

A Design and Fabrication of Fish Feed Pelleting Machine.

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Abstract.

Irrespective of the increasing effort of fish farmers to grow fish continuously and feed the nation with diet full of fish, survey has pointed fish feed as one of the outstanding factors limiting the progress of the farmers as the high cost of the feeds scares poor farmer from active farming. This paper present to you a well-designed and locally fabricated electrically powered fish feed pelleting machine, driven by three electric gear motors of 3hp, 1.8hp and 0.7hp that drive the screw conveyor at the barrel, the hopper conveyor and the extrusion cutter respectively. The components of the machine were locally sourced and locally fabricated. The hopper, the screw conveyors, the barrel and the cutter are made of stainless steel to reduce contamination due to rust. The machine measures 183mm length, 38mm width and 115mm high. It is calculated to have pelleting efficiency of 0.97% and is capable of producing 0.0539kg of feed per second.

Keywords: feed, pelleting, fish and machine

Introduction of Design

1.0 General background study

Feeding livestock with pellets is advantageous to the livestock and the farmer as it is economical and also supplies the required nutrients to the livestock. However, the feed pelleting machines are not favourable to the local farmers due to its high cost. Pelleting or pelletizing machine is the machine used in the production of the feed in pellets. Palletizing machine is an equipment used for making mainly powdery materials and some solid of variable size into pellets [1]. It is used usually for mass or batch production and is applied in industries like ceramics industry, agro industries, iron and steel industry, chemical industry, pharmaceutical industry, cement industry, it is equally used in metallurgical workshops and some related industries. The machine pelletizes many kinds of powdery material especially when mixed with the right solvent.

Considering need for farming business in our nation, researchers has swomped into action to design a cost effective machine capable of converting powdery feed material into pellets. Such machine is expected to be of high efficiency

in order to minimize the cost of farming and improve economy through income generation. The machine, when applied in agriculture will make animal rearing attractive. And create job for the workforce.

1.1 Problem statement / Justification.

The interest of the government towards agriculture has drawn the attention of many youths towards farming, with a great number of them engaging in fish farming. For this reason, the demand for feeds has greatly increased, therefore, mounting serious pressure on the fish feed production companies, thereby increasing the cost of the feed. This has therefore called for an urgent intervention of the researchers to come up with an improved system of the pelletizing machine to salvage this situation and rescue the nation (Nigeria) from recession and create more jobs for the workforce.

1.2 Aim and Objectives of the study.

The aim of this work is to design a pelleting machine that will be capable of producing 500 bags of 50kg feed per day. The objectives of this projects are as follows;

- To fabricate the said machine with a locally sourced materials.

- To evaluate the operating performance of the machine in terms of pelleting time, pelleting capacity, moisture loss of pellets produced and total solids, and physical parameters of pellets like particle size, shape and bulk density; and
- To boost fish farming and create job.

2.0 Literature Review.

Feed is the major cost to animal production. Thus, quality control of its use, will have a considerable impact on the performance of an enterprise [2]. The value of a feed is dependent on how much particular nutrients in the feed that the animal is able to utilize to meet the requirements of various body processes. Due to technological advancement grinding machines were developed for grinding of cereals and grain with the mixture of other nutrients into powder form. With time, it was discovered that the animals preferred feeding on solid and soft nutritious meal. Pelletizing machine is one of the devices required to produce such feed [3].

Moulding of animal feeds inform of capsules, small enough for easy consumption by fishes and poultry beds is the major function of pelleting machine. It equally used in iron ore for pellet production in varying sizes and same goes for chemical factories, where some chemicals are produced in pellets [4]. Livestock feeds is processed with the aim of maximizing utilization efficiency of the nutrients [5].

Studies have revealed that feeding certain livestock with pellets have great benefits. [6] Noted that pelleting amaranth diets improved the nutritional value and was beneficial in improving growth of chicks. [7] Also stated that highly compressed pellets facilitate storage and transportation, as large quantity of feeds could be carried economically from one location to the other. [8] Pointed out some other advantages of pelleting feeds, which includes the saves made through decrease food wastage, improvement on feed efficiency, reduced selective feeding, control of undesired micro-organism, increase in bulk density and better handling characteristics. They added that quality addition to the feed include better durability and fewer fines of the pellets, complete pasteurization, increased utilization of feeds, starch gelatinization increment and production of by-pass fat and by-pass protein. Their views were shared by, [9] and [10]. According to [11], techniques have been developed years back on the way to process feeds

for livestock. The feeds are basically on cereals and their by-products. The process is classified as either hot or cold depending on the required temperature (heat). It may equally be classified as wet or dry process. Different techniques adopted for this processes include particle size reduction or grinding, rolling, crushing, micro-organization, roasting, chopping, cracking or crimping, popping, hot and cold pelleting. This views was shared by [12]; [13] and [2]. Meanwhile, [14], revealed that similar techniques could be adopted for production of manure (fertilizer).

