

The Design, Fabrication and Testing of Pelletizing Machine

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Abstract

Feed is one of the major determining factor in the profitability of fish farming especially in Nigeria where most feeds are imported. Few of the available Pelletizing machine are expensive and not affordable to of fish farmers in the country. A pelletizing machine is designed fabricated and tested. The machine comprised of auger cased in a barrel, a die size of 6mm through which the pellets are extruded. A hopper that receives the feed, gasoline engine was used as a prime mover, outlet chute, frame and belt drive. The auger convey and compressed the feed to a solid mass against the die. The machine test was carried out from ten trials of 5kg each of the feed samples to determine the pelleting efficiency. In each trial, the weight of pellets was recorded. The ratio of the weight of pellets to the weight of feed expressed in percentage was recorded as the pelletizing efficiency. The ratio of the weight of feed to the time taken for all the feed to pass through the machine was used to determine the throughput capacity. The maximum machine efficiency was obtained to be 82.0% while, the minimum value of 68% was obtained both at 6mm. The average pelletizing efficiency is 77.6% and the throughput capacity is 35 kg/h. The efficiency is high enough for utilization by farmers during production. Performance evaluation of the machine should be carried out to determine optimum combination of parameters for optimum efficiency.

Keywords: Pelletizing Machine; Efficiency, feed meals, die size.

Introduction

Fish farming is greatly expanding in Nigeria with many entrants into the business on a regular basis. However, this has not translated into increased yield as a result of non-availability and affordability of rich balanced feed (Gabriel *et al.*, 2007; Galen *et al.*, 2008 and Malgwi *et al.*, 2020). High cost of feed has been identified as major factor among other that militate against fish production in Africa as a whole and Nigeria in particular (Orimaye *et al.*, 2019). There are abundant feed ingredients locally produced that could be used by fish farmers but the technics of transforming them into pellets of the acceptable form is not within the reach of low income farmers (Anyadike *et al.*, 2014). Many of the machines are not manufactured locally (Orimaye *et al.*, 2019).

Pelletizing machine is an equipment for transforming powdery materials into some solid of variable sizes called pellets by extrusion (Ikebudu *et al.*, 2015 and Malgwi *et al.*, 2020). It consists of a barrelled screw auger that convey and compressed feed in moist to semi-solid mass form (Ikedudu *et al.*, 2015). There are universally two types of pelleting machines which are the disc-die type and ring die type (Kaankuka and Osu, 2013; Orimaye *et al.*, 2019). Pelleting machines perform the function of moulding feed meals into soft capsules for

animals. The factors mostly influencing the nature of the pelletized product have been classified into operating conditions of the machine (like temperature, pressure, diameter of the die aperture), operating speed and the rheological properties (like moisture content and the physical state of the feed) amongst others (Malgwi *et al.*, 2020). However, the feed pelletizing machines are not favourable to the local farmers due to its high cost (Muo *et al.*, 2016). Therefore, this research attempt to design, fabricate and test a low cost pelletizing machine to meet the need of the poor resource fish farmers within the environment.

Materials and methods

Materials

All the materials for the fabrication of the pelletizing machine were sourced locally. Materials for the fabrication of the Pelletizing Machine includes: Metal sheet, Angle iron bars, Pulleys, belts, electrode and Prime mover.

Design Considerations

The following factors were put into considerations before embarking on the design;

- portability
- strength
- ease of maintenance
- prime mover independent of electricity
- continuous and ease of discharge of pellets

Criteria for material selection

- Availability
- Cost
- Durability
- Strength
- Corrosion resistance

Design Calculations

The following calculations for the various components design of the Pelletizing Machine were considered and carried out as reported by (Veronica, 2018; Malgwi *et al.*, 2020). The following parameters were used.

