

# DEVELOPMENT OF A MOTORIZED FISH FEED PELLETIZING MACHINE

**Y. I. Tashiwa\*, K. A. Mojeed, H. U. Kabri and A. A. Jilima**

Department of Agricultural and Environmental Engineering, School of Engineering and Engineering Technology, Modibbo Adama University of Technology Yola

\*Corresponding author email: [ytashiwa@mautech.edu.ng](mailto:ytashiwa@mautech.edu.ng)

## ABSTRACT

*As the world's population increases so also is the demand in terms of food for the rapidly increasing population. Fish an essential source of animal protein could be made available in the local markets when production of standard fish feeds is accelerated. A motorized fish feed pelletizing machine was design, construction and its performance was evaluated in the workshop of department of Agricultural and Environmental Engineering, Modibbo Adama University of Technology Yola, Adamawa State. Materials for the construction were purchased in the Jimeta main market, which include 2.5mm galvanized metal sheet, pulley, 1Hp electric motor, pipes, 2.5mm angle iron etc. The machine efficiency was found to be 63% at 28% moisture content, while the production rate was 38.2kg/hr. It was recommended that there is need to further improve on the efficiency and the quality of the pellets produced at various moisture contents and to find out the best moisture/mixes combination for effective production of fish feed pellets.*

**Keywords:** Fish, Pelletizing, Machine, Design, Construction

## 1 INTRODUCTION

To meet the need of the world's increasing population in term of protein requirements animals need to be fed with meals that would aid their growth and development. These feeds are processed using simple techniques as size reduction, crushing, rolling, steam-flaking, roasting, chopping, cracking or crimping, popping, hot or cold pelletizing. Though, advances in technological development has made it possible for different types of machines to be developed to ease grinding of cereals and grain mixing with other nutrients to produce animal feeds [1].

Therefore, using cheap feeds without considering the nutritional requirements has a major constraint to the growth and development of fish. Like in all animals, best performance could only be obtained if the fish have a balanced diet and the feed are palatable, easily digestible and does not disintegrate into water before the fish can consume it. Fish should be fed with the correct feed of the right quality by knowledgeable person who is aware of fish feeding response.

Pelletized feeds have been defined as "agglomerated feeds formed by extruding individual ingredients or mixtures by compacting and forcing them through the die openings by any mechanical process". Basically, the purpose of pelletizing 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. These larger particles are easier to handle, more palatable and usually result in improved feeding when compared to the un-pelleted feeds [2].

Pelletized feeds have the following advantages homogenous nutritional value, less influenced by external factors such as oxidation, moisture etc. It is easy to store and easy to digest. It minimizes wastage during the eating process [2]. Pelletizing machines are used to produce animal feeds in the form of soft capsules, which can easily be consumed by fishes and poultry. The fish feed are not normally dumped into ponds or tanks, but fed according to the fishes feeding response. Feed is expensive (up to 60 - 70%) of operating cost and is normally the bane of most farmers who embark on

fish production without considering where and how to obtain the right feed before embarking on fish production.

There is an inadequate supply of fish feed to farmers who are into fish production. Fish production is generally low and the industry is slow rising because farmers find it hard to acquire or produce feeds for their fishes. Also, the price of fish feeds per kg is high and is out of reach for most farmers who are in the industry. Most quality feeds available in the market are foreign (imported) and the locally made feeds are grappling with various challenges, ranging from inadequate formulation and poor binding of constituents, which most of the times causes feeds meant to stay afloat for some time to sink [3]. This causes leaching of the nutrients into the pond as it dissolves, making the water turbid thereby decreasing fish visibility and increases the frequency at which the water in the pond is changed. This is not economical to the fish farmer considering the amount of money expended to purchase fuel to power generators or tariffs on electricity.

Therefore, there is need to produce high grade fish feeds that would compete favourably with the imported feeds at reduced cost using local raw materials. Hence, the need for the development of a fish feed pelletizing machine.

