved basing on the operating principle of the former. Flat die pellet mills are used for small to medium scale pellet production whilst round die pellet mills are used for medium to large scale pellet production. The boiler energy usage were researched and the table below shows the summary.

Table 1: Comparison of calorific values (Riley, 2014).

Typical calorific values of fuels

Net calorific value (CV) or Lower Heating Value (LHV) given for all fuels. This means that the latent heat of vaporization of the water vapour created by combustion is not recovered by condensation.

Fuel	Net Calorific Value (CV) by mass GJ/tonne	Net Calorific Value (CV) by mass kWh/kg	Bulk density kg/m³	Energy density by volume MJ/m³	Energy density by volume kWh/m³
Wood chips (30% MC)	12.5	3.5	250	3,100	870
Log wood (stacked - air dry: 20% MC)	14.7	4.1	350-500	5,200-7,400	1,400-2,000
Wood (solid - oven dry)	19	5.3	400-600	7,600-11,400	2,100-3,200
Wood pellets	17	4.8	650	11,000	3,100
Miscanthus (bale - 25% MC)	13	3.6	140-180	1,800-2,300	500-650
House coal	27-31	7.5-8.6	850	23,000-26,000	6,400-7,300
Anthracite	33	9.2	1,100	36,300	10,100
Heating oil	42.5	11.8	845	36,000	10,000
Natural gas (NTP)	38.1	10.6	0.9	35.2	9.8

3. Methodology

The alternative which would have met the requirements is the one that will be designed. The design process will depend on several factors to include the quality of pellets that are needed, capacity required, estimated budget among other factors. It is from these basic parameters that the sizing of the equipment to be used is done. Power consumption is also put into consideration as it will determine operating costs of the machine. Solidworks was used in detail for analysis.

3.1 Case study

The incinerator at Pine Company is worn out as shown in figure 2 and has partially been cannibalized so at the present moment the plant is experiencing poor housekeeping with large heaps of sawdust and other waste material all over the place. According to Environmental Management Agency (EMA), the incinerator should allow flue gases to be secreted only 30metres above the ground but this is not the case with the incinerator at Pine Co. as thick clouds of smoke can be seen at a height as low as 2metres. A significant fraction of sawdust is finding its way into this worn out incinerator causing massive pollution. On the 22nd of June 2015 EMA visited the company and it was fined US$2000 for air pollution amongst other poor housekeeping offenses. The conversion of saw dust into pellets for fuel use comes in as a value added waste disposal method dealing effectively with environmental management system requirements. It is also in line with the much recommended and talked about cleaner production.

Figure 2 Incinerator at the Pine Company.

The abundance of wood and sawdust resources at the plant implies that the company will produce more pellets than what is consumed at the plant meaning the excess pellets can be packaged and sold thus creating income for the company. Pellets due to their low ash content and high calorific value will have a great market base.

Figure 3 Sample of pellets ready for the market

Pelletizing sawdust makes it suitable for the boiler design that is currently on the ground. The boilers makes use of fire grates below as their burning surface. Raw saw dust cannot be directly fed into the boiler because it tends to block the fire grates blowing out combustion.

Figure 4 Fire grates of boilers at Nyanga pine

4. Results and discussion

4.1 Design

The boiler at the company uses wood chips as its fuel with an average consumption of $1\,440kg\ per\ hour$.

Using the information from figure 6.1, daily boiler consumption is calculated as:

Daily Consumption $(1\,440\ x\ 3.5CV\ of\ wood\ chips\ per\ kg\ x\ 24) \quad = \mathbf{120\,960kWh}$

Weekly consumption $(120\,960\ x\ 7) \quad = \mathbf{846\,720\ kWh}$

4.1 Theoretical Fuel produced from the sawmilling operations

The Pine plant on average processes 400cubic meters of raw logs per day. All things being equal the plant having its highest availability enough boiler fuel is produced from the milling operations. After timber processing 56% of the volume input goes to waste in form of sawdust and woodchips which contribute 14% and 42% respectively (USFS, 1987). Fuel supply $(400\ x\ 0.42\ x\ 870CV\ of\ wood\ chips\ per\ m^3)$ $=\ 140\ 279\ kWh$