Screw diameter $d_s = 100\text{mm}$

Length of the screw conveyor $L_s = 230\text{mm}$

Pitch of the screw $s = 60\text{mm}$

Shaft diameter $d = 30\text{mm}$

Loading efficiency $\psi = 0.25$

Friction factor for material $\mu = 0.6$ assumed

Factor of inclination $k = 1$ for horizontal conveyor

Material factor $W_o = 2$ assumed

Height of the screw to horizontal $H = 0$

Maximum density of the material $\rho = 1200\text{ kg/m}^3$

Speed of the screw $n = 500\text{rpm}$

Capacity of the screw auger

The capacity of the screw auger was computed using equation expressed by Ezewu, (2021) as

$$I_v = 15\pi d_s^2 sn\psi k \text{ m}^3/\text{hr}$$

$$I_v = 15 \times \pi \times (0.1)^2 \times 0.06 \times 500 \times 0.25 \times 1 \text{ m}^3/\text{hr}$$

$$I_v = 3.534 \text{ m}^3/\text{hr}$$

Power requirement

$$P = \rho_v \times I_v \times (L \times f \pm H) \text{ (Ezewu, 2021)}$$

$$P = 1200 \times 3.53 \times (0.23 \times 2 \pm 0)$$

$$P = 1948.56\text{W}$$

$$P = 1.94856\text{kW}$$

A 5.5hp gasoline engine (4.1kW) will be adequate.

Load propulsion speed

$$v = \frac{sn}{60} \text{ m/s (Singh, 2003)}$$

$$v = \frac{0.06 \times 500}{60}$$

$$v = 0.5 \text{ m/s}$$

Shaft design

Maximum shear stress due to torsion is evaluated from

$$P = T\omega = \frac{2\pi NT}{60} \text{ (Burr, 1982; Khurmi and Gupta, 1979 and Orisaleye et al, 2009)}$$

$$T = \frac{60P}{2\pi N} = 138.2\text{Nm}$$

$$T = \frac{60 \times 1948.56}{2 \times \pi \times 500}$$

$$T = 37.2\text{Nm}$$

$$\tau_{max} = \frac{Tr}{J} = \frac{37.2 \times 0.015}{0.098 \times 0.03^4}$$

$$\tau_{max} = 7.03 \text{ MN/m}^2$$

The drive

A V-belt and pulley arrangement were selected to transmit power from the prime mover (gasoline engine of 5.5hp) to the shaft of the machine's mixing unit because of its flexibility, ease of use, low maintenance cost and the ability to absorb shocks.

Pulley diameters

The diameter of the pulley for the screw auger was calculated using the expression below;

$$D2 = \frac{N1D1}{N2}$$

$$D2 = \frac{1800 \times 70}{500}$$

$$D2 = 252\text{mm}$$

Where;

N1, N2 = Speeds of prime mover pulley and mixing auger pulley respectively (rpm).

D1, D2 = Diameters of prime mover pulley and mixing auger pulley respectively (mm).

Belt length

The relationship below was used in determining the belt length for the mixing drive

$$t = 2c + 1.5(d2 + d1) + \frac{(d2 - d1)^2}{4c}$$

$$t = 2 \times 0.4 + 1.5(0.24 + 0.048) + \frac{(0.24 - 0.048)^2}{4 \times 0.4}$$

$$t = 1.26\text{m}$$

Where;

t = Belt length (m).

c = Centre distance between pulleys (m).

d1 = Pitch diameter of driver pulley (m).

d2 = Pitch diameter of driven pulley (m).

Fabrication and assembling of component parts of pelletizing machine

The fabrication of the Pelletizing Machine was carried out through various stages and processes, which includes marking and cutting out required dimensions of materials, welding, boring and drilling, coupling, filling and painting process. The fabricated machine produced is shown in Figure 1 and 2 below.

Pelleting efficiency (P.E)

It is the ratio of the quantity of actual feed pelleted obtained at the main die orifice to the total feed input per unit time (Ojomo *et al.*, 2010; Davies *et al.*, 2011). This was determined using the following Equation;

$$P.E = \frac{W_p}{W_m} \times 100$$

Where;

W_p = The quantity of actual feed pelleted (kg).

W_m = The total feed input mass (kg).

Test Procedure

Compounded fish feed was prepared from locally sourced materials. The ingredients were soya bean meal, groundnut cake, maize, fishmeal, palm kernel, cottonseed, leguminous crops, green plant meals, and premix. Some starch and little water were added as binders to the compounded feed, and thoroughly mixed with hand manually. 5kg of the compounded mix was fed through the machine's hopper after the machine was switched on. The pelletized feed was collected through the outlet chute. The time taken to complete the process was recorded.

