



Design, Fabrication and Performance Evaluation of A Two Chains and Sprockets System Manual Fish Feed Pelletizer

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ABSTRACT

A 12.6kg/hr two chains and sprockets system (2CSS) fish feed pelletizer which produced 4mm, 6mm and 8mm diameter pellet was designed and fabricated. The pelletizer was driven manually with the aid of a winding handle connected to 2 chains and sprockets system. This study is to contribute to the existing fish meal pelletizers in Nigeria through the designing, fabrication and performance evaluation of a 2CSS. Feed was compounded and the performance evaluation of the machine was carried out using three (3) interchangeable die plates of 4mm, 6mm and 8mm diameter perforations. Results showed that the average mean pelletizing efficiency was 79%. Beneficiaries of this machine are the fish farmers as well as livestock farmers, research institutions, feed processing industries and small medium enterprise. It was recommended that farmers should avail themselves of this machine since it is cheap and easy to operate. It also does not need electricity or fuel to function. It can also be produced by entrepreneurs to make it locally available.

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INTRODUCTION

The increasing growth in population in Nigeria and the need for good health requires improved methods of increasing fish production to increase protein supply the people. Fish serves as a good source of protein which will help to maintain good health. To grow the fish in aquaculture requires proper care and feeding. In Nigeria, for good health to be achieved, it is necessary for aquaculture farmers to acquire improved methods that will help in increasing fish production output for the increasing populace.

Fish feeds are produced in the form of pellets. This is to aid easy consumption by fishes at different stages. Pelletizing is necessary after the various fish

feed materials are mixed in the right proportions. Atoyebi (2007) recommends that fish meal be made into pellets which contain ingredients that constitute a balanced diet for the fish. Such ingredients consist of soya beans (18-50% by weight), lipids which are fat (10-25% by weight), groundnuts and carbohydrates (15-20% by weight), and cereal, (mostly maize is used in Nigeria) 10% by weight. Feed pelleting has grown steadily so that about 80% of all feeds produced are currently in pellets. The benefits of pelleted feed include improved ease of handling, reduced ingredient segregation, less feed wastage and increased bulk density.

The need to produce more pellet feeds has prompted many researchers to



design and fabricate fish feed pelleting machines. Olusegun and Adekunle (2009) produced a screw-type fish meal pelletizer that required no usage of steam to gelatinize the ingredients. Heat generated by the screwing action of the machine together with the chemical binder added to the ingredients caused the binding of the ingredients. In order to produce different sizes of pellets, the machine had a die at the end of the screw chamber which was interchangeable. Ojomo Agbetoye and Ologunagba. (2010) also designed and fabricated a fish feed pelletizing machine which consists of a hopper, barrel, which houses the screw conveyer (auger), the cutting knife and the die orifice. It was observed that the pelletizing efficiency, through put capacity and the percentage recovery of the machine increased with increase in moisture content and the speed of the machine. The machine had a through put capacity of 19.7 kg/h with a pelletizing efficiency of 87.6%; moisture content constituted a greater portion of variability in efficiency than speed.

A revolving die and roller fish feed pellet machine was developed by Kaankuka and Osu (2013). The machine used an electric motor to drive the die connected to the shaft through the pulley. The machine due to the higher heat generated during the production process which resulted in gelatinization of the carbohydrates in the ingredients. Though the machine was tested at two speed levels of 507 and 761 rpm, higher pellet output was obtained from a die speed of 761 rpm.

Odesola, Kazeem and Ehumad (2016), designed and constructed a fish feed extruder with improved qualities to that of Kaankuka and Osu (2013). The machine was also said to be cheaper in cost as it used locally available materials in its production and could be very affordable by local small-scale farmers. The machine by

Odesola *et al's* (2016) showed significant improvement in the quality of the processed pellets.

In another study, Olusegun, Adekunle, Ohijeagbon, Akande and Mohammad (2017) developed a fish meal pellet processing machine that produced 4mm pellets at a throughput capacity of 113kg/hr. The machine used a 5hp motor which was connected to the speed reduction gear by pulleys with diameters of 6cm and 12cm respectively. The efficiency of the fish meal pelletizing machine was evaluated at 94.2%.

In further research to realize an efficient but low cost fish feed pelletizer, Tiough, Obahi and Afaor (2020) designed and fabricated a chain and sprocket system (CSS) fish feed pelletizer machine. The main purpose was to give fish farmers a machine that would not require use of electricity or gasoline. The machine was manually operated with a winding handle. The produced machine by Tiough *etal* (2020) was found to have a performance efficiency of 85% and a throughput capacity of 16.5kg/hr. The fish feed pelletizer produced pellets of 4mm, 6mm and 8mm diameters respectively, with three different die plates. The production of this machine aims at alleviating the suffering of small-scale fish farmers who incur losses through high cost of imported feeds for their fish.

