Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
ISSN NO. 2320-5407
Article DOI: 10.21474/IJAR01/xxx
DOI URL: http://dx.doi.org/10.21474/IJAR01/9970

***RESEARCH ARTICLE***

# DESIGN ANALYSIS OF DUALLY OPERATED FISH FEED PELLETIZER.

**Fasoyin, S.A., Akinfiresoye, W.A., Ale M.O. and AbisuwaT. A.**
Department of Agricultural and Bio-Environmental Engineering Technology, Rufus Giwa Polytechnic. Akure. Nigeria.

***Manuscript Info***

***Manuscript History***
Received: 05 September 2019
Final Accepted: 07 October 2019
Published: November 2019

***Key words:-***
Gamba grass, accessions, yield, crude protein, mineral contents, Benin.

***Abstract***

Pelletisation of fish feed is necessary for growth rate measurement of the fish and wastages of the feed. The modern pelletizer is expensive and not portable, hence only large scale fish farmers who can afford it are using them, whereas, the small and medium fish farmers do not have the financial capacity to afford the machine. Hence the development of a portable, manually and mechanically operated pelletizer for the small and medium scale farmer. The machine was developed using available local materials. It has the hopper, the screw auger shaft, the barrel, the frame and the electric motor or drive lever as major components. The machine was developed and tested with 3 kg of fish feed mill using 2.2 kW electric motor of speed 2,900 rev/min. The feed was mixed with 200 $cm^3$ water to slurry form to aid the extrusion and weighed to 3 kg before fed into the extrusion chamber of the machine. The screw auger kneaded the feed thoroughly and conveyed it to the discharge unit where it was forced through 8-holes die to form pellets. The efficiency of the machine was calculated to be 88.3% while the throughput was 30 kg/h. The machine is affordable at the cost of NGN 70, 000 and easy to maintain and operated.



## Introduction:-

Formulated fish feed cost forms the major expenses in fish farming and therefore must be managed efficiently to avoid wastage and for effective quality control (Orisaleye. *et al* 2009). According to Abubakre *et al.*, (2014), fish farming is growing in Nigeria today without sufficient equipment to meet up with this growth. One of the major equipment used in fish farming is a pelletizer. This machine cut livestock feed into specific uniformed sizes for easy swallow and optimization of the feed rations. Deb and Ahmed (2013) defined pellets as agglomerates produced from diverse raw materials using different pieces of manufacturing equipment. These agglomerates include fertilizers, animal feeds, iron ores and pharmaceutical dosage unit and do not only differ in composition, but also in sizes and shapes. Pelleting is one of the techniques used in processing livestock feeds, others include grinding, rolling, steam flaking, roasting, chopping, cracking or crimping and popping (Orisalaye *et al.* 2009). Pelletisation of feed also improved the nutritional value of the feed, facilitate efficient storage and easy transportation (Kabuage *et al.* 2000). For many years, pelleting was considered as luxury exclusively reserved for commercial feeds or the most discriminating of production of livestock feed producers (Adam, 2012). For this reason, small and medium scale fish farmers do not have access to this machine. Their feeding methods was using bare hands to measure the quantity of the feed which leads to its wastages, improper feeding mechanism and loss of profit. This is what led to the conception of a mini fish feed pelletizer that is affordable, portable, easy to operate, maintained, and can be

**Corresponding Author:-S.A. Fasoyin.**
Address**:-**Department of Agricultural and Bio-Environmental Engineering Technology, Rufus Giwa Polytechnic. Akure. Nigeria..

manually and mechanically operated. The manual operation was added because of the epileptic nature of electricity in Nigeria. Farmers can now operate the machine where there is no other source of power for its operation.

## Materials and Methods:-

The pelletizer were designed, fabricated and tested as explained below.

**Design Consideration**

The factors considered in the selection of materials for the design of the pelletizer included availability of the fabrication materials sourced locally, its durability, toughness, strength, cost and machinability, especially the shaft.

**Machine Conception and Description**

The pelletizer has the hopper to act as the feeding point of the feed directly into the extrusion chamber. This chamber has the shaft with screw auger which knead the material against the walls of the barrel and conveyed same to the discharge unit. The discharge unit has a die with 8 holes at its end where the extrudate come out in a thin threaded-like shape. The machine can be powered manually through a driver or mechanically through belt and pulley drive attached to the shaft and an electric motor. Figures 1, 2 and 3 shows the orthographic, isometric and exploded view of the pelletizer respectively.