Weekly fuel supply $(140\ 279\ x\ 7)$ $\boldsymbol{=\ 981\ 955\ kWh}$

4.1.1 Actual fuel produced

At the present moment the Nyanga pine plant is operating at a low plant availability of 75% as a result shortage of wood chips for boiler consumption is inevitable. Weekly Fuel available$(981\ 955\ x\ 0.75)$

= $\boldsymbol{767\ 340\ kWh}$

4.1.2 Weekly Fuel shortage

Theoretical – actual fuel produced $(981\ 955\ \ -767\ 340\ )$ = 214 615 kWh

From the above calculations the pelleting machine should have a capacity to produce pellets which will supply energy equivalent to **214 615 kWh.**

4.2 Machine capacity

The quantity of pellets required to produce 214 615 kWh is calculated as follows using information from figure 4.

Volume of pellets $\frac{energy}{calorific\ value} = \frac{214\ 615}{3\ 100}$ $= 69.2\ m^3$

Mass of pellets $\rho\ x\ volume$ $(650\ x\ 69.2)$ $= 45\ 140\ tonnes$

Daily pellet production (5 working days a week) $\frac{45\ 140}{5}$ $= 9\ 028\ tonnes$

Hourly production (10 working hours a day) $\frac{9\ 028}{10}$ $= 902\ kg$

From the above calculations the pellet machine should have a capacity of **900kg per hour** working 10 hours a day, 5 days a week.

4.3 Area of the roller causing shear of the material$(\boldsymbol{A_R})$

Pellet specifications: diameter 8mm; length 32mm

Volume of a single pellet πr^2 H $(\pi\ x\ 0.004^2\ x\ 0.032\ )$ $=1.6\ x\ 10^{-5}\ m^3$

$density\ of\ a\ standard\ pellet$ $650kg/\ m^3$ (wiley, 2014)

Mass of a single pellet $(1.6\ x\ 10^{-5}\ \ x\ 650\ )$ $=\ 0.01\ 04\ kg$

Number of pellets per hour $\frac{900}{0.01\ 04}$ $= 86\ 538\ pellets/\ hour$

Pellets per 10 seconds (extrusion speed) $\frac{86\ 538}{360}$ $= 237.6\ pellets$

Die holes area πr^2 $(\pi\ x\ 0.004^2\ )$ $= 0.000\ 050\ m^2$

Area for 480 holes $(0.000\ 050\ x\ 238)$ $= 0.012\ m^2$

The area of the shear roller causing shear of the material $\boldsymbol{A_R}$ is equal to twice the total area of the die holes which is $\boldsymbol{0.024\ m^2}$ (IJEIR, 2013).

4.4 shear stress acting at the roller-die contact point

Shear stress $\tau = \mu \, x \, \gamma$

Where μ = viscosity of the feed material, Nms^{-2}

γ = shear rate of the feed material, $s^{-1} = \frac{V_R}{H}$; V_R = roller speed $4m^{-1}$ (KAHL, 2014) and H = depth of the gear teeth on the roller, 0.002m $\gamma \ (\frac{4}{0.002})$ $= 2000 s^{-1}$ μ =32 Nsm^{-2} (blaze, 2010)

τ ($2000 \ x \ 32$) = $64\,000 \ Nm^{-2}$

The shear stress acting on the roller-die contact is $\boldsymbol{64\,000 \ Nm^{-2}}$

4.5 Force required for pelleting $\boldsymbol{F_R}$

Force $F_R = \tau \, x \, A_R$ $(64\,000 \ x \ 0.024)$ = $1536 \ newtons$

Since there are four rollers, the force applied will be multiplied by four

($1536 \ x \ 4$) = $6144 \ newtons$

The total force needed for pelleting is $\boldsymbol{6144 \ N}$

4.6 Power required for pelleting $\boldsymbol{P_P}$

P_P = F_R x V_R ; $(6144 \ x \ 2)$ = $24\,576 \ watts$

The power required by the pelletizer is 24 576 watts so a **25 KW** electric motor is selected.