The importance of mean particle size or grind of ingredient and their formulations to production of high quality pellets was emphasized by [8]. However, there is a limitation to the use of the livestock feed pelleting machine because of the high cost of the equipment for pellet processing [10]. Hence, the local livestock farmer, in Nigeria in particular, finds it very difficult to utilize the sophisticated livestock feed pelleting machine. Hence, the need for this project.

3.0 Materials And Methods

The design considerations of the pelleting machine are discussed here, while the equipment is to be fabricated in Mechanical Engineering Workshop of Institute of Management and Technology (IMT) Enugu.

3.1 Components Description and Specifications

The parts that will make up the fish feed pelleting machine are the frame, barrel, hopper, screw conveyor or auger, die, pulley and motor. The machine frame is made of mild steel (Figure 1).

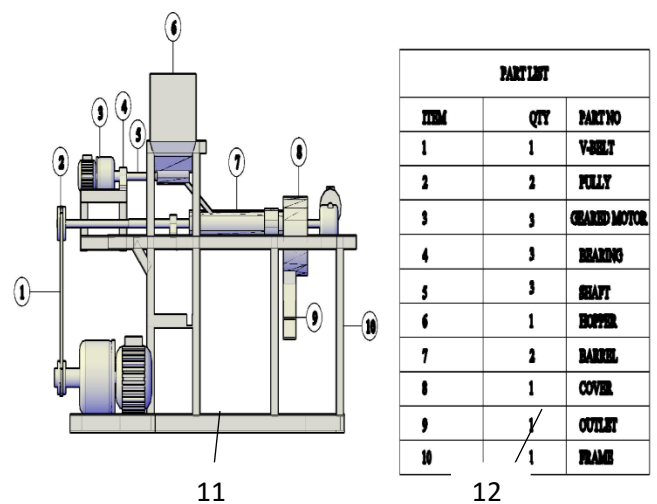


Figure 1: Livestock feed pelleting machine
The machine component description are as follows:

Part no	Component parts	Qty	Dimension
1	V-belt	1	800mm dia
2	Pulley	2	100mm and 70mm dia
3	Gear motor	3	3hp, 1.8hp and 0.7hp
4	Pillow bearing	3	40mm dia
5	Shaft	3	40mm
6	Hopper	1	35 x 35
7	Barrel	1	50mm Θ x 660mm
8	Cover	1	100mm Θ
9	Out let	1	7 x 7mm
10	Frame	1	183 x 115 x 38mm
11	Screw conveyor	1	40mm Θ x 655mm
12	Heater band	1	45mm Θ

3.2 The Frame

The frame is the support base for other components. It is rigid and designed to withstand dynamic stresses and it measures 183 x 115 x 38mm.

3.3 The Barrel

This is a cylindrically shaped component with a 50mm diameter and 660mm length. It is made of stainless steel of thickness 2.5mm.

3.4 The Screw Conveyor

This a stainless cylindrical screw shaft of 46mm external diameter and 660mm length, placed inside the barrel for the purpose of conveying feed components to the die at a constant rate. It is connected to an electric gear motor with a v-belt.

3.5 The Die Plate

The die is a plate placed at the terminal of the screw, it is made of stainless steel and of 5mm thickness with six holes of 8mm drilled onto it. Note that the die can be of variable sizes depending on the size of the feed pellet required.

3.6 Feed Hopper.

Hopper is the input point for the feed components. The mixed feed is fed in through hopper and with the help of a feed conveyor attached to the hopper, the feeds are transferred to the barrel, from where it will be taken to the die for extrusion. It has an outer and inner dimension of 350 x 350mm and 210 x 210mm respectively, at an angle 90°. The

dimension of the outlet of the hopper leading to the barrel is 40 x 40mm, with a height of 350mm. A gauge number 20 stainless steel was used to prevent sticking of feeds to the feed hopper and to allow easy cleaning.