Fish farming is now trending in Nigeria. However, the cost of fish feeds is high and so many small-scale fish farmers find it difficult to break even and make profit in their fish farming because of the high cost of the feeds. It is however observed by Kaankuka and Osu (2013) that when pellets are compressed the loss of nutrients through leaching is minimized. Unlike loose powdered feed. This prompted one of the researches by Tiough *etal* (2020) where they developed a chain and sprocket system fish pelletizer machine.



This study therefore seeks to improve on the chain and sprocket system machine by Tiough *etal* (2020) by incorporating another chain into the machine to evaluate its performance. This is also manually operated but with two chains. It is therefore a two chain and sprocket system (2CSS) fish feed pelletizing machine that uses similar principle as that of the CSS and with 3 interchangeable die plates.

Purpose of the Study

The main purpose of this study is to design and fabricate a manual two chains and sprocket system (2CSS) fish feed pelletizer machine with interchangeable die plates that will be affordable by local small-scale farmers. Specific objectives include to:

1. Determine the efficiency of the fabricated fish feed pelletizer machine and
2. Determine the production rate of the pelletizing machine.

Research Questions

Two research questions were formulated to guide the study.

1. What is the efficiency of the produced fish feed pelletizer?
2. What is the production rate of the pelletizing machine?

MATERIALS AND METHOD

Design Considerations

In design and production of this machine, certain factors were taken into consideration. These factors were availability of the designed and selected materials, cost of the materials and overall cost of the produced machine, efficiency and output of the machine as well as die plate thickness and die plate hole

diameters. Furthermore, the quality and quantity of feed produced was also of concern.

Pelletizing Machine Description and Operation

The machine components consist of Hopper, Shaft, Spiral conveyor, Pellets' outlet, Ball bearing, Industrial bearing, perforated die, Pelletizer cylinder, Hopper throat, Chain, Sprocket, Chain guard, Collection tray, Handle and Frame, (See figure 1). This machine operates on the principle of rotational motion of the shafts. Sprockets and chains are used to transmit power to the four shafts. The spiral conveyor is attached to the shafts that rotate in same direction, the loading of un-pelletized feed is done manually through the hopper, the un-pelletized feed falls due to force of gravity, the handle is wound rotating the chain and sprocket system through the shaft as well as the spiral conveyor in the pelletizer cylinder where the feed experiences circular orbit in a horizontal plane about the axis. With the help of the shaft and cylinder, the force on the cylinder compresses the feed into solid which is pushed through the dies to produce pellets of uniform sizes and shape and discharges out through the holes of the die. The important components of the pelleting machine are the hopper where the feed meal is fed into the machine and the pelleting chamber in the form of worm auger or screw shaft which is seen to propel the feed. The shaft is operated by chain and sprocket system that is powered manually. The output pellet is produced by compacting and forcing it through a die opening via a mechanical process. These whole components rest on the frame which gives support to the machine.

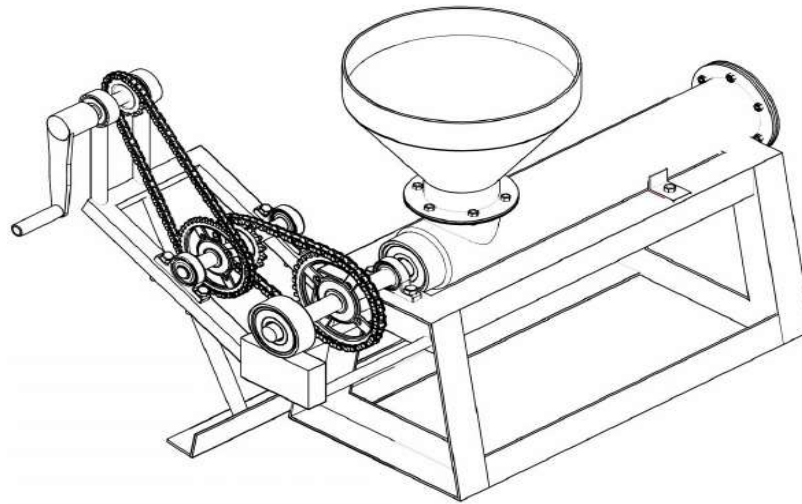


Figure 1: Assembled view of the 2CSS machine

Summary of Components Design Analysis and Bill of Engineering Quantities

The summary of component design analysis is given in Table 1; it covers the machine parts used

Table 1: Summary of component's design analysis

S/N	Components designed	Design specifications
1	Hopper	The hopper capacity is 0.031m ³
2	Pelletizing cylinder	The cylinder has a volume capacity of 0.00242m ³ , joint to a pellet outlet with a flange of diameter 144mm of galvanize steel pipe.
3	Sprocket and chain	The driver sprocket has 14 teeth while the driven sprocket has 42 teeth, having a drive ratio of 3:1. The chain length is 74 pitch units/Chain links and having a center distance of 22.98 pitch units.
4	Perforated die	There are 3 interchangeable die of 4mm, 6mm and 8mm diameter with 5mm thickness mild steel.
5	Power source	The machine is manually operated with the use of a wind handle connected to a chain and sprocket system.
6	Spiral conveyor	Length of 365mm and diameter 35mm of mild steel.
7	Shaft	25mm diameter and 360mm length of mild steel.
8	Chain	Motorcycle chain model: 420-1-106L
9	Bearing	The bearing type is single row, deep groove, ball bearing and has the following parameters; bore (35 mm), width (17 mm) and outside diameter (72 mm).