4.6.1 Speed of electric motor

Motor speed is calculated using these parameters:

Roller velocity V_R = $4 \ ms^{-1}$ Roller diameter D_R = $0.14m$ (KAHL, 2014)

$N_R = \frac{V_R \, x \, 60}{\pi \, x \, D_R} = \frac{4 \, x \, 60}{\pi \, x \, 0.14}$ = $546 \ rpm$

Velocity Ratio $V.R = \frac{D_d}{D_R} = \frac{N_R}{N_d}$

Where D_d is the diameter of the flat die; N_d Is the rotational speed of the die in r.p.m

Thus N_d is found this way:

$\frac{0.5}{0.14} = \frac{546}{x}$, N_d = $153 \ rpm$

The die shaft receives power through a gear drive connection with a velocity ratio of 3.1 therefore the pinion speed is $\boldsymbol{153 \ x \ 3}$ giving **459 rpm.**

The speed reduction gear drive receives power from a v belt connection connected to the electric motor with a velocity ratio of 2.1. The speed of the electric motor pulley is found by $\boldsymbol{459 \ x \ 2}$ giving **918rpm.**

From this we take standard the electric motor speed of **960 rpm**.

4.7 design of power transmission belts

Power to be transmitted by the belt to the bevel gear shaft is **25kW from** belt dimensions *(GUPTA, 2005)* and groove angle for different belts *(GUPTA, 2005)*. From the above tables the specifications for belt C are as follows:

Table 2: Specifications for the belt

Driving pulley diameter	=200mm	driven pulley diameter	$=400mm$
Top width	=22mm	motor speed N_1	$=960\ rpm$
Thickness	=14mm	coefficient of friction μ	=0.2
Weight per meter length	=3.43N/m	maximum stress σ	$=2.1\ MPa$
Groove angle 2β	=38 degrees	cross sectional area a	$= 230mm^2$
Distances between centers x = 1m			

4.7.1 Calculating the number of belts required

Power = $(T_1 - T_2)\ x\ n\ x\ V$

Where n is the number of belts required ; V is the belt speed in m/s; D_D Is the diameter of the driven pulley.

Belt speed $v = \frac{\pi\ x\ D_D\ x\ N}{60} = \frac{\pi\ x\ 0.4\ x\ 459}{60}$ $= 10.05ms^{-1}$

$\sin\alpha = \frac{O_2\ M}{O_1\ O_2} = \frac{D_2 - D_1}{2x} = \frac{400-200}{2\ x\ 1000}$ $\alpha = 5.7°$

Angle of contact on the small pulley $Q_1 = 180 - 2\alpha = 180 - 2x5.7$ $= 168.5°$

$168.5\ x\ {}^{\pi}/_{180}$ $= 2.94\ rads$

Angle of contact on big pulley $Q_2 = 180 + 2\alpha = 180 + 2\ x\ 5.7$ $= 191.4°$

$191.4\ x\ {}^{\pi}/_{180}$ $= 3.34\ rads$

When pulleys have different angles of contact the design is for the pulley with a small μQ which is the smaller pulley.

$\mu Q = \mu\ x\ Q_1\ x\ cosec\ \beta = 0.2\ x\ 2.94\ x\ cosec\ 19$ $= 1.8°$

Centrifugal tension in the belt T_C

$T_C = mv^2$ $(0.3496\ x\ 10.05\ x\ 10.05)$ $= 35.33N$

$T = T_1 + T_C$ Where

T Is the maximum belt tension

T_1 Is the tension in the tight side

$T = \sigma\ x\ a\ (7\ x\ 230)$ $= 1610N$

$T_1 = T - T_C$ (1610 -35.33) $= 1575\ N$

$2.3\log\frac{T_1}{T_2} = \mu . Q_2$ $(0.2\ x\ 3.34)$ $= 0.668$

$\frac{T_1}{T_2} = 1.95$ $T_2 = 808\ N$

Power = $(T_1 - T_2)\ x\ n\ x\ V$

$25\ 000 = (1575 - 808)\ x\ 10.05\ x\ n$ $n = 3.04$

Thus **3 belts** are required.