3.7 Operation procedure.

Connect the power cable to a three phase power source, on the control panel and the three electric motors will gain power and begin to rotate in clockwise direction. The 3hp motor will transmit torque to screw conveyor through the v-belt connected to the second pulley attached to the conveyor shaft. The 1.8hp motor which is attached to the shaft of a hopper conveyor will keep the conveyor rotating. When the grounded feed components are poured into the hopper, the hopper conveyor will transfer the feed to the barrel, the screw conveyor will control the feed down to the heating chamber while some moisture is lost due to friction increase at the barrel. At the heating chamber, the feed is further dried and pushed to the die orifice of 8mm each. The extruded feed will be subjected to a cutting blade powered by a 0.7hp motor every 7 seconds of extrusion, thereby producing a feed of about 7mm high by 8mm diameter.

4.0 Design Analysis

4.1 The Screw Conveyor

The parameters considered in the design of the screw conveyor were obtained from design specifications and relevant tables that give parameters corresponding to the nominal screw diameter with regard to the material to be pelleted (the feed in this case). In a bid to determine the power required to drive the screw, the following formular was employed.

$$Q = 150\pi D^2 S n \psi \rho C \quad \text{kN/hr [15]} \quad (4.0)$$

Where D = diameter of the screw 0.04m

S = screw pitch 0.8D = 0.032m

n = speed of conveyor = loading efficiency

$$n = n = \frac{N_1 D_1}{D_2} = \frac{1420 \times 0.007}{0.008} = 1242.5 \text{ rpm} \quad (4.01)$$

ρ = free bulk density of the material,

c = loading factor depending on the inclined angle to the horizontal

The recommended values by [16] for slow flowing abrasive material are $S=0.8D$ $\psi =0.125$ and $c=1$ for inclination angle $b^\circ = 0$.

ρ = free bulk density of the material (the feed in this case) 900kg/m

c = loading factor = 1

$\psi = 0.125$

$Q = 150 \times 0.04^2 \times 0.032 \times 1242.5 \times 0.125 \times 0.9 \times 1$

$Q = 1073.52\text{KN/hr}$

The power required to drive the screwed was calculated using

$$P = \frac{QL(W_0 + \sin \beta)}{3600\eta} \text{ Kw [15]} \quad (4.1)$$

$$p = \frac{1073.52 \times 0.66(2 \times 3.142 \times 1242.5)}{3600 \times 1242.5 \times 60}$$

$$P = 0.02\text{kW}$$

Load proportion speed is calculated as

$$v = \frac{Sn}{60} \text{ m/s [15]} \quad (4.2)$$

$$v = \frac{0.032 \times 1242.5}{60} = 0.663\text{m/s}$$

Load per meter length of screw will be worked as;

$$q = \frac{Q}{3.6v} \text{ N/m [15]} \quad (4.3)$$

$$q = \frac{1073.52}{3.6 \times 0.663}$$

$$q = 449.77\text{N/m}$$

The axial thrust experienced by the conveyor can be evaluated as;

$$F_A = qL\mu N \text{ N [15]} \quad (4.4)$$

For 20° screw angle,

Then, $\mu = \tan\theta$

i.e $\mu = \tan 20^\circ$

$$\mu = 0.36$$

$$F_A = 449.77 \times 0.66 \times 0.36 \times 1242.5$$

$$F_A = 132,780.2\text{N}$$

$$F_A = 132.8\text{kN}$$

4.2 Shaft Design

For the rotating shaft, pure torsion was assumed and maximum shear stress due to torsion was employed and the angle of twist were considered. The values of which was gotten from relevant tables and chart.

4.3 Determination of Axial Force needed for extruding

Let effective area of baffle = A_c ,

Output Area of die = A_o

$$A_o = \frac{\pi}{4} (d_o^2) \quad (4.5)$$

$$A_o = \frac{3.142}{4} (0.01^2)$$

$$A_o = 7.85 \times 10^{-7} \text{m}^2$$

Internal diameter of barrel $d_b = 0.13\text{m}$

Diameter of shaft $d_s = 0.04\text{m}$

Then

$$A_c = \frac{\pi}{4} (d_b^2 - d_s^2)$$

$$A_c = \frac{3.142}{4} (0.13 - 0.04)$$

$$A_c = 0.07\text{m}^2 = 70\text{mm}^2$$

4.4 Determination of the Screw Conveyor's Press Torque

Assuming a 95% conveying efficiency, the torque can be determined by the relation

$$T = \left(\frac{Fdl}{2\pi} \right) \left(\frac{95}{100} \right) [17] \quad (4.6)$$