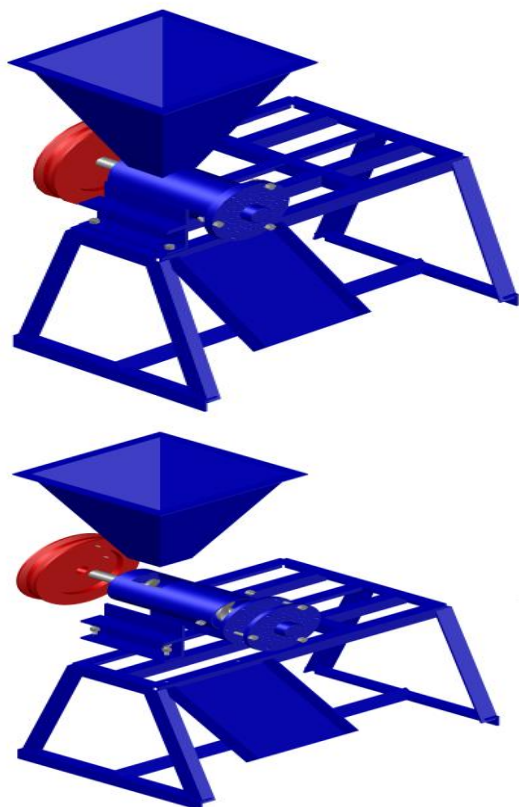


Figure 1: Pelletizing Machine Isometric and Exploded Drawings

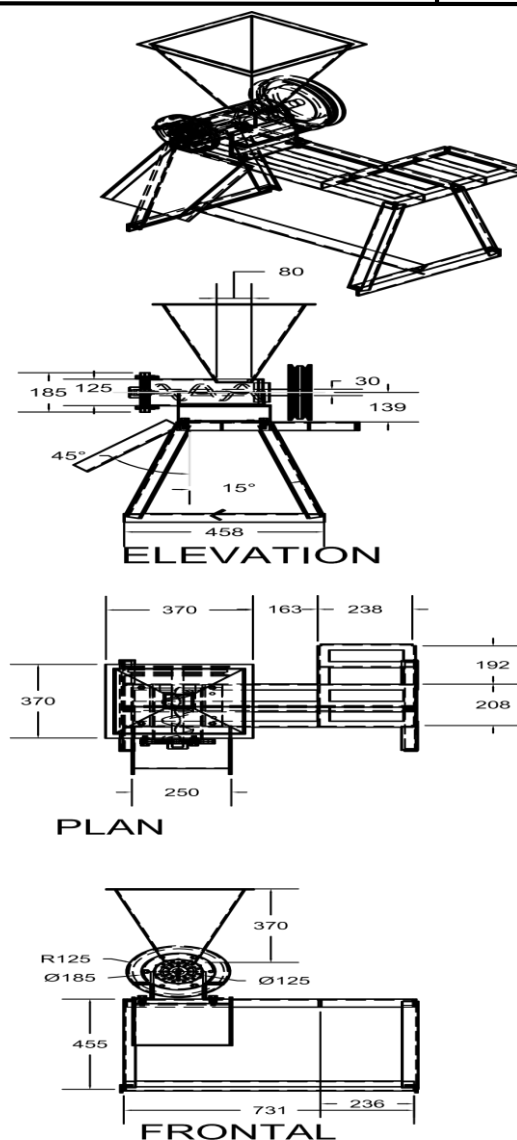


Figure 2: Orthographic Drawing of Pelletizing Machine

Results and discussion

Table 1 showed the results of the pelletizing machine efficiency. The machine test was carried out on ten trials of 5kg each of the feed samples in the evaluation of pelletizing efficiency. The maximum machine efficiency was obtained to be 82.0% and while the minimum value of 68% was obtained both at 6mm using 8.6mins for the processing period. The throughput capacity obtained is 35 kg/hr. The results are similar to what was reported by Ezewu, 2021, Orimaye *et al.*, 2019 and Ojomo *et al.*, 2010.



Table 1: Results of Pelletizing Machine Efficiency

Trial	Input Weight (kg)	Output Weight (kg)	Efficiency (%)
1	5	3.4	68
2	5	3.5	70
3	5	4	80
4	5	4	80
5	5	4.1	82
6	5	4	80
7	5	3.8	76
8	5	3.9	78
9	5	4.1	82
10	5	4	80
Average	5	3.88	77.6

Conclusion

The following conclusion was drawn from this study:

- Pelletizing machine efficiency obtained is high enough for effective utilization by farmers during production.