4.7.2 Length of each belt (L)

$$L = \pi\, x\, (R_1 + R_2) + 2x + \frac{(R_2 - R_1)2}{x}; \ = \pi\, x\, (0.2 + 0.1) + 2\, x\, 1 + \frac{(0.2-0.1)2}{1} \qquad = 2.95 \text{ m}$$

Table 3: Materials for various components.

Component	Material
Pulleys	Cast iron to reduce weight
Belts	Rubber
Driven pulley shaft	Mild steel

4.8 Selection of pellet cutting knife

The cutting knife is located below the revolving flat die. It is a stationary knife which cuts the emerging strands of feed into pellets as they are discharged from the pelletizer.

The pellets cutting knife is made of 2 mm mild steel having length of 30 mm and sharpened at the edges. The vertical position of the pellet cutting knife from the die determines the length of the cut pellets. Pellet cutting knife variables:

- Blade speed – Pelletizer has a stationary blade.
- Blade angle – 90 degrees to direction of rotation of flat die.
- Blade sharpness – 0.05-0.1mm range. The sharper the blade the less the energy required for cutting.
- Blade Clearance – Blade clearance between cutting edge and die was set between 10mm - 15mm for convenience.
- Moisture Content – Cutting force increased slightly with major decrease in moisture content. Moisture content of 20-30% wet basis is well suited for cutting without high deformation tendencies.

4.9 Design of the flat die

The die is made of **stainless** steel because of its great wear resistant properties. The pelletizing chamber housing the die and rollers is a hollow cylinder originating below the hopper and terminating below the flat die. The diameter of the chamber is 515mm. The diameter of the die is taken to be 500mm to allow for free rotation in the chamber of 515 mm diameter. The die holes are of diameters of 4 mm and the arrangement considered to be a pressure vessel. The thickness of the die was calculated using the equation below.

$$t = k.\, D_d \sqrt{\frac{P}{\sigma_y}}$$

Where,

t = thickness of the die (mm)

k = coefficient of friction which depends on the material (stainless steel 0.2)

D_d = diameter of the die, 500mm

P = compressive pressure of feed through the die holes. It is assumed that the maximum possible pressure developed by the rotating rollers will not exceed 150MPa.

σ_y= yield stress for stainless steel is 280MPa.

$$t = 0.2\ x\ 500\ \sqrt{\frac{150}{280}} \qquad = 73mm$$

The inlet of die holes is countersunk into taper shape to let feed stock flow into die holes. The inlet angle is usually around 30 to 40 degrees on small holes dies.

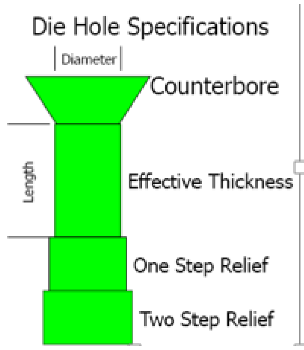

Figure 5: Die structure

The die is machined using the milling machine and its drilling tools. The work piece is machined with relief steps for easy movement of the pellets after compression. The die holes are made using the G-codes of canned cycles. The inner diameter d_1 = 32mm and the outer diameter d_2 = 40mm. The thickness t, to inner diameter ratio is t/ d_1 = 2.28125. A cylinder with t/ d_1 less than 0.05 is generally considered to be a thin cylinder and this die having a greater ratio is a thin walled cylinder with radial stress σ_r and hoop stress σ_h at a diameter d in the cylinder body calculated as:

$$\sigma_r = \left(\frac{{d_2}^2 - {d_1}^2}{{d_2}^2 - {d_1}^2}\right)\frac{{d_1}^2}{{d_1}^2}\ x\ P_1 \qquad (1)$$

$$\sigma_h = \left(\frac{{d_2}^2 + {d_1}^2}{{d_2}^2 - {d_1}^2}\right)\frac{{d_1}^2}{{d_1}^2}\ x\ P_1 \qquad (2)$$

The minimum stress occurs at the die bore which is d_1 and the internal pressure is equal to the extrusion pressure.