The pelletizing machine for the production of organic fertilizer plant was successfully designed and fabricated. It consists of an integrated system of a single phase 3 kW electric motor, 50 mm shaft, screw auger, pelletizing barrel, ball bearing, pulley, 8 mm thick V-belt. Pellet sizes of organic fertilizer produced was in the range of (2 – 6 mm) according to the 3 different mesh sizes (2, 4 and 6 mm). The total mass of pellets increases as mesh size increases, hence pelletizing efficiency also increases with increase in mesh sizes [3]. This machine does not have a cutter and as such there was need to fabricate more mesh size die. The required length of the pellets was gotten by manually cutting the pellets as it comes out of the die. This problem is energy exhausting and time consuming.

Generally, the pelletizing process consists of a pelletizing device, a steam generator, oil and molasses, a cooling device, a separator and a sieve [4]. It has been pointed out that the mean particle size or grind of ingredient, and formulation play a major role in producing high quality pellets [5]. However, there is a limitation to the use of the livestock feed pelletizing machine because of the high cost of the equipment for pellet processing [6]. Hence, the local livestock farmer, in Nigeria in particular, cannot afford to utilize the sophisticated livestock feed pelletizing machine.

## 2 MATERIALS AND METHODS

### *Design Calculations*

$$\text{Volume Hopper} = \frac{1}{3} h (A_1 + A_2 + \sqrt{A_1 A_2}) \quad (1)$$

Where,  $A_1 = \text{Bottom length} \times \text{width} = L_1 \times w_1$

$$A_2 = \text{Top length} \times \text{width} = L_2 \times w_2$$

### *Weight of pulley*

$$W_p = m_p g \quad (2)$$

### *Determination of shaft diameter*

$$d^3 = \frac{16}{\pi t_s} \sqrt{(K_b \times M_b)^2 + (K_t + M_t)^2} \quad (3)$$

Where,  $t_s = \text{allowable stress for steel without keyway, N/M}^2(50\text{MN/m}^2)$ ,  $K_b = \text{combined shock and fatigue factor applied to bending}$ ,  $M_b = \text{maximum, vertical bending moment}$ ,  $M_t = \text{horizontal torsion moment Nm}$ ,  $K_t = \text{combined shock and application to torsion bending moment,} = 1.0$  (Spots, 1988)

### *Pulley speed*

$$\frac{\omega_1}{\omega_2} = \frac{N_1}{N_2} = \frac{D_1}{D_2} \quad (4)$$

Where,  $\omega_1$  = angular speed at driver pulley,  $\omega_2$  = angular speed at driven pulley,  $N_1$  = no of revolutions of driver pulley,  $N_2$  = no of revolutions of driven pulley,  $D_1$  = diameter of driver pulley,  $D_2$  = diameter of driven pulley.

Angular speed of input shaft ( $\omega_1$ )

$$\omega_1 = \frac{2\pi N}{60} \quad (5)$$

Velocity ratio

$$\frac{N_1}{N_2} = \frac{D_1}{D_2} \quad (6)$$

Angular speed of output shaft ( $\omega_2$ )

$$\omega_2 = \frac{\omega_1 N_2}{N_1} \quad (7)$$

Selection of belt

$$L_b = 1.57(D_1 + D_2) + \frac{(D_1 - D_2)^2}{4C} + 2C \text{ (Open belt)} \quad (8)$$

Where,  $L_b$  = length of belt,  $bt$  = belt thickness,  $\rho$  = density of belt,  $C$  = centre distance between pulleys.

$$\text{Mass of belt} = bt \times l \times \rho \quad (9)$$

Therefore, the centrifugal force developed at pulley end is given as:

$$F_c = M_b \omega^2 r \quad (10)$$

$$\text{Velocity of belt: } V = \frac{\pi D_1 N_1}{60} \quad (11)$$

$$T_c = M_b V^2 \quad (12)$$

Where,  $V$  = velocity of belt,  $T_c$  = centrifugal tension,  $M_b$  = mass of belt,  $r$  = radius of pulley.

