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DESIGN AND FABRICATION OF MODEL FEED PELLETIZER

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ABSTRACT: This research is on the design, fabrication and testing of motorized mechanical feed pelletizer to meet the basic needs of researchers and commercial animal farmers at affordable cost. This research is aimed at providing local technology and skills, making available the machine in the local markets and consequently reducing or eliminating the prohibitive cost of importation. Feed manufacture involves grinding, mixing, extruding ingredients into homogeneous pellets that are water stable, and consequently drying the feed to the required moisture level. The fabrication finds its application in the mixing and pelletizing of domestic animals feeds and aquatic (fish) dietary that require the above processes. In the design and fabrication of this device, focus was directed to obtain a prototype (model) that would function at relatively low energy expenditure. The fabrication involved machining and welding among other processes. Almost all the materials used were sourced locally. The machine was tested and its efficiency increased with increase in die size. The throughput efficiency and feed rate for 7mm diameter die were found to be 97.8% and 0.0407 respectively, whereas 95% and 0.0267 were found to be for the 5mm diameter die.

INTRODUCTION

For the past two decades, there has been an outcry about the inadequacies in fish farming equipment for experimental and commercial fish feeds in Nigeria. This made research very difficult resulting to sharp decline in the quality and capacities of the graduates of fisheries. It also affected the quality and quantity of fish feed available for our local fish industries. The high cost of available equipment which are mostly imported has drastically reduced the productivity of fish. Feed manufacture involves grinding, mixing, forming feed ingredients into homogeneous pellets that are water stable and drying the pelletized feed.

Materials and Methods

The following materials, tools, equipment were used during the fabrication. Stainless steel pipe diameter 100mm by 760mm length by 7mm thick, diameter 12mm stainless steel rod, Aluminum alloy scrap for casting the pulleys, power transmission belts, 5HP electric motor, 2 inch by 2 inch angle iron, 1030mm by 30mm diameter shaft bolts and nuts. Equipment used were: lathe, drilling, grinding and spraying machines.

3.0 Design Analysis

3.1 Determination of Volume of Barrel (Extrusion Chamber): The volume of the extrusion barrel could be computed using the relationship given as $v = \pi r^2 \mathrm{h}$, since the barrel is cylindrical volume:-

V = volume of extrusion barrel, r = radius of barrel,and h= length of barrel

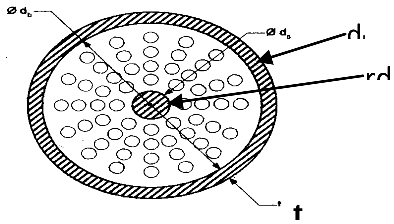

Figure 1. Cross-sectional area of barrel and shaft assembly

3.3 Determination of operating pressure in the extrusion barrel: The pressure in the extrusion barrel is computed using $P = I/_Z$, Where: P = Operating pressure, I = Power,Z = Volume operation (capacity),Power (P) = 0.7353 x c x 2 x Q (Kubota, 1995), Where:P = power,L = length of barrel,Q = capacity,C = constant = 1 for horizontal auger

P = 0.7355 x c x L x Q (3)

3.4 Determination of Thrust Force (W): The thrust force (w) moving the material inside the extrusion barrel could be computed using the expression W = PA……………4Where:- P = pressure in the barrel,A = area of extruder = $\pi \frac{(D^2 - d^2)}{4}$,and W = thrust force

3.5 Determination of tangential force: The force which lift the feed material as it moves inside an extrusion barrel is tangential and is computed using,F = WtanΘ (5)

Where:- F = tangential force,W = thrust force,Θ = helix angle,And tanΘ = $\frac{head}{\pi\ x\ pit\ diameter}$

3.7 Determination of Extrusion Pressure: For a constant feed rate speed of extrusion, feed composition and material density, extrusion pressure then only varies with die size, in this work, two dies are designed to extrude pellets. The dies are:

(a) A 5mm diameter die with 84 holes (b)A 3mm diameter die with 96 holes.

The pressure of extrusion in respect of the dies are computed using the relationship $P = \frac{W}{A}$ (6) Where P = Extrusion pressure W = thrust force ,A = total area of extrusion holes ,and

$A = \frac{N\pi D^2}{4}$ Where :- N = number of holes on die, and D = diameter of hole

3.8 Determination of Material Hold up (H) in The Extrusion Barrel :This may be computed using the relationship expressed by Van Zuilichien et at (1989):

H = ΔV_{Tot} (7),

Where:-H = material hold up m^3 ,D = degree of fill obtained as 46%` (Mu'azu, 2008).

V = reaction volume of the extruder = vol of barrel – vol of screw.

DESIGN CALCULATIONS

Calculation of Axial force needed for extruding

Considering equation 3.1, the axial force is calculated thus, where,

d_b = 0.1 m, d_s = 0.03 m, P = 9.2 MPa, L = 0.76 m , $F = \frac{\pi}{4}(d_b - d_s)\left(\frac{P}{2} + L\right)$ = 30450 N

4.2 Calculation of Screw conveyor's Toque: From equation 3.5, the torque to mix, convey and extrude is calculated as, where *p = 0.04m,*

c = 1.05 $T = \frac{Fp}{2\pi} c$, = 238.468 Nm

4.3 Calculation of Power to extrude:From equation 3.5, the power to extrude is calculated thus , $P = 2T\pi \frac{N}{60}$, $P = 2 \times 238.468\pi \times \frac{120}{60}$ = 29964 W = $\frac{29967}{760}$ = 4.017 HP.Based on the above result, a standard electric motor size of 5HP with a speed of 1440 rpm is selected to power the screw conveyor.