$$P_1 = \frac{design\ extrusion\ force}{bore\ area}.$$

$$P_1 = 6144/\pi\ x\ \frac{32^2}{16} \qquad = \quad 30.6\text{N}/mm^2$$

$$\sigma_r = \left(\frac{40^2 - 32^2}{40^2 - 32^2}\right)\frac{32^2}{32^2}\ x\ 30.6$$

$$\sigma_h = \left(\frac{40^2 + 32^2}{40^2 - 32^2}\right)\frac{32^2}{32^2}\ x\ 30.6$$

From equation 1 and 2 the radial stress at the bore is P_1 = 30.6 N/mm^2 and the hoop stress at the bore is σ_h = 139.4N/mm^2. The axial stress in this case ia taken to be zero.

4.9.1 Checking the die strength

To check the die strength the maximum octahedral shearing stress criterion of failure is used. The criterion is given as:

$$\sigma_{oct} = \frac{1}{3}\sqrt{\{(\sigma_h - \sigma_r)^2 + (\sigma_r - \sigma_z)^2 + (\sigma_z - \sigma_h)^2\}}$$

$=\frac{1}{3}\sqrt{\{139.4-30.6)^2+30.6-0)^2+\ 0-139.4)^2\ \}}\ \ =\frac{2}{3}Y$

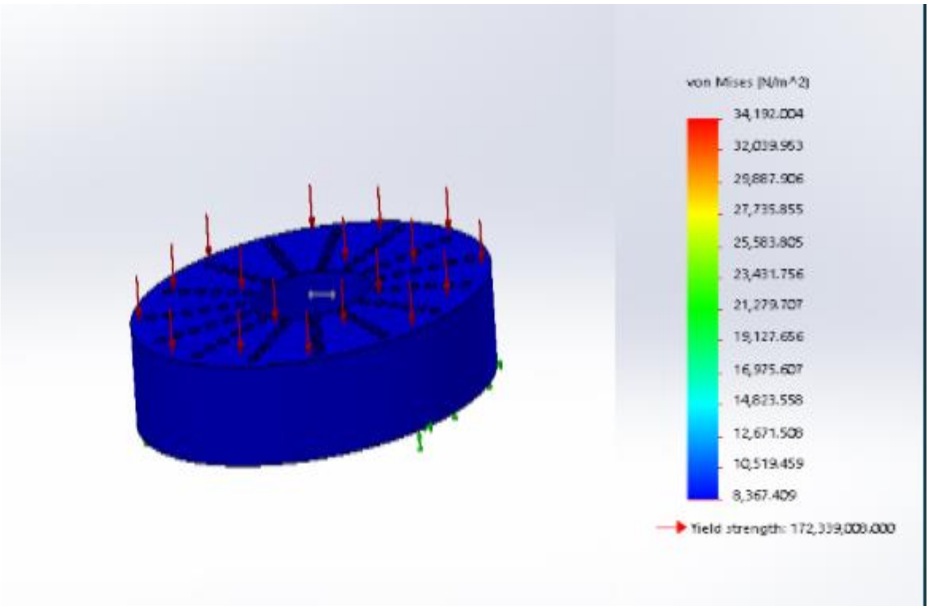

Figure 6: Misses results

Y = 89.7 N/mm^2 which is less than the yield stress of mild steel (Y = 280 N/mm^2). Therefore **the die design is okay**.

4.10 Roller frame design

The rollers are held by a four armed frame. The frame is made of a circular section with four arms attached 90degrees apart. Polar moment of inertia J $= 2\pi r^3 t$ ($2\ x\ \pi\ x\ 0.05^3 x\ 0.005$) = 3.92 x $10^{-5}\ m^4$

Torque of circular section T_{tube} = $\frac{\tau\ x\ J}{R}$($\frac{56\ x\ 10^6\ x\ 3.92\ x\ 10^{-6}}{0.05}$) = 4 390.4Nm

Torque of bars T_{bar} = $\frac{\pi\ x\ \tau\ x\ d^3}{16}$ ($\frac{\pi\ x\ 56\ x\ 10^6\ x .005^3}{16}$) = 1 374Nm