$$\sin \alpha = \frac{r_2 - r_1}{c} \text{ for open belt drive} \quad (13)$$

$$\alpha = \sin^{-1} 0.1 = 5.7^\circ$$

$$\theta = (180^\circ - 2\alpha) \frac{\pi}{180} \text{ rad} \quad (14)$$

Where,  $\alpha$  = angle of tilt,  $\theta$  = angle of lap,  $\mu$  = static coefficient of friction

$$\frac{T_1 - T_c}{T_2 - T_c} = e^{\mu \theta} \quad (15)$$

$$\frac{T_1 - 2.92}{T_2 - 2.92} = e^{0.3 \times 2.9} \text{ and } T_1 - 2.92 = 2.4T_2 - 5.$$

$$T_1 = 2.4T_2 - 2.78 \quad (16)$$

$$P = (T_1 - T_2) V$$

$$745 = (T_1 - T_2) 3.7 \quad (17)$$

Where,  $T_1$  = tension at tight side,  $T_2$  = tension at slack side

Power Requirement for open belt drive

$$P = (T_1 - T_2) V \quad (18)$$

The frame was constructed with 45mm x 45mm mild steel angle iron. Two lengths of the material were procured and cut into appropriate dimensions using power saw. The frame measures as follows: Length 400mm; width 300mm; and height 400mm. These dimensions were cut out and joined together by arc - welding, bolts and nuts of M8 x 30 size. The frame was braced across the length and width to provide required strength for the frame. 2mm mild steel metal sheet was fastened to the base

of the frame for mounting of the electric motor. Figure 1 and 2 shows the front and rear views of the pelletizing machine, plate 1 shows the pelletizing machine.