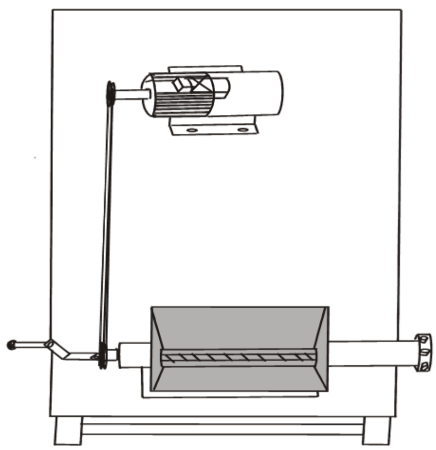

**Fig 1:-**Orthographic view fish feed pelletizer

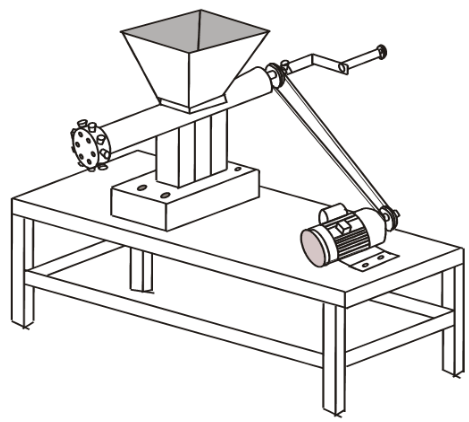

**Fig 2:-**Isometric view of fish feed pelletizer

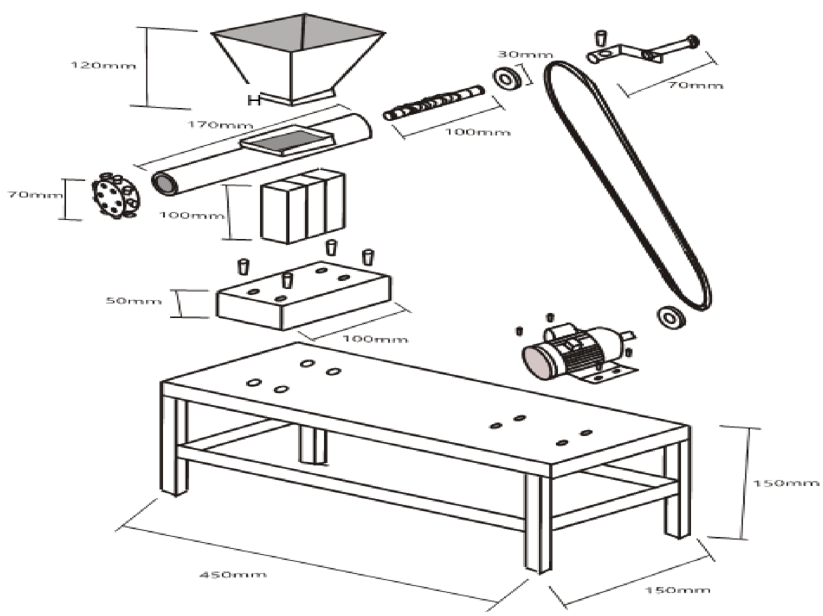


**Fig 3:-**Exploded view of fish feed pelletizer

**Design Analysis**

The pelletizer's major parts were designed as follows:

**The Hopper**:

Galvanized mild steel sheet of 2 mm thickness was selected because of its strength in the design of the hopper. The shape was trapezoidal with its angle of inclination, α, and volume V calculated from the relationships in eqn. (1) and (2) respectively according to Olutayo (2014). μ is the coefficient of friction of granular material, a is the length of the upper part of the hopper, b is the lower part and H is the height.

$\alpha = \tan^{-1} \mu$ eqn. (1)

$V = \frac{1}{3}\, a^2\, H - \frac{1}{3}\, b^2\, H$ eqn. (2)

**The Shaft**:

This was made of a 25 mm diameter of 40C8 alloy cast iron according to IS 1570 of 200 mm length. The diameter was calculated from the relationship in eqn. (3) according to Allen *et al.*, (2009)

$d^3 = \frac{16}{\pi \sigma_s}\left(\sqrt{(K_b M_b)^2 + (K_t M_t)^2}\right)$ eqn. (3)

where d is the diameter in mm, π is constant, $\sigma_s$ is the allowable shear stress of metal with key way, $M_b$ is the maximum bending moment, $M_t$ is the torsion moment, $K_b$ is the combined shock and fatigue factor applied to bending moment and $K_t$ is the combined shock and fatigue factor applied to torsional moment.

b.i). The Torsional moment or torque, *T,* on the shaft was considered and calculated from the relationship in eqn. (4) according to Khurmi and Gupta (2005).

$T = \frac{P \times 60}{2 \times \pi \times N}$ eqn. (4)

Where *P* is the power transmitted by the shaft (kW) and *N* is the machine speed (rpm).

b.ii). The maximum stress due to torsion, $\tau_{max}$, on the shaft was calculated in eqn. (5) according to Khumi and Gumpta (2005).

$\tau_{max} = \frac{2TJ}{d}$ eqn. (5)

Where *J* is the polar moment of inertia of the cross section area about the axis of rotation (N/m$^2$) and d is the diameter of the shaft (mm).

b.iii) The Angle of Twist, $\theta$, of the shaft was also considered and calculated from the relationship of eqn. (6) according to Allen (2009).

$\theta = \frac{T \times L}{G \times d^4}$ eqn. (6)

Where T is the Torque, L is the length of the shaft, G is constant and d is the diameter of the shaft.