Total torque = T_{tube} + $4T_{bar}$ (4 390.4 + 4 x 1 374) = 9 886.4Nm

The maximum stress that can be transmitted using a **safety factor of 1.5** on steel having elastic limit in tension of **300 N/mm^2** is calculated using Maximum shear strain energy criterion of failure:

$\sigma_Y = \frac{1}{2}[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]$

$(\frac{300\ x\ 10^6}{1.5})^2 = \frac{1}{2}[(\tau - 0)^2 + (0-(-\tau))^2 + ((-\tau) - \tau)^2]$

200 x 10^{12} = $3\tau^2$

τ = 66.67 N/mm^2

This maximum stress is more than the allowable design stress of 56 N/mm^2 which means the **design is safe.**

4.11 Design of the hopper

The hopper is a truncated cone of gravity-flow type. The slant height is such that the content of the hopper empties unaided into the pelletizing chamber. For dough like materials of moisture content higher than 20%, the hopper slant angle is preferably between 60-70 degrees.

A hopper in form of a rectangular based pyramid frustum made of mild steel is considered.

These dimensions are used in the design:

Top face of the hopper: 1000mm x 1000mm

Bottom face of the hopper: 300mm x 300mm

Height: 750mm

The development of the hopper is such that the measurements are marked out and cut from a mild steed sheet as below and welded together.

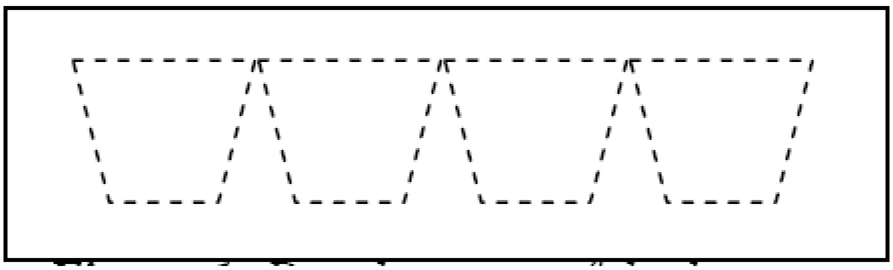

Figure 7 Development of hopper

The flat die pelleting concept was chosen as the best solution and was further developed by doing all the necessary design calculations taking into consideration the **safety factor** whose value differed from component to component. Solid works **Von Misses stress analysis** was done for the main moving component of the mill which is the roller die section. Various methods of analysing failure criterion of all the other designed components was done to ensure the safety of the design and also to avoid over designing. Solid works was used in developing the 3D diagrams together with the working drawings.

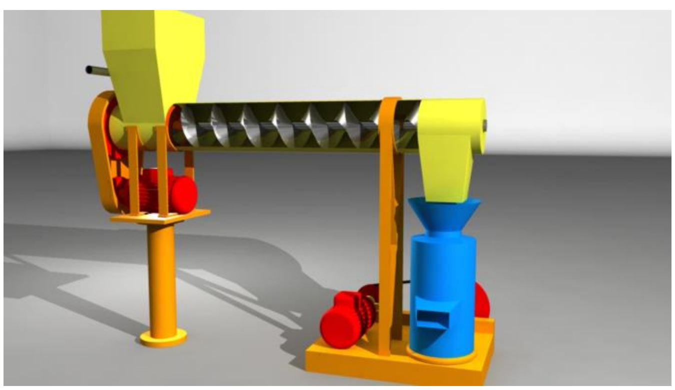

Figure 8:2 The full pelleting machine

Above is the full design of the machine with two electric motors, one powering the worm screw and the other one powering the pelleting chamber. The feed comes in through the hopper where it is conveyed forward by the worm screw. The worm screw is situated inside the conditioning chamber where mixing into uniform malt is achieved.

Friction between the sawdust particles in the conditioning chamber produces heat which then starts to activate lignin, a natural binder found in sawdust. By the time the feed reaches the pelleting chamber it is well mixed which makes the pelleting process whole lot easier. The grinding of the rollers against the flat die generates heat which further activates lignin which holds the pellets in a compact form thus reducing fines.