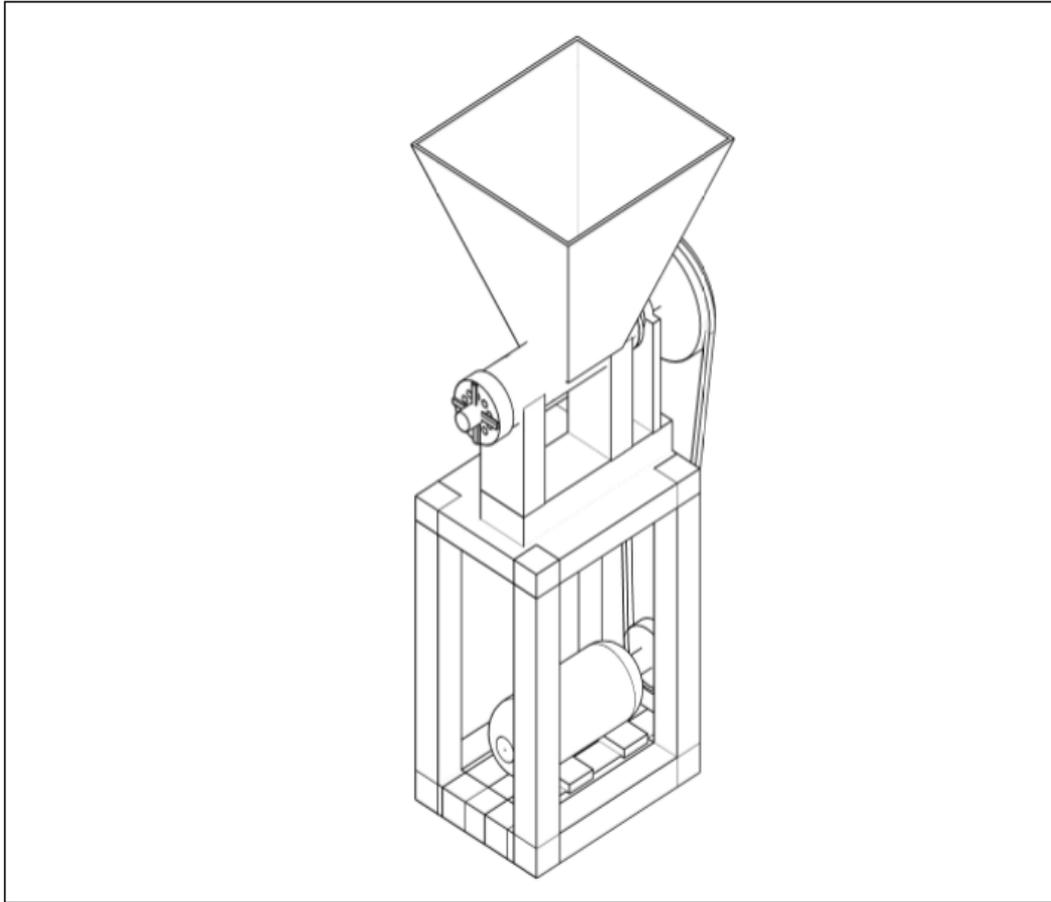


Figure 1. Front View of the Pelletizing Machine

#### *Operating principles of the machine*

The feed mixes are loaded into the hopper of the pelletizing machine and the feed falls into the pelletizing chamber by gravity. The motor provides power that rotates the auger in the cylinder in which the feed experiences circular motion in a horizontal plane about the axis. The feed is pressed against the die and it comes out through the openings in spiral forms. Then cutter cuts the feed at the outlet of the die at a desired length.

The testing was carried out following the method of [6]. (i) Three parts of feed mix, each 1 kg, were prepared. (ii) Prepared at 20% of moisture content was added to one part and thoroughly mixed. (iii) The machine was powered and the moist feed was fed through the hopper gradually. (iv) The pellets resulting were collected on a tray and dried. (v) Ten pellets selected randomly were weighed and their dimensions were taken. (vi) The test was repeated for the other two parts at 25% and 28% moisture content respectively.



Plate 1. The Pelletizing Machine

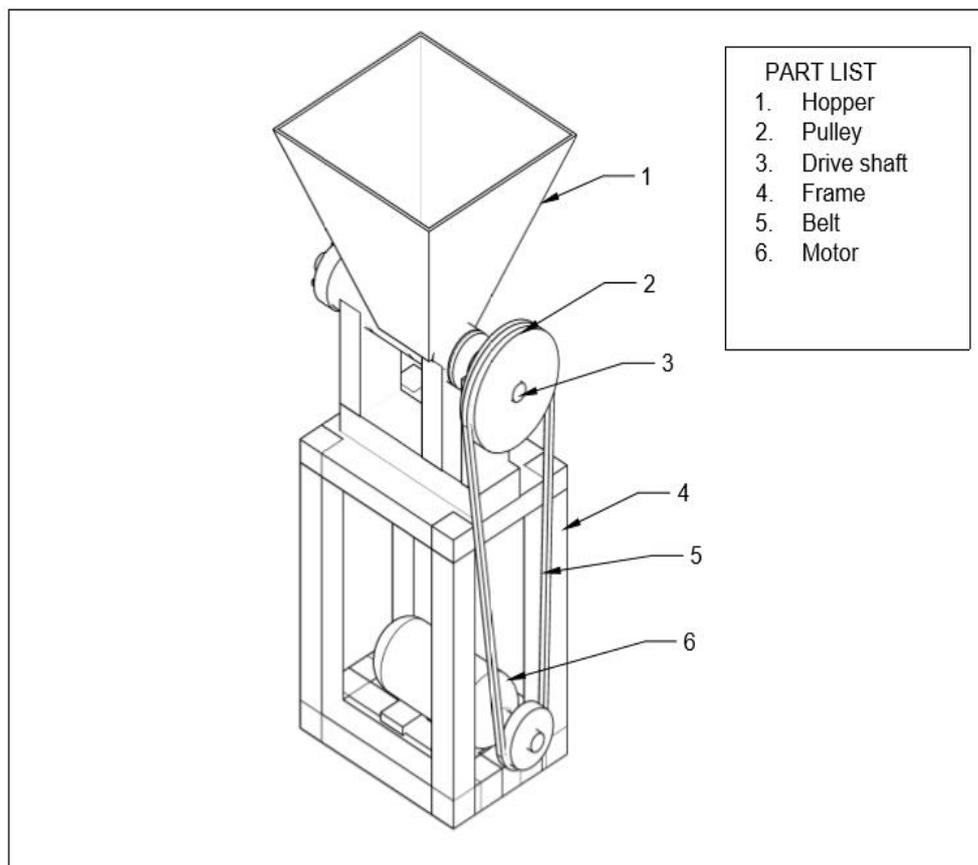


Figure 2. Rear View of proposed Pelletizing Machine

### 3 RESULTS AND DISSCUSSION

The Table 1 presents results of performance test of the machine. Water was used to precondition the feed mixes. The pellets formed were not all that smooth and was whitish in colour. This may be due to the rise in temperature during the extrusion process around the caking section which was relatively high. Pellets were formed with 500 and 750 cm<sup>3</sup> water. Though, at 500cm<sup>3</sup> the pellets were mostly in a friable state. However, when 1000 cm<sup>3</sup> of water was used, no pellets were formed, because the moisture was almost at the liquid limit. Hence the feed could not be caked as there were no restrictions to keep it in the caking chamber.

