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Research Article

Development of a fish feed pelletizer

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Abstract: Fish feed is one of the critical factors limiting the active participation of farmers due to the high cost that scares the poor farmers away from farming. The fabricated fish feed pelletizing machine was done to assist the farmers in producing fish feeds at a cheaper rate, improving the performance of the existing technology, and determining its implementation for future applications. Design calculations were carried out to determine the machine specification and parameters for its development, and the performance of the machine was evaluated. Data generated from the theoretical analysis were used to fabricate the machine using locally available and durable materials to encourage the local technology as most of those available are imported. The pelletizing machine was tested, using 2.5kg fish feed and the results obtained show that the pelleting efficiency and capacity are 90% and 30kg/h respectively. The cost of the machine is relatively cheap when compared with available pelletizers. Therefore the machine is suitable for small and medium-scale fish and poultry farming and can be used for pelletizing different materials provided the ingredient meets the required moisture content.

Keywords: Pelletizer, Pellets, Fish Feed, Pelletizing Efficiency, Pelletizing Capacity

1. INTRODUCTION

Fish farming is one of the most profitable businesses that can guarantees a return on investment in Nigeria but the cost of feeding contributes a lot to the expenses of fish farming. Thus, the input cost needs to be minimized. High-quality fish feed is cheaper to produce when compared to the cost involved in purchasing ready-made one and can be prepared from local ingredients. But these locally produced fish feeds are unstable or do not float, leading farmers to rely on foreign pellet feeds (Henan, 2019).

Fish farming is the most tedious and challenging operation as it involves more than half of its operation time in taking reasonable and adequate care of the fish and feeding (Igbmosun, 2015). A compound diet of feed comprised the combination of nutrients required by the fingerlings. This feed entails the entire nutrient needed by fish and it is used by an aqua-culture system that depends on the artificial feed for sustenance. The basic knowledge of the available feed ingredients, their respective nutrient requirement by the fingerlings, processing techniques, and equipment are essential (Gabriel, *et. al,* 2007). Factors that influence the pelletizing processes include moisture, temperature, ingredients, composition, ingredient quality, and their source, and as well as die condition (Keysuke *et. al,* 2015).

Pelletization is a process by which finely subdivided materials are made to agglomerate into larger masses of given shapes and measures, called pellets. Agglomeration is a dry process that occurs under pressure with the aid of special binders. Thus, the

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pellets obtained most possess specific physical and mechanical properties to make them suitable for subsequent utilization (Italtraco, 2002). The early pellet processes involve grinding and mixing the feed ingredients and producing them with no further treatment. This approach aimed to prevent alteration to vitamins and proteins due to the action of heat to the feed mixed.

Fish feed pelletizing machine is used in turning fish feeds into pellet form. The main ingredients used in fish feed include rice bran, fish meal, soybean meal, maize, peanut cake, etc. The challenge of making fish feed in Nigeria is not limited to sourcing ingredients but requires technology in the formulation and processing it in two ways such as pelleting or extrusion (Henan, 2019).

Fish feed comprises different components, mixed to meet the nutritional requirements of the fish. Therefore, feeding the fish directly with these granular and loose feed particles may result in poor feeding due to the high risk of separation of individual components, slow growth which increases the vulnerability to the problem and causes the rate of cannibalism (Bhosale, 2010). Thus, it is obvious that the problems of the fish feeding system are due to loose granular particles of the fish feed. According to a laboratory experiment conducted by Rothschild in 1967, poor feeding injected directly causes mortality in fish.

Fish is an essential source of food and income for both the rich and poor people in Nigeria. Many people in the riverine area depend wholly or partly on the fisheries sector for their livelihood (Amadi, 2007).

Pelleting of fish feed involves the integration of the feed mixture into smaller units called pellets. Pelletizing machine is essential equipment in which pellet feed preparation is being processed into the particular size required. The pellet production was stimulated by the need to improve the uniform shape and size of fish feed needed by the users of animal feed producers (Gabriel, 2007).

Operation of the pelleting machine involves pushing the dough through the hopper and a rotating shaft compressing it into a die to form a hard pellet that is resistant to crushing or disintegration when in water. Previously, pellet machines capable of producing pellets of this type were not available locally (Oresegun *et al,* 2005). But, the pelletizing machines are fabricated locally and adopted to produce feed pellets of variable hardness. Before the advent of mechanized pelletization, manual / hand pelletizing was being used to pelletize fish feed compounds, which usually results in drudgery and waste. Domestic hand pelleting involves using a perforated cylindrical shaft that can aid the feed dough pressed against the uniform perforation on the button plate.