F = axial force

d = barrel diameter

L = length of barrel

$$T = \left(\frac{132780.2 \times 0.13 \times 0.66}{2 \times 3.142} \right) \left(\frac{95}{100} \right)$$

$$T = 1,722.5\text{N}$$

4.5 Determination of Extrusion Pressure (P)

$$P = T\omega = \frac{2\pi NT}{60} \text{ N/mm}^2 \text{ [18]}$$

(4.7)

Figure 2: isometric view of the feed pelleting machine

$$P = \frac{2 \times 3.142 \times 1242.5 \times 1722.5}{60}$$

$$P = 224,121.9 \text{ N/mm}^2$$



Plate 1: pelleting machine



Figure 2: pelleted feed

4.6 Performance evaluation.

50kg of feed was fed into the hopper, the machine was allowed on for about 20 minutes and all the feed were collected as pellets as the time taken for all the feed to be pelleted was noted with a stop watch and the pellets was reweighed with a weigh balance to ascertain the weight loss. The procedure was repeated for five times and the data was recorded as shown in the table below.

Table 4.1: time- table for pelleting rate

S/NO	Input Time (s)	Feed Weight Before Pelleting (kg)	Output Time (s)	Feed Weight After Pelleting (kg)
1	0.000	50	920	48.5
2	0.000	50	900	48.5
3	0.000	50	900	49

4	0.000	50	900	49
5	0.000	50	900	48.7
AVG	0.000	50	904	48.74

The pelleting rate $P_{\text{rate}} = \text{output/time}$

I.e $P_{\text{rate}} = 48.74/904 = 0.0539 \text{ kg/s}$

Operating performance O.P = output/ input

i.e $O.P = 48.74/50 = 0.97$

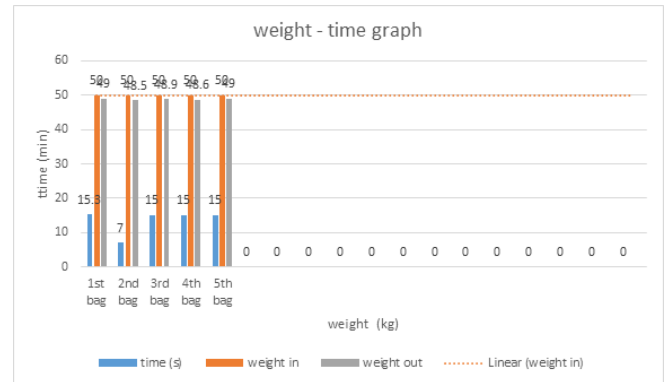


Figure 3: weight – time graph

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5.0 Discussion And Conclusion.

The materials used for the construction were all sourced from Keyeta market Enugu State of Nigeria. The feed components were equally sourced from Ogbete main market Enugu. The fabrications and the assembling were all carried out in IMT Industrial Center. At the cost of fabricating this machine, so many adjustments were made to suit the performance standard of the machine specification. Gear motor were adopted to reduce the speed of the conveyors, the pillow bearings were used to ensure free rotation of the shafts. It was considered wise to reduce the hopper outlet in order to suit the inlet capacity of the barrel for effective performance. In the barrel, the screw conveyor was made in such a way that the screw pitch decreases as the shaft increases. This is to ensure that the feed in the barrel is compressed to increase their binding force and equally for moisture reduction. Though, the heater

band was installed with regulator to ensure that moisture is removed to the barest minimum. The heater band was covered to minimize injury. The dies are detachable in order to give room for the production of other sizes of feed. 0.7 hp motor of 12rpm is installed opposite the die to cut the feeds as the extrudes out. The pellets were collected and reweighed. It was found out that for every 50kg of feed pelleted there is a corresponding moisture loss of about 1kg. The pelleting rate of the machine is calculated to be 0.0539 kg of feed per second. I.e about 47bags of 50kg for every 12hrs of operation.

In conclusion, the fish feed pelleting machine has been successfully fabricated, and it is capable of producing about 50 bags of 50kg per day. The material were all locally sourced. The operating performance is calculated to be 0.97 and the pelleting rate as 0.0539kg/s. The pelleted feed is completely solid and cylindrical in shape, with 7mm height and diameter ranging from 6 – 12mm, depending on the die hole.

This product is good both for large and low scale farmers. It will boast fish farming, create jobs and in return improves the nation's economy.

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