DESIGN AND FABRICATION OF ANIMAL FOOD PELLET MAKING MACHINE

¹Yogesh Y. Nandurkar, ²Vikas Borade, ³Surendra Gautam and ⁴Sunil S. Akant

¹Asst. Professor, ^{2,3} Student, ⁴Asso. Professor
Department of Mechanical Engineering
Yeshwantrao Chavan college of Engineering ,Nagpur, India
Email: {surendragautam@gmail.com, ynandurkar1@gmail.com}

Abstract

The Animal food pellet making machine was designed for making animal food pellets for production of animal food pellets. Pelleted food items have many advantages including proper diet to animals and reducing wastage. Major components of Pelletizing Machine consist of die, roller, shaft, transmission system, hopper and electric motor. This idea came up with the help of Engineering Department of Dr. PunjabRao Deshmukh Krushi Vidyapith, Akola for attempting feasible production of pellets for different livestock. Designed machine provides advantage of producing different size of pellets using different dies

Key Words : Design; Animal food pellets; pelletizing machine; die and roller; Electric motor

1. Introduction

Pelleting: Pelleted feeds have been defined as “feeds formed by extruding individual ingredients or mixtures by compacting and forcing through die openings by any mechanical process”. The purpose of pelleting is to take a finely divided, sometimes dusty, unpalatable and difficult-to-handle feed material and, by using heat, moisture and pressure, form it into larger particles[1-2]. These larger particles are easier to handle, more portable and usually result in improved feeding results when compared to the unpelleted feed.

Need of pelleting for animal food[3-6]:

- We need to use homogenous nutritional value in feeds.
- Pelleted feeds are less influenced by external factors; such as oxidation, moisture etc...
- It is easy to carry and store pelleted feeds
- The heat generated in conditioning and pelleting make the feedstuffs more digestible by breaking down the starches
- Pelleting minimizes waste during the eating process.
- If given the choice between the same feed in pellet or mash form will prefer the pellets.

Considering the number of advantages of pelleted food items for livestock pelleted food items have gained popularity in Indian market. The farmers buy the pelleted food directly from the market considering the high cost of pelletizing machine.

According to the husbandry department of Dr. Punjabrao Deshmukh Krushi Vidyapith, Akola following are the ideal size of pellets for different animals.

Table 1
Pellet size for animals

Animal	Pellet size Dia.(mm)
Fish	1.5-2
Poultry	3-4
Goat	8-10
Cattle	12-13

Considering the High cost of pelletizing machine available in the market. The attempt was made With the Help of Dr. Punjabrao Deshmukh Krushi Vidyapith , Akola (P.D.K.V) to design optimized pelletizing machine at low cost to provide alternate solution for Indian Farmers of in house production of pellets.

The attempted Machine was designed considering the manufacturing facilities available at engineering department of P.D.K.V, Akola. It is to be powered by 3 HP electric motor driven. Important components of the machine are Roller, Die, Hopper, Transmission system and knife.

2. Material and Parts Used

According to the strength, availability, and cost different materials were selected for different parts. Following is the list of major component and material to be used for them.

Table 2
Specifications of Material and parts used

Sr. No.	COMPONENT	MATERIAL USED
1.	Roller	SAE 1030
2.	Die	Alloy steel
3.	Transmission Shaft	Plain carbon steel (MS)
4.	Hopper	Galvanized sheet tin
5.	Frame	Mild steel angles
6.	Motor	Electric
7.	Knife	M.S

3. Design of Different Parts

A. Pelletising power

Pelletizing power is the power required to make the pellets. As source of power used is electric motor the specification of motor to be used was calculated considering the pelleting power required to push the raw product through the Die. As the roller acts as main component for pushing the feed, so the power required is the product of roller speed and force acting on roller given as following [1].

$$P_p = V_r \times P_r$$

P_p = Pelletizer power

V_r = Roller velocity

F_r = Pelletizing Force

Also, we know that

$$V_r = \frac{\pi \times D_r \times N_r}{60} = \frac{\pi \times D_d \times N_d}{60}$$

Also we know that

$$D_r \times N_r = D_d \times N_d$$

Force acting on roller was calculated by

$$F_r = T \times A_r$$

$$A_r = 0.1 A_d$$

T = Shear Stress

A_r = Area of roller causing shear

A_d = Area of die Now,

$$T = \mu \times r$$

On performing subsequent calculations the motor of 3 HP was selected to serve the purpose.

B. Gearing arrangements

For transmitting power between two shafts which are perpendicular to each other bevel gears were used. Gearing ratio was taken 5:1 [4].