The Agricultural sector has played a vital role in employment generation, improving the standard of living and technological challenges inherent globally in the sector. Thus, the need to diversify human occupation in the agro-fish business through fish feed machines of various types is essential. Pelletizing is the change in the phase of raw materials due to the application of a medium to raise the temperature and transform it to the final phase in asolid and capsular form after passing through the desired die shape. Fish farmers faced various methods of producing pelletized feed for fingerlings fishes through a knife or meat grinder to cut the pellet (Fellows, 1998).

This study aim to develop a fish feed pelletizer with the following objectives; to design an electrically powered fish feed pelletizing machine with the auger as the conveying mechanism and pressure-generating device, to fabricate the fish feed pelletizer using locally available materials, and to carry out performance evaluation on the pelletizing machine.

Thus, the fish feeds pelleting machine's design is necessary to improve food security and technology for the comfort of animals such as fish, turkey, chicken, birds, etc. Thus, this project is geared towards producing a simple pelletizer for small-scale farming. The pelletizer can reduce the moisture content of the pellets and reduce the stress associated with sun drying in small-scale feed production.

2. LITERATURE REVIEW

Past research has shown that feeding some livestock with pellets has great benefits. The studies also note that pelleting amaranth diets can increase the nutritional value and benefit the growth of chicks (Kabuage, 2005). They have noted that highly compressed pellets contribute to the storage and transportation of large quantities of feeds from one place to another (Salmatec 2000). The studies highlight some advantages of pelleting feeds, such as decreased food wastage, reduced selective feeding, control of undesired micro-organisms, improved feed efficiency, increased bulk density, and better handling characteristics (Galen, 2008).They discovered that quality addition to feeding has better durability, fewer fines of pellets, increased utilization of feeds, increased starch gelatinization, complete pasteurization, and increased by-pass fat and protein production. Their findings were supported by Mikro (2002) and Joseph (2009). According to Halle (1998) there are techniques developed to process feeds for livestock some years back. Fish feeds are mainly found on cereals and their by-products and have their processes classified as either hot or cold and wet or dry based on the required temperature (heat). Several techniques adopted for this process include the reduction or grinding in particle size, micro-organization, roasting, rolling, crushing, chopping, popping, cracking or crimping, and hot and cold pelleting. The findings were shared by (Harris, 2005); (Donald, 1987) and (Hasting, 2008). Furthermore, (Jeremy, 2014), discovered that similar techniques could be adopted for the production of manure (Galen, 2008) emphasized the significance of grinding the ingredient or mean particle size and their formulations to the production of high-quality pellets. Consequently, the high cost of the equipment for pellet processing has limited the application of livestock feed pelleting machines (Joseph, 2009). Thus, the local livestock farmer in Nigeria finds it hard to maximize the available livestock feed pelleting machine.

Different terms used in pelleting are:

i. Pellets: The pellet is a small round mass or hardball or tablet of substance compressed. They are usually formed by compacting and forcing the mixed feed through a die opening by a mechanical process. Pellet feeds are usually for animal-like cattle, poultry, rabbits, fish which are dominantly fed with pellet feeds together (Balami, 2013).

ii. Dry and Non-dry Feeds (Moist): Dry feeds are made from dry ingredients or a mixture of dry and moist ingredients. The dry feeds are not entirely devoid of moisture which contain 6 –10% water, depending on the environmental condition while the Non-dry feed (moist) can be either wet or moisture wet feed made from a wet ingredient such as trash fish, slaughterhouse (Abattoir), waste and contain 45 – 70% moisture.

iii. Grinding: This is the process of reducing the particle size and increasing the surface area of ingredients thereby facilitating mixing, pelleting, and digestibility. Grinders are plate mills, grinder mills, or hammer mills.

iv. Mixing: Ground ingredients are mixed in the desired proportion to form a homogenous blend. Generally, the dry ingredients are mixed first followed by liquid ingredients as the mixing continues.

v. Pelleting: Conversion of the homogenous blend of the ingredients into durable forms having physical characteristics that make them suitable for feeding. The basic types of pellets are compressed pellets and extruded pellets. Compressed pelleting involves exposing the mixture to stream for 5 – 20 seconds attaining 85 ^{o}C and 16% moisture while the extruded Pelleting involves the use of different physical conditions and result in a very different product having a temperature increased to about 125 –150 ^{o}C in a pressurized condition chamber for 20seconds and the moisture is increased to about 20 – 24^{o} enhancing gelatinization of starch.