**The Screw Auger**:

The screw auger of thickness 5mm was made from cast iron alloy and was designed as worm conveyor of 28 mm outer diameter wound around the shaft to give clearance between the screw and barrel of internal diameter of 30 mm. The screw shaft is driven by the pulley connected to an electric motor of 2.2 kW and can also be manually driven through hand driver. The screw auger was designed with parameters of relevant tables according to Singh (2003). The nominal screw diameter, D, is 40 mm, the screw pitch, *s*, is 40 mm and covers a length, L, of 100 mm of the shaft. The maximum speed of the screw, *n,* is 120 rev/min, the solid shaft diameter, *d,* is 25 mm, the loading efficiency, ψ, is 0.25, the frictional factor, μ, of the granulated material is 0.6, the feed factor $F_f$ is 4, the inclination factor, $I_f$, is 1 for horizontal conveyors and the angle of inclination of the screw to the horizontal is *β,* which is $0^0$, the maximum density of the feed, *ρ,* is 200 kg/m$^3$. The capacity of the screw conveyor, which include the loading speed,*v*,in m/s, the feed loading per meter length of the screw, *q,* in N/m, and the axial thrust, $F_a$ were calculated using the relationship in eqn. (7), (8) and (9) according to Singh (2003).

$v = \frac{s\, n}{60}$ eqn. (7)

$q = \frac{Q}{3.6\ x\ v}$ eqn. (8)

$F_a = q \times L \times \mu$ eqn. (9)

The power required to drive the screw auger, $P$, and the screw auger capacity, $Q$, were determined by eqn. (10) and (11) respectively according to Singh (2003)

$$P = \frac{QL\left(F_f + Sin\,\beta\right)}{3600}\ kW \qquad \text{eqn. (10)}$$

$$Q = 150 \times \pi \times D^2 \times s \times n \times \varphi \times \rho \times F_f \qquad \text{eqn. (11)}$$

**The Barrel**
The barrel covered the screw shaft and was made of hollowed metal steel of thickness 5 mm with internal and external diameter of 30 and 35 mm respectively. The barrel has a flange at the discharge unit to support the die plate.

**Die Plate**
The die was a cylindrical shaped plate of 60 mm diameter made from 40C8 alloy cast iron because of its strength and machinability. It has 16 holes of 6 mm diameter drilled to restrict the flow of the feed and forced it into cylindrical shape as it passes through the holes to form pellets.

**The Frame**
This is the support for the machine. It is made from angular mild steel iron of thickness 50 mm. It was designed to withstand vibration from the machine and the motor.

**The Prime Mover**
The machine was powered by a 2.2Kw electric motor with speed 2900 r/min

**The Cost**
The total cost of developing the machine was Seventy Thousand Naira only (₦ 70,000:00) as shown in Table 2.0.

**Table 2.0:-**Cost of developing fish feed pelletizer

| **S/N** | **MATERIAL** | **PRICE (NGN)** |
|---|---|---|
| 1 | Mild Steel of thickness 2 mm | 5,000:00 |
| 2 | Hollowed pipe of 35 mm thickness of 200 mm length | 4,000:00 |
| 3 | Cast Iron of 35 mm diameter | 4,000:00 |
| 4 | Bought out components | 45,000:00 |
| 5 | Workmanship/Miscellaneous | 12,000:00 |
| | **TOTAL** | **70,000.00** |

**Machine Testing**
The following procedure were followed to test the fabricated pelletizer:

1. Formulation of feed from maize, groundnut cake, cotton seed, wheat meal soya beans cake and palm kernel cake.
2. Feed was formed into slurry by mixing with 200 $cm^3$ of water and weighed, $W_1$ to 3 kg
3. Slurry feed was fed into the pelletizer powered by 2.2 Kw electric motor with speed 2900 r/min
4. Screw conveyor knead slurry together and extrude the pellets through the die
5. Pellets were collected into a tray and weighed, $W_2$ before drying as 2.65 kg

According to Olutayo (2014), the pellet efficiency, $P_e$, mechanical loss/damage, $M_l$ and throughput capacity, $T_p$ were calculated from equations (12), (13) and (14) respectively.

$$P_e = \frac{W_2}{W_1} \times 100 \qquad \text{eqn. (12)}$$

Where $W_2$ is 2.65 kg, $W_1$ is 3.0 kg

$P_e = 88.3\%$

$$M_l = \frac{W_r}{W_1} \times 100 \qquad \text{eqn. (13)}$$

Where $W_r$ is (3.0 – 2.65) kg = 0.35 kg

$M_l = 11.6$ %

$T_p = \frac{W_1}{t}$

Where, $W_1$ is 3 kg and $t$ is the time taken to pelletize the feed, which is 6 minutes, that is, 0.1 h

Therefore, $T_p$ is 30 kg/h

## Conclusion:-

Dually operated fish feed pelletizer was designed and developed for small scale fish farmers. It was tested and found to suit its purpose. The machine can be replicated locally in developing countries so bridge the gap between medium and small scale fish farmers.

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