Table 3
Parameters of the gear1

	Sr No.	Parameter	Abbreviation	Value
Pinion	1.	Speed	N_p	1440 rpm
	2.	No. of teeth's	T_p	12
	3.	Pitch or Centre angle	Y_p	11.31°
	4.	Module	m	4 mm
	5.	Width	b	28 mm
	6.	Diameter	D_p	48 mm

Table 4
Parameters of the gear2

	Sr No.	Parameter	Abbreviation	Value
Gear	1.	Speed	N_g	288 rpm
	2.	No. of teeth	T_g	60
	3.	Pitch or Centre angle	Y_g	78.69°
	4.	Module	m	4 mm
	5.	Width	b	28 mm
	6.	Diameter	D_g	240 mm

C. Die

The number of holes and size of die was selected on the basis of availability in the market and manufacturing feasibility. Die is important part of pelletizing machine as it determines the number and size of pellets formed. To reduce the cost of die optimum thickness of die was calculated considering the Die arrangement to be pressure vessel. Using formulae from the design data book by B.D. Shiwalkar as given below [3].

$$t = \frac{kD\sqrt{P}}{\sqrt{S}}$$

t = thickness of the die, mm

k = coefficient of friction which depends on the material

D = diameter of the die, mm

P = compressive pressure of feed through the die holes. It is assumed that the maximum possible pressure developed by the rotating rollers.

S=allowable design stress, MPa.

Die is housed in the Pelletizing chamber with diameter of chamber more than diameter of die for easy movement of die in chamber.

The hole size initially is considered for feeding Goat with diameter of pellet as 6 mm .The length of pellets depends on slots of Roller and Knife which was taken 20-30mm.

D. Roller Design

Roller Design was done considering Roller and Die Surface as frictional Wheel. Die is rotated by power from motor which is transmitted with the help of bevel gear and the transmission shaft which is keyed to the die, as the die rotates rollers rotate in the opposite direction. There will be slip in between the die surface and roller surface .The roller will be rotated by die as long as tangential force exerted by wheel of roller does not exceed the maximum frictional resistance between the two wheels. But when the tangential force exceeds the frictional resistance, there will be an occurrence of slip between the two wheels, using this concept diameter of Roller Wheels where selected.

The teeth on wheels of roller act to pick up feed materials from the hopper and compress into the die holes and also to prevent slippage when in contact with wheel of roller. For safe limits the diameter of roller was taken 80 mm.Shaft diameter was taken as 25 mm .The ball bearing selected was of dimension 25×52×15.

Fig. 1 : Cad model of roller in creo 4.0

E. Shaft

The shaft was designed to carry the weight of the die. It is subjected to bending and twisting moment from the contact between the roller and the die. The shaft diameter was designed on the basis of strength using equation.

$$T_e = \frac{1}{16} \pi d^3$$

Where,

T = equivalent twisting moment, N-m

from Design data book by B.D.Shiwalkar [3] we have ,

$$T_e = \sqrt{(K_m \times M)^2 + (K_t \times T)^2}$$

K_m = Shock and Fatigue factor for bending,

K_t = Shock and Fatigue factor for torsion,

M = Bending moment, N-m

T = Torque acting on the shaft, N-m

Therefore torque, T transmitted by the shaft is given by

$$T = \frac{P \times 60}{2\pi N}$$

P = power of electric motor (kW)

N = Speed of electric motor (rpm)

On performing subsequent calculation diameter of shaft was taken to be 20mm.

F. Knife

The knife will be used for cutting the material coming out of the holes into pellets. Knife will be located below the revolving die. The vertical position of the pellet knife from the die determines the length of the cut pellets so depending on the length of pellets position of knife was decided.

The knife of 2 mm thickness and 50mm length.

4. Assembly and Discussions

The main components of the machine are shown in the figure 2. The main components are hopper, roller, rotating die, chamber, frame, gearing arrangements, and electric motor. The feed to be converted in pellets is introduced into the

Hopper and this flows down into the pelleting chamber by Gravity flow. The die is connected to the shaft which with the help of gearing arrangements is connected to the electric motor, thus rotation of die is done with the help of electric motor. The rotation of the die initiates the rotation of the rollers which pick up the feed material and compress it into the die holes to form pellets. The emerging pellets are cut by a knife and discharged through the pelleting chamber to the discharge tray by a tangential force of the rotating die. The pellets are collected into a bowl and sun-dried. Fig 3 shows the . Cad model of hopper and chamber assembly and Fig. 4 shows the CAD model of Frame.

Fig., 2 : Cad model of assembly in creo 4.0

Fig. 3 : Cad model of hopper and chamber assembly in creo 4.0

Fig. 4 : Cad model of frame in creo 4.0

5. Conclusion

Depending on the manufacturing feasibility, cost and required parameters pelletizing machine was designed for the dimensions specified in the table (1), the designed machine can provide cost effective solution for Indian farmers for inhouse production of pellets. Market survey also was done for ensuring the manufacturing feasibility apart from considering the manufacturing facility available at P.D.K.V, Akola.