I. Cutting: It makes the pellet have a reasonable equal length by cutting manually with hand or knife-edge placed on the shaft which, cut the pellets as it comes out from the auger mechanize.

ii. Drying: This is the process of reducing the moisture content present in the pellet feed. Drying is divided into two methods; sun drying and mechanical method.

iii. The sun-drying involves putting the pellet in the sun to allow it dry while the mechanical method involves the use of a fan and heating element to remove the moisture content from the pellet.

3.0 MATERIALS AND METHODS

3.1 Methods

3.1.1 Design Considerations

For the design of a pelleting machine, (Mott, 1985) stated that the acceptable requirements are:

i. To steadily receive the mixture of feed into the machine.

ii. To introduce the mixture of feeds into the cutting unit uniformly.

iii. To uniformly cut the mixture of feeds.

iv. To steadily discharge the pellets out of the machine with ease.

Other factors also considered while designing the fish feed pelleting machine are (Paul et. al., 2019);

i. Availability of machine

ii. Type of machine to be used

iii. The durability of the materials

iv. Cost of materials

3.1.2 Machine Description and Operation Procedure

iv. The fish feed pelletizing machine uses the principle of rolling friction to produce the pellets.

v. The design employed uses a low-speed electric motor in the ratio of 20:1.

vi. The pelletizer housing houses the feed mix as well as the two rollers attached to a shaft.

vii. The rollers rest on the shaft

viii. The pelletizer housing incorporates a clamping device on the roller shaft at both ends to ensure steady contact as the shaft and the roller for the required friction devices between the disc and the rollers in the process, pellets are forced out down through the auger and collected as appropriate.

3.2 Description of Component Of The Machine

3.2.1 Hopper Design

The hopper is designed in form of a truncated pyramid with an inclination angle of

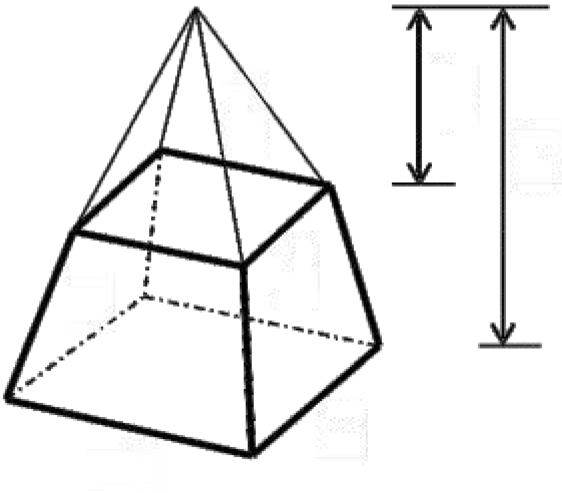

Fig. 1: Hopper

The volume of frustum = volume of the big pyramid – volume of the small pyramid

$Volume = 1/3(ABH - abh)$ [1]

From figure 5 below, the upper and the lower face of the hopper are given by;

A = 340mm, B = 250mm, a = 180mm, b = 160mm, H= 500 mm and h = 100mm

$Volume\ (V) = 1/3(ABH - abh) = 13{,}206{,}666.67mm^3 = 0.0132m^3$

3.2.2 Shaft Design

The shaft can be either solid or hollow shaft materials used in various kinds of operations. The design of the shaft is essential to determine the minimum diameter which will ensure a satisfactory strength and rigidity when the shaft is in use.

3.2.2.1 Twisting Moment

To determine the diameter of the shaft undergoing twisting moment, the equation applicable is the torsion equation;

$\frac{T}{J} = \frac{\tau}{r}$ |[2]

Where T = twisting moment

J = polar moment of inertia of the shaft

τ = tensional shear street

R = distance from neutral axis to the outer most fibre; r = d/2

For solid shaft;

$J = \frac{\pi d^4}{32} = 3.835 \times 10^{-10} mm^4$

τ = the lowest yield strength = $200N/mm^2$ and choosing factor of safety of 0.27