Table 1. Results of test for each part of feed mix fed into the machine

	1 <sup>st</sup> part	2 <sup>nd</sup> part	3 <sup>rd</sup> part
Mass of feed used (kg)	1	1	1
Quantity of water added cm <sup>3</sup>	500	750	1000
Mass of pellets formed (kg)	0.65	0.85	0.90
Mass of un-pelleted feed(kg)	0.35	0.15	0.10
Time taken (hr)	0.50	0.30	0.06
Throughput (kghr <sup>-1</sup> )	1.3	2.8	15

[7] proposed that good pellets which are properly formed have their lengths about two and a half times their diameters, which was particularly so for pellets formed using 500 and 750 cm<sup>3</sup> of water. The density of pellets produced varied between 0.6 and 0.85 g/cm<sup>3</sup> which is higher than 0.5 to 0.6 g/cm<sup>3</sup> obtained by [5] and lower than that obtained by [6] 0.55 to 0.65 g/cm<sup>3</sup> obtained using a typical Universal Pellet Cooker [8]. And the pelletizing efficiency estimated using the relationship.

$$\text{Efficiency } \eta_p = \frac{W_r}{W_p} \times 100 \quad (19)$$

Where, W<sub>r</sub> = Total weight recovered, W<sub>p</sub> = Total weight fed in.

The throughput of the machine was calculated using

$$\text{Production rate (kg/h)} = \frac{\text{mass produced (kg)}}{\text{Time (h)}} \quad (20)$$

### 4 CONCLUSION

A motorized fish feed pelletizing machine was designed, constructed and tested. And the machine efficiency was 63% at 750cm<sup>3</sup> water preconditioned feed mix and a production rate of 38.2kg/h. With this machine a local fish farmer can produce his feed at home, which will save a lot of cost incurred to purchase feed. This also allows the farmer to manipulate his feed formulation and sizes base on types of fish.

### REFERENCES

1. Aremu, A.K., Kadiri, A.O. and Ogunlade, C.A. (2014). Development and testing of screw type kenaf (Hibiscus cannabinus) pelletizing machine. *International Journal of Agricultural Technology*, vol. 10, no. 4, pp.803-815.
2. Yogesh Y. Nandurkar, Vikas Borade, Surendra Gautam and Sunil S. Akant (2017): Design and Fabrication of Animal Food Pellet Making Machine. *Journal of Research in Engineering and Applied Sciences*, JREAS, vol. 2, Issue 3.
3. Tacon, A.G.J. (1990). Standard Methods for the Nutrition and Feeding of Farmed Fish and Shrimp. Argent Laboratories Press. Redmond, USA.
4. Hardy R.W. and Barrows. F.T. (2002). Diet formulation and manufacture. In: Fish Nutrition. 3rd Ed. Elsevier Science. New York, USA, pp. 505-600.

5. Food and Agricultural Organization, FAO (2008). Aquaculture Development and Coordination Programme, Fish Feed Technology, Retrieved March 3, 2008 from [http://www.fao.org/Chapter 18 feed milling processes2\\_files/fao.html](http://www.fao.org/Chapter 18 feed milling processes2_files/fao.html).
6. Orisaleye, J.I.; Ojolo, S.J. and Fashina, A.B. (2009) Design and Development of a Livestock Feed Pelleting Machine, *Journal of Engineering Research*, vol. 14, no. 1.
7. Food and Agricultural Organization, FAO (1996). Livestock Feed Processing Equipment. Retrieved January 9, 2005 from <http://www.fao.org/DOCREP/005/Y1936/y1936>.
8. Galen, R., Rob, S. and Brian, P. (2008). Pelleted Livestock Feed Production Process Description. Retrieved March 3, 2008 from <http://www.engormix.com>.