Recommendations

The following recommendations were drawn from this study;

- The processing parts and features (size of die, pulley diameter and machine operating time moisture content of feed, biding ratio, and machine operating speed) should be considered for optimum efficiency of the machine
- The samples utilized for the testing should be taken to the laboratory for proximate analysis.

References

Anyadike, C. C., Onyia, M. N. and Mbunwe, M. J. (2014) Handling the feed challenges of fish farmers in Nigeria. Society of Women Engineers. Available: <https://www.slideshare.net/SWE/Marketing/handling-the-feed-challenges-of-fish-farmers>

Burr, A. H. (1982). Mechanical Analysis and Design, Elsevier Publishing Co., USA.

Davies, R. M., and Davies, O. A. (2011). Development and performance evaluation of manually operated fish pelleting machine. *Innovations in Science and Engineering*, 1(1): 9-16.

Diarra, S., Kwari, I. and Kwari, H. (2001). Effect of Substituting Wheat Bran with Millet Bran on Nutrients Digestibility and Intestinal Morphology of Broiler Chickens. *Proceedings of the 6th Annual Animal Science Association of*

Nigeria, 17-19 September 2001. ASAN Proceedings no. 64, pp. 1-13.

Ezewu, K. (2021) Design of an NPK Fertilizer Pelletizer. *Nigerian Journal of Technology (NIJOTECH)*. 40(5): 837 – 845

Gabriel, U. U., O. A. Akinrotimi, D. O. Bekibele, D. N. Onunkwo, and P. E. Anyanwu. (2007). Locally produced fish feed: potentials for aquaculture development in sub-Saharan Africa. *African Journal of Agricultural Research*, 2(7): 287-295.

Galen, R., Rob, S., and Brian, P. (2008). Pelleted Livestock Feed Production-Process Description. <http://www.engormix.com>

Ikedudu, K. O., Chukwumuanya, E. O., Swift, O. N. K and Nwokeocha, T. (2015). Design of Pelletizing Machine (Balling Disc). *International Journal of Materials, Mechanics and Manufacturing*. 3(1):9-12.

Kaankuka, T. K and Osu, D. T. (2013) Development of a revolving die and roller fish feed pelletizer. *International Journal of Engineering Innovations and Research*. 2(1):105- 110.

Khurmi, R. S. and Gupta, J. K. (1979). Machine Design, Eurasia Publishing Co., Delhi

Malgwi, G. S., Abdulkadir, S. A. and Dodo, S. M. (2020) Modification and Performance Evaluation of a Fish Feed Pelletizing Machine. *Arid Zone Journal of Engineering, Technology and Environment*. 16 (3): 509 - 518

Muo, V. I., Okpe, B., Okolokwe, V., Ogbu C. C. (2016). A Design and Fabrication of Fish Feed Pelleting Machine. *International Journal of Scientific Research and Management (IJSRM)*, 6 (7), EC-2018-78-84. DOI: 10.18535/ijssrm/v6i9.ec01

Ojomo, A. O., Agbetoye, L. A. S. and Ologunagba, F. O. (2010). Performance evaluation of a fish feed pelleting machine. *Asian Research Publishing Network (ARPN) Journal of Engineering and Applied Sciences*, 9(5):88-97.

Orimaye, Q. S., Ajewale, P. O. and Oni, I. O. (2019). Design, Fabrication and Performance Evaluation of Indigenous Fish Feed Pelletizing Machine for Low Income Farmers in Nigeria. *Journal of Engineering Research and Reports*, 4(3):1-31.

Orisaleye, J. I., Ojolo, S. J. and Fashina, A. B. (2009). Design and Development of a Livestock Feed Pelleting Machine. *Journal of Engineering Research*, 14(1): 1 - 9

Singh, S. (2003). Khanna's Mechanical Engineers Handbook, 2nd edition, Khanna Publishers, Delhi.

Veronica, I. M., Benard, O., Vincent, O. and Chima, C. O. (2018). Design and Fabrication of Fish Feed Pelletizing Machine. *International Journal of Scientific Research and Management (JERM)*, 6(2): 78-84