$\tau = 200N/mm^2 \times 0.27 = 54N/mm^2$

Therefore,

Twisting moment is given by $T = \frac{\pi\tau d^3}{16}$ for the solid shaft (Khurmi & Gupta, 2006)

$T = 0.0001657N/mm^2$

3.2.3.1 Shaft Subject To Bending Moment

The bending moment is given by; $\frac{M}{I} = \frac{\sigma_b}{y}$ solid shaft (Khurmi & Gupta, 2006)

For solid shaft;

$I = \frac{\pi d^4}{64}$ [3]

$I = \frac{\pi d^4}{64} = 0.01917 \times 10^{-6} mm^4$ and $y = \frac{d}{2} = 0.0125mm$

$M = \frac{\sigma_b \times I}{y}$

Where $\sigma_b = 400MPa = 400N/mm^2$

$M = \frac{\sigma_b \times I}{y} = 0.0006134N/mm^2$

3.2.3.2 Tension in the Belt

Shaft subjected to combine twisting moment and bending moment maximum shear stress theory (Guests Theory) usually applicable to ductile materials

$\tau_{max} = \frac{\sqrt{(\sigma_b + 4\tau)^2}}{2}$ [4]

Where $\sigma_b = 400N/mm^2$ and $\tau = 54N/mm^2$

$\tau_{max} = 254N/mm^2$

3.2.4 Design of the Belt Drive

3.2.4.1 Velocity of the Motor on the Pulley

$V = \frac{\pi D_2 N_2}{60}$ [5]

Where; $D_2 = diameter\ of\ the\ driving\ pulley = 120mm = 0.12m, N_2 = speed\ of\ the\ driving\ (motor) = 1450rev/\min\ and\ V = velocity\ (m/s)$

$V = \frac{\pi D_2 N_2}{60} = 9.112m/s$

The type of shaft selected for the pelletizer is a solid conveyor shaft

3.2.4.2 Speed and Diameter of the Pulley

The speed of driving pulley versus speed of driven pulley can be expressed by Khurmi and Gupta (2006) as;

$N_1 D_1 = N_2 D_2$ [6]

$D_1 = \frac{N_2 D_2}{N_1}$ [7]

Note; speed ratio $N_2/N_1 = 5/2$

Where; $N_1 = speed\ of\ the\ driven\ pulley, N_2 = speed\ of\ the\ driving\ pulley, D_1 = diameter\ of\ the\ driven\ pulley, and\ D_2 = diameter\ of\ the\ driving\ pulley$

$D_1 = \frac{N_2 D_2}{N_1} = 0.3m = 300mm$

$N_1 = \frac{N_2 D_2}{D_1} = 580 rev/min$

3.2.4.3 Torque Transmit on the Motor

$T_S = \frac{60 \times P}{2\pi N_2}$ [8]

$T_S = Torque\ of\ the\ motor$

$P = Power\ of\ the\ motor = 5 \times 750w = 3750W = 3.75kw$

$N_2 = speed\ on\ the\ motor = 1450\ rev/min$

$T_S = \frac{60 \times P}{2\pi N_2} = 24.7Nm$

The type of electric motor selected for the pelletizer is a single phase (1.5hp, 1440rpm & 220V)

3.2.4.4 Tension in the Belt

Tension T_1 acting on the tight side of the belt and the tension T_2 acting on the slack side of the belt. The values of T_1 and T_2 are calculated using the Eq. (9);

$T_S = (T_1 - T_2)\frac{D_2}{2}$ [9]

Where; $T_2 = Tension\ in\ the\ slack\ side\ of\ the\ belt, D_2 = Diameter\ of\ the\ driving\ pulley = 120mm = 0.12m$, and T_s = torque produce on the motor

$24.52 = (T_1 - T_2)\frac{0.12}{2}$

$(T_1 - T_2) = 409Nmm$

$T_1 = 409 + T_2$

Note that; $\frac{T_1}{T_2} = 3\ (Assume\ belt\ tension = 3)$

$T_1 = 3T_2 = 409 + T_2$

Then; $3T_2 - T_2 = 409$

$2T_2 = 409$

$T_2 = 205N$

And tension on the tight side is $T_1 = 409 + 205 = 614N$

3.2.4.5 Torque Produced By The Machine

Also, the torque transmitted by the machine can be determined by;

$T_T = (T_1 - T_2)\frac{D_1}{2}$ [10]