Table 1

Dimensions of different parts of pelletizing machine

Components	Dimensions(mm)	Material used
Hopper	height = 240 lower dia.=160 upper dia.=352	Galvanized tin sheet
Roller	dia.=80 shaft dia. =25 bearing dia. = 52	SAE 1030
Die	dia. = 150 hole dia. = 6-8 thickness =20	Alloy steel
Chamber	dia.=160	Galvanized tin sheet
Frame	20x20x20	Mild steel angles
knife	thickness=2 length=50	Mild steel
Electric motor	1 HP 1440 rpm	

References

- [1] O.A. Olugboji, M.S. Abolarin, M.O. Owolewa and K.C.Ajani "Design construction and testing of poultry feed testing machine" IJETT vol 24 nov-april 2015
- [2] Kaankuka, T. K., & Osu, D. T. (2013). Development of A Revolving Die and Roller Fish Feed Pelletizer. International Journal of Engineering Innovations and Research, 2(1), 105.
- [3] J.E. Shigley and C.R. Mischike , "Mechanical Engineering design", McGraw- hills publication.
- [4] Pathare, Nilesh R., and C. K. Tembhurkar. "Fabrication of Pellet Making Machine." International Journal of Innovations in Engineering and Science, Vol. 1, No. 1, 2016, p. 28-30.
- [5] Salas-Bringas, C., et al. "Noncontact temperature monitoring of a pelleting process using infrared thermography." Journal of food process engineering 30.1 (2007): 24-37.
- [6] Harrison HR, inventor; Pelleting Concepts International, Inc., assignee. Method for preparing animal food pellets. United States patent US 5,744,186. 1998 Apr 28.

6. Conclusion

A single phase seven level PWM inverter is presented. Simulations are done in MATLAB and concluded that the proposed multilevel inverter that can effectively increase the number of output voltage levels with simple PWM control and less number of components. Another major problem in multilevel inverters are the voltage unbalancing problem, so that a modified switching scheme is applied in the suggested topology for the balancing of capacitor voltage. This switching method ensures improved performance in the proposed seven-level PWM inverter.

References

- [1] M. F. Kangarlu and E. Babaei, "A generalized cascaded multilevel inverter using series connection of submultilevel inverters," *IEEE Trans. Power Electron.*, vol. 28, no. 2, pp. 625–636, Feb. 2013.
- [2] A. Mokhberdoran and A. Ajami, "Symmetric and asymmetric design and implementation of new cascaded multilevel inverter topology," *IEEE Trans. Power Electron.*, vol. 29, no. 12, pp. 6712–6724, Dec. 2014.
- [3] S. Gautam and R. Gupta, "Switching frequency derivation for the cascaded multilevel inverter operating in current control mode using multiband hysteresis modulation," *IEEE Trans. Power Electron.*, vol. 29, no. 3, pp. 1480–1489, Mar. 2014.
- [4] J. Dixon et al., "Static Var compensator and active power filter with power injection capability, using 27-level inverters and photovoltaic cells," in *Proc. IEEE Int. Symp. Ind. Electron.*, 2006, pp. 1106–1111.
- [5] M. Rotella, G. Penailillo, J. Pereda, and J. Dixon, "PWM method to eliminate power sources in a nonredundant 27-level inverter for machine drive applications," *IEEE Trans. Ind. Electron.*, vol. 56, no. 1, pp. 194–201, Jan. 2009.
- [6] N. A. Rahim, K. Chaniago, and J. Selvaraj, "Single-phase sevenlevel grid-connected inverter for photovoltaic system," *IEEE Trans. Ind. Electron.*, vol. 58, no. 6, pp. 2435–2443, Jun. 2011.
- [7] J. Mei, B. Xiao, K. Shen, L. M. Tolbert, and J. Y. Zheng, "Modular multilevel inverter with new modulation method and its application to photovoltaic grid-connected generator," *IEEE Trans. Power Electron.*, vol. 28, no. 11, pp. 5063–5073, Nov. 2013.
- [8] E. Babaei, "A cascade multilevel converter topology with reduced number of switches," *IEEE Trans. Power Electron.*, vol. 23, no. 6, pp. 2657–2664, Nov. 2008.
- [9] K. Wang, Y. Li, Z. Zheng, and L. Xu, "Voltage balancing and fluctuation suppression methods of floating capacitors in a new modular multilevel converter," *IEEE Trans. Ind. Electron.*, vol. 60, no. 5, pp. 1943–1954, May 2013.
- [10] E. Najafi and A. H. M. Yatim, "Design and implementation of a new multilevel inverter topology," *IEEE Trans. Ind. Electron.*, vol. 59, no. 11, pp. 4148–4154, Nov. 2012.
- [11] Jin-Sung Choi, and Feel-soon Kang, "Seven-Level PWM Inverter Employing Series-Connected Capacitors Paralleled To A Single DC Voltage Source," *IEEE Trans. Ind. Electron.*, vol. 62, no. 6, pp. 3448–3459, Jun. 2015.