Calculation of thickness of barrel :The thickness of the barrel is given by the equation 7 where

P =*9.2 MPa*, d_b = 0.1 m, σ = 340Mpa, n = 5., $t = \frac{nPd_b}{2\sigma}$ $t = \frac{5 \times 9.2 \times 10^6 \times 0.1}{2 \times 340 \times 10^6}$ =0.007 m Therefore, the thickness of the barrel is taken as 7m

4.8 Determination of diameter of shafts.

a. Screw conveyor shaft: Considering equation 4, the pre-determined diameter of 0.03m is substituted to check on the maximum shear stress obtained, where

$M = BM_{CR}$ = 211.233 Nm, T = 238.468 Nm, F = 34050 N, $\tau_{\max} = \left(\frac{2}{\pi d^3}\right).\left[(8M + Fd)^2 + (8T)^2\right]^{1/2}$ (Shigley & Mischke,1989).

$$\tau_{\max} = \left(\frac{2}{\pi \times 0.03^3}\right).\left[(8 \times 211.233 + 34050 \times 0.03)^2 + (8 \times 238.468)^2\right]^{1/2} = 44992340.477 \text{ Pa}$$

The chosen diameter (0.03) of shaft is acceptable because the resulting shear stress is below that of allowable stress of 60 x 10^6N/m^2

4.9 Determination of material hold-up (h) in the extrusion barrel.: This is extrusion using the relationship expressed by van zuilichem et al (1989):

H = DV_{Tot} from equation 7,Where: H = material hold up in ,D = degree of fill obtained as 46% (Mu'azu 2008), V_{Tot} = reaction volume of auger = vol of barrel – vol of auger

From 1 volume of barrel = 0.0596m^3 and volume of auger $\pi^2 l = \frac{\pi(D^2-d^2)l}{4}$ = 0.0425m^3

4.9 Determination of thickness of die plates :Where w = 8.672×10^6N/m^2, ν = 3, r = 0.05 m, the thickness of die is calculated from the formula:

t = 0.0164 m = $\frac{\pi(0.095^2-0.03^2)x0.760}{4} = 0.0485m^3$ H = ΔV_{Tot} = 0.46 x (0.0596 – 0.0485) = 4.25 x 10^{-2} = 0.0425m^3

4.9 Determination of thickness of die plates : Where w = 8.672×10^6N/m^2, ν = 3, r = 0.05 m, the thickness of die is calculated from the formula:

t = $\sqrt{\left[\frac{3wr^2(3+\nu)}{8\sigma_{\max}}\right]}$ t = 0.0164 m

RESULTS AND DISCUSION

The performance of the machine in pelleting feed formulation "G" using two cylindrical dies of sizes 5mm and 7mm diameter respectively shows that for 5mm die, the efficiency of the screw conveyor decreased by 0.03% compared with 7mm die whose efficiency (η) was found to be 98%. In other words, the bigger the dies, the higher the efficiency. This is in line with the findings of Sena and Trevor (1995) who stressed that in extrusion process die size and machine (η) efficiency are directly proportional to each other i.e. increase in one leads to increase in the other, likewise a decrease in one leads to a decrease in the other. With increase feed rate, more materials are compacted in the barrel, and this cause a drop in the extrusion pressure, hence rate

CONCLUSION

Feed drying is an important aspect for all small scale and commercial feed production in most developing countries and is a special problem in Nigeria. In this work, pelletizer of 4.82t/hr has been successfully designed, constructed and tested. This effort will boost local production of fish feeds. The higher production capacity results from mechanizing the various component of the machine. In the extrusion process, the screw conveyor efficiency was established to be a function of die size and material feed rate. The efficiency of the extruder increases with an increase in die size regardless of the feed formulation used. The possibility of die clogging is affected by material feed-rate and die size. Increase in feed rate and use of small size die raises the probability of die blockage and by implication causes a reduction in the efficiency of the extruder.

REFERENCES

[1]Oguntimein, Garba A. B (2009). Design and fabrication of fish feed pelleting Machine and Dryer Thesis submitted to the Department of Mechanical Engineering F,U,T Minna pp 1-79.

[2]Hasting, W.H and D. Higgs (1980): feed milling process in fish feed technology. ADCP/REP/80/H, UNDP/FAO, Rome Pp 293-313.

[3]Kubota L, Akira E.D and Assennato, L. (1995) Havesting and Drying in rice post harvest Technology. The Food Agency, Ministry of Agriculture forestry and Fisheries, Japan p 224.

[4]Khurmi R.S Gupta J.K(1989). A text book on machine design practice, Hall. Mumbai India. Pp104 – 685).

[5]Montgomery, D.C (1991): Design and analysis of experiments 3rd edition. John Wiley and sons, New York. Pp 278-86.

[6]Mu'azu .A (2008) Design and construction of Mixer-Pelleting machine for poultry feed, Department of Agricultural and Bio-resource Engineering Federal University of Technology Minna, Niger State. Pp11-25