Where; $T_1 = Tension\ in\ the\ slack\ side\ of\ the\ belt =$

$D_1 = Diameter\ of\ the\ driven\ pulley = 300mm = 0.3m$

$T_T = (T_1 - T_2)\frac{D_1}{2} = 61.4Nm$

2.2.4.4.5 Power Transmitted by the Machine

Maximum power transmitted by the machine;

P = $(T_1 - T_2)v$ [11]

Where; $T_2 = Tension\ in\ the\ slack\ side\ of\ the\ belt = 205Nm,$

$T_1 = Tension\ in\ the\ slack\ side\ of\ the\ belt = 614Nm\ and\ V = Motor\ Velocity = 9.112m/s$

P = $(T_1 - T_2)v = 3.73KW$

3.2.4.6 Efficiency of Belt Drive

The efficiency of belt drive is given as;

$Efficiency\ (\varphi) = \frac{Output\ Power}{Input\ Power} \times 100$ [12]

Power Output = Maximum power transmitted by the machine = 3.73KW

Power Input = Power transmitted by the electric motor = 3.75KW

$Efficiency\ (\varphi) = 99\%$

3.2.4.7 Power Loss due to Friction

$Power\ Loss = Input\ Power - Output\ Power$ [13]

$Power\ Loss = 3.75 - 3.73 = 0.02$

3.2.4.8 Centre Distance Between the Machine Pulleys

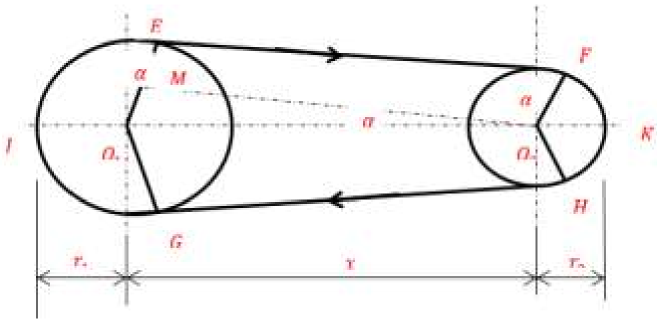

Fig. 2: Determination of centre distance between a pulley of a V belt. Source: (Khurmi & Gupta, 200).

The centre distance between the machine pulleys can be determined using;

$$X = \frac{1}{2}(D_1 - D_2) + D_1 \qquad [14]$$

Where; D_1 = Diameter of the driven pulley (motor pulley) = 0.3m, D_2 = Diameter of the driving pulley = 0.12m and X = distance between the centre of the two pulleys (m)

$$X = \frac{1}{2}(D_1 - D_2) + D_1 = 0.39m = 390mm$$

3.2.4.9 Belt Length

$$L = \frac{\pi}{2}(D_1 + D_2) + 2X + \frac{(D_1+D_2)^2}{4X} \qquad [15]$$

(Khurmi & Gupta, 2014)

Where; L = Length of the belt, $D_1 = Diameter\ of\ the\ driven\ pulley = 0.3m, D_2 = Diameter\ of\ the\ driving\ pulley = 0.12m, X = distance\ between\ the\ centre\ of\ the\ two\ pulleys = 0.39m\ and\ L = Belt\ length$

$$L = \frac{\pi}{2}(D_1 + D_2) + 2X + \frac{(D_1-D_2)^2}{4X} = 1.46m = 1460mm$$

3.2.5.0 The angle of Contact or Lap

When the two pulleys of different diameter are connected by means of an open belt, then the angle of contact or lap is given by;

$$sin\alpha = \frac{D_1 - D_2}{2X} \qquad [16]$$

$$sin\alpha = 0.23$$

$$\alpha = sin^{-1}(0.23) = 13.3^0$$

The angle of contact or lap can be determined by;

$$\theta = 180^0 - 2\alpha$$

$$\theta = 180^0 - 2 \times 13.3^0 = 153.4^0$$

The type of belt used is a V belt of length 1460mm

3.3 Die Construction

Die is connected to the extruder to sustain the high pressure generated from the material conveyed by the feed screw. The die was made using a mild steel plate of 5mm thickness of 88mm diameter which is removable. Forty (40) holes were drilled around the plate surfaces to allow the resin pellets to pass through at a diameter for each hole per die to be 2,4,6,8, and 10mm for the first, second, third, fourth, and fifth die respectively.