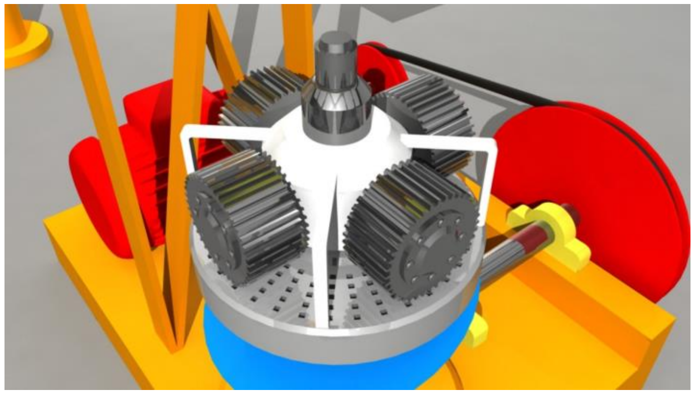

Figure 9 Flat die-roller setup

The rollers are coupled to a roller frame with four arms and the frame itself is coupled to the rotating shaft. As the shaft rotates the rollers rotates in the same direction pressing and compacting the feed into the die holes thereby producing pellets. The rollers and the die are considered to be circular frictional plates. The die is considered to be a plain circular plate whilst the rollers are toothed circular plates. Rollers rotate inside scrapers whose job is to scrap off extra feed sticking on the rollers. If the feed is not scrapped it causes slipping on the roller-die contact.

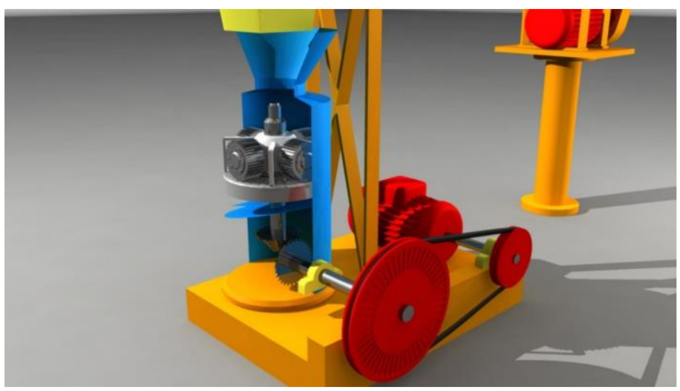

Figure 10 the pellet machine drive

The pelleting chamber is powered by a 25kW electric motor mounted on base of the machine. From the electric motor transmission is through V belts with a velocity ratio of 2:1 to the bevel gear connection. The bevel gears are meeting at a right angle and the power is transmitted with a velocity ratio of 3:1. The pinion shaft then transmits

5. Recommendations and conclusion

The environmental management agency should discourage the public and all timber processing industries from open burning of their waste. The waste from the production line should be converted into pellets which is a value addition process very much in line with the cleaner production ideology.

5.1 Policies

Apart from industrial boilers pellets can be used for domestic purpose and this will help reduce pressure on the much scarce electricity in our country. Since pellets are produced from trees they are considered renewable. As long as trees are replanted will never run out of sawdust pellets. Pellets also come in as a better alternative to raw wood because it burns with less ash and pollutants at the same liberating high amount of energy. The general public should be encouraged to use pellets as they have numerous advantages and this will help reduce strain on our limited non-renewable resources.

5.2 Re-designing

The design idea of the pellet machine can be re-structured to allow for further improvement of the system. The concept will be used to develop bigger and more robust machines that can be used for large scale production.

5.3 Conclusion

The pelleting machine has been designed with a production capacity of 900kg per hour. This project if resized to a larger scale can provide job opportunities to the unemployed graduates, and small-scale entrepreneurs can be empowered by the government by making pellets from sawmill wastes which is in line with the much emphasized cleaner production. This will reduce unemployment rate in Zimbabwe and dependence on petroleum products and nonrenewable coal for heating and cooking. It will also utilize waste generated by the sawmill industries thereby reducing open air burning and attendant environmental pollution.

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Biography

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