3.4 Materials and Specification

Table 1: Material specification of a fish feed pelletizing machine

Materials	Specification	Quantity
Shaft	...	1
Mild steel sheet	1200X5400X1.2mm	1
Angle iron	35X25X854	2
Ball Bearing	Φ 30	2
Small machine pulley	Φ 120	1
Big machine pulley	Φ 300	1
Cylindrical pipe	Φ 900 X 210 X 6.00mm	1
Bolt and Nut	17, 12, 10	4 each
V-Belt	A40	1
Electrode	Gauge 12	2 dozens
Electric motor	1.5 horsepower	1
Purchase of Fabrication Materials	cutting, welding, grinding, painting & assembly	-

3.4 Pelletizing Machine Fabrication

The machine was fabricated based on the design specification. The construction was carried out with locally sourced materials to reduce the cost of production to meet the design objective. Each of the components was designed and fabricated following the due fabrication process as

shown in Fig. 3. This entails marking and cutting out the required shape and dimension, welding of the parts to form the components, and surface finishing improving on the aesthetics. The fabricated components were:

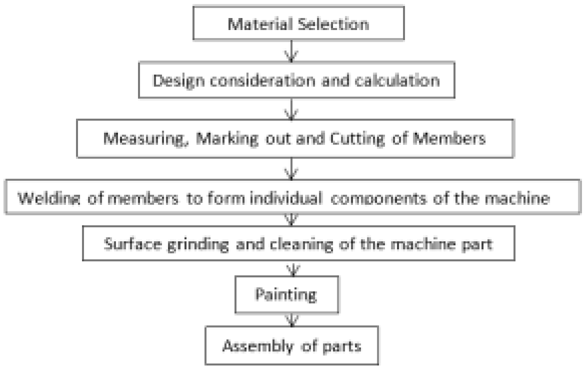

Fig. 3: Flowchart of fabrication processes

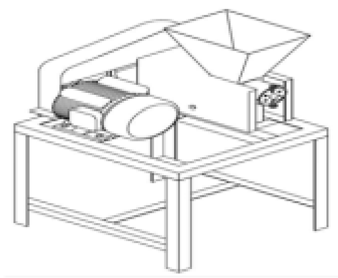

Fig. 4: Isometric View of the Fish Feed Pelletizing Machine

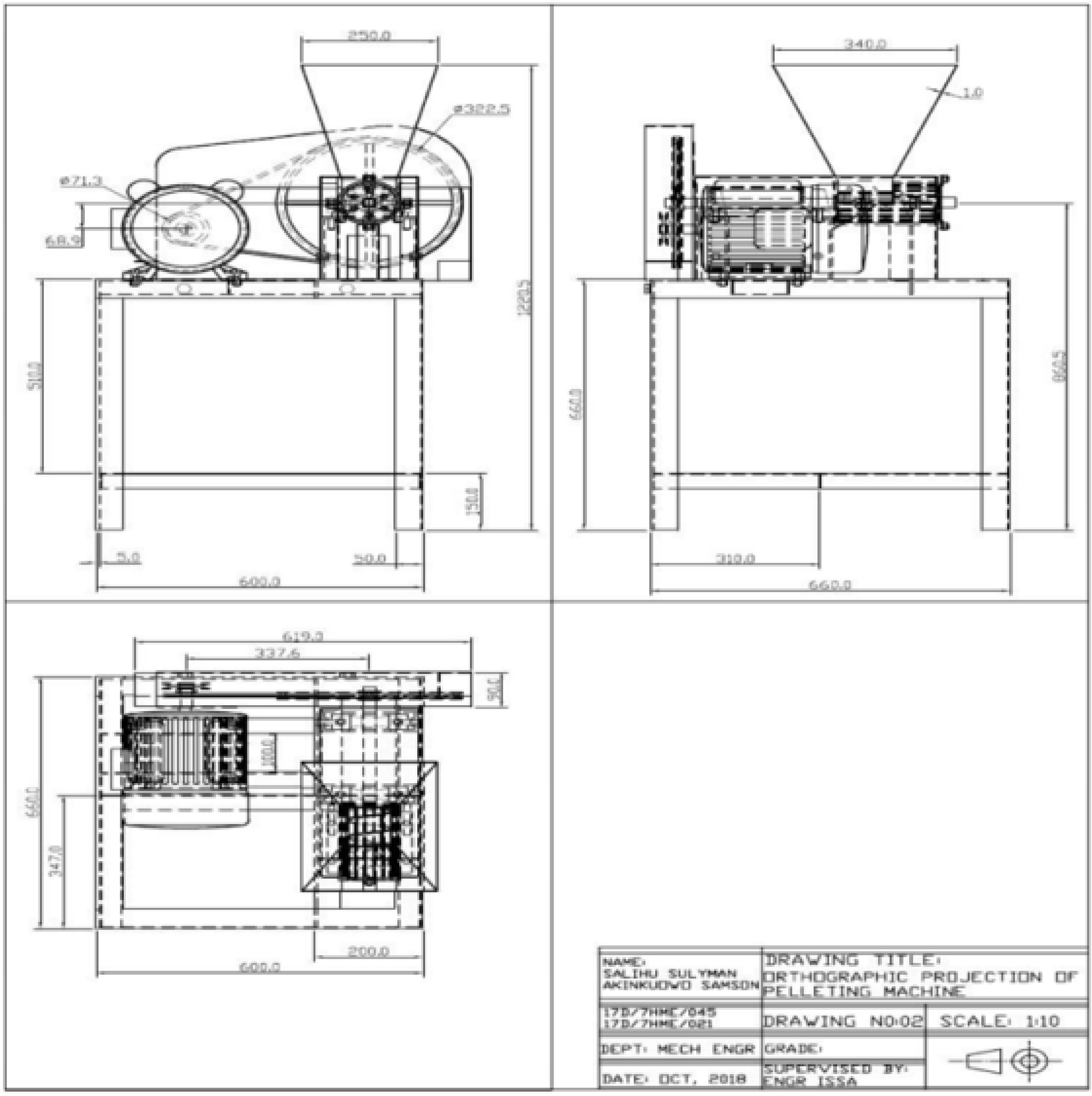

Fig. 5: Orthographic View of the Fish Feed Pelletizing Machine

4. RESULTS

After fabricating the machine, testing was done using average quantities of 3.0kg of fish feed introduced into the machine. The material composition of the ingredient and the result obtained from the performance evaluation are shown in table 2 and table 3 below.

Table 2: Material composition of the ingredient used in making the fish feed

Ingredients	Weight (g)	Percentage composition (%)
Soya bean	480	16.0
Groundnut cake	720	24.0
Fish meal	600	20.0
Maize	480	16.0
Palm oil	240	8.0
Cassava	360	12.0
Bone meal	12	0.4
Common salt	12	0.4
Vitamin pressure	24	0.8
Lysine	60	2.0
Methionine	12	0.4

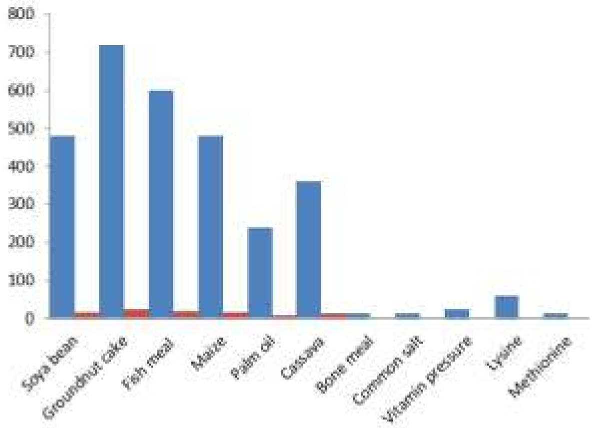

Fig. 4: Weight against the material composition of the ingredient

The following results were obtained after the test was carried out;

Table 3: Performance evaluation of the pelletizer

[illegible]	[illegible]	[illegible]Feed Time (s
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

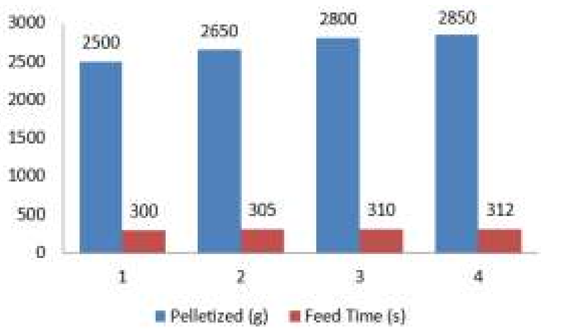

Fig. 5: Weight of the pellet against the Pellet feed time

4.1 Performance Test

The parameter used in evaluating and computing the efficiency of the machine throughout involves the following methods;

- Pelletizing efficiency (n_P): is the ratio of the quantity of the feed pelletized to the ratio of the total quantity of the feed metal formula introduced into the machine
- Cutting efficiency (n_C): is the ratio of the quantity of the pellet cut with equal length to the total quantity of pellet produced
- Pelletizing capacity or rate (P): is the quantity pelletized in kilogram per hour

The pelletizing efficiency of the machine can be determined by;

$$Pelletizing\ efficiency\ (n_P) = \frac{X_P}{Q_i} \times 100\% \quad [17]$$

Where; n_P=Pelletizing efficiency (%), X_P= Average quantity pelletized = 2700g and Q_i = Average quantity introduced to machine = 3000g

$$Pelletizing\ efficiency\ (n_P) = \frac{2700}{3000} \times 100\% = 0.9 \times 100\% = 90\%$$

The pelletizing capacity or rate can be determined using;

$$P = \frac{X_P}{T} \quad [18]$$

Where; P = Pelletizing capacity or rate = ? , X_P=Average quantity of pelletizing=2700g=2.7kg and T= Average time taken = 307 sec = 0.09 hr

Therefore, the pelletizing capacity or rate is;

$$P = \frac{2.7}{0.09} = 30kg/h$$

5.0 DISCUSSION

After fabrication, a performance test was done by mixing various ingredients such as soya bean, groundnut cake, fish meal, maize, palm oil, cassava, bone meal, common salt, vitamin pressure, and lysine into paste form using methionine which served as the binding agent as shown in table 2 above. The materials are then, feed into the hopper, and the machine is set to gyration to allow the materials to pass through the screw conveyor shaft to be cut to the desired size before passing through the die.

The feed was gradually increased until the machine was fully loaded and 500g of water was added to the feed mix to allow free flow of the material in the machine and avoid watery compaction. The pellet was collected at the joint of the die and allowed to dry. The process was timid from the introduction of the feed formula to the time it took to pass through the machine. The output was observed by visual inspection, the pellets feed, broken pellets and those remaining in the machine were sorted and weighed.

It was discovered that the pelletized feed may break before getting to the desire sizes as the materials become sticky due to an inconsistent mixture of the ingredients

The results obtained after the test were carried out on 3000g of the feed mixed as shown in Table 3 and Figure 5 above; the result showed that as the rate of the moisture removal from the feed materials increased the time taken for the moisture to be removed also increased.

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This project focused on the development of a fish feed pelletize for peasant farmers. The machine was designed effectively and adequate material selection criteria were employed during fabrication. Consideration was made while selecting materials for fabrication such that the deficiencies associated with the existing fish feed pelletizer in times of the size of the hopper, pellet plate, shaft diameter, diameter of pellet holes, and choice of electric motor that affects the overall performance are reduced.

The main components of the developed pelletizer are the hopper, pulley, supporting frame, screw conveyor shaft, bearing housing and electric motor driven by 1.5 horsepower fully designs after putting the necessary factors into consideration.

The fish feed pelletizing machine is fabricated to assist the farmer and investor in getting returns on their investment on time, boost the economy, enhanced their productivity, help the industrial sector to create employment, improve their standard of living, and to lead to the national development in Nigeria. The fish feed machine is affordable and can produce a large quantity of pellet for fish on time with less drudgery. The parts are designed using engineering principles; the electric motor as the source of power; pulleys, and belts as a means of transferring power; fabrication of the hopper using 4mm metal sheet; fabrication of shaft, drilling of round metal sheet to form the die (screen), assembling of the fabricated parts into complete machine, painting of the machine and testing the performance of the machine.

The pelletizer was tested using 3kg fish feed and found to perform efficiently well and its mass production will assist the fish farmers to meet their production target and boosting the food production capacity. The performance test was carried out to determine the pelletizing efficiency and pelletizing capacity which gave a value of 90% 30kg/hr respectively.

The developed fish feed pelletizer is easy to operate, maintain, cheap, portable, and environmentally friendly.

Therefore the machine is suitable for small and medium-scale fish and poultry farming and can be used for pelletizing different materials provided the ingredient meets the required moisture content.

6.2 Recommendations

i. Modification is required on the fabrication processes to suit conditional and environmental changes during the application

ii. The pelletizer should be maintained regularly by lubricating all the moving parts and replace the worn-out part to improve its efficiency, capacity, and life span

iii. The pelletizer must be operated such that the safe working load is not exceeded

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