EVALUATION OF THE MACHINE

The performance evaluation was carried on the machine using three different die plate sizes (4mm, 6mm and 8mm) at a steady speed. The feed used for the test was poultry feed (Oracle starter chicken mash), which was milled again to give very fine aggregates. A sample of the feed weighing 2kg was prepared and tested on the machine for each die plate operation. The output of the machine in terms of pelleting efficiency, production rate and broken percentage were calculated using the formulas below;

PE = Pelleting efficiency

PT = Pelleting throughput

$$PE = \frac{100(\text{quantity of feed pelleted})}{\text{Total feed input}} Kg$$

$$PT = \frac{\text{Quantity of pelleted feed}}{\text{Total time for pelletization}} Kg/hr$$

RESULTS

Efficiency of 2CSS Machine

The efficiency of two chain and sprocket system showing the efficiency of the machine is given in Figure 2. The variation in die plate perforation diameters of 4 mm, 6 mm and 8 mm against pelletizer

efficiencies was done for the two chains and sprockets manually operated system. For the 4 mm die plate; 2Kg of wet feed was fed into the machine's hopper and was pelleted. The efficiencies of the machine using a 4 mm die plate having replicates of 1, 2 and 3 were 78%, 80% and 82% under the processing time of 0.134, 0.117 and 0.116 (hour) respectively. While the 6 mm die plate as well was tested using 2Kg wet feed was fed into the machine's hopper and was pelleted, efficiencies for replicates of 1, 2, and 3 were 79%, 80% and 81% with processing time of 0.104, 0.092 and 0.1 (hour) respectively. Lastly, the 8 mm die plate was as well tested using 2Kg wet feed mash was fed into the machine's hopper and was pelleted having replicates of 1, 2 and 3 for 2Kg wet feed pelleted has efficiencies 72%, 77% and 81% with processing time of 0.07, 0.06 and 0.06 (hour) respectively. The average pelleting efficiency of 2CSS for 4mm, 6mm and 8mm perforated die plate were derived to be 80%, 80% and 77% respectively. The total average Pelleting efficiency of 2CSS was derived to be 79%.

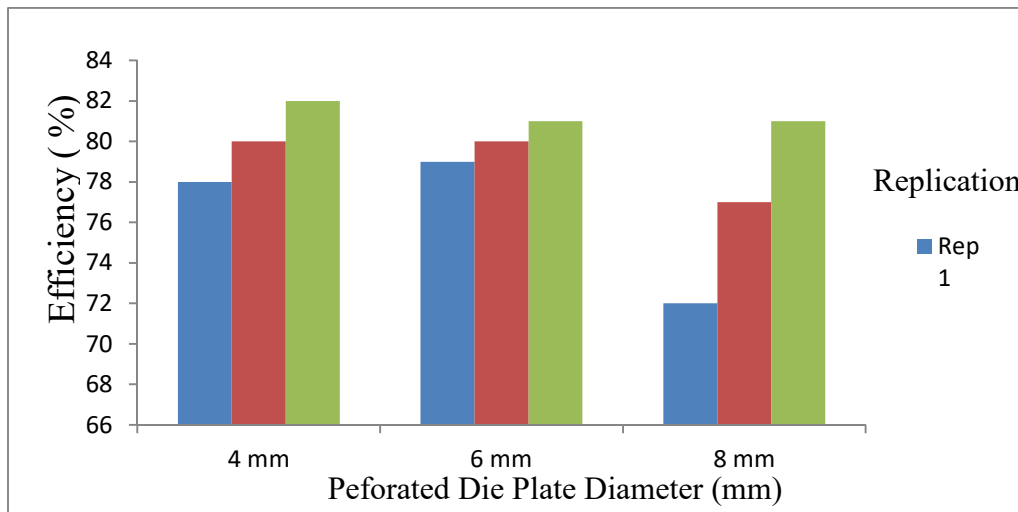


Figure 2: Two chains and sprockets system showing the efficiency of the machine.

Production Rate of the Pelleting Machine

The two chains and sprocket system showing the production rate of the machine is given in Figure 3. The 4 mm die plate perforation diameter had the production rates (Kg/hr.) of 8.2, 9.5 and 9.6 under replication 1, 2 and 3 respectively. The 6 mm die plate perforation diameter production rates (Kg/hr.) were 10.5, 12.0 and 11.1 under replication 1, 2 and 3 respectively. While the 8 mm die plate

perforation diameter production rates (Kg/hr.) were 14.1, 18.4 and 20.1 under replication 1, 2 and 3 respectively. The average production rate of 2CSS for 4mm, 6mm and 8mm perforated die plate were derived to be 9.1kg/hr, 11.2kg/hr and 17.5kg/hr. respectively. The total average production rate using the 2CSS was derived to be 12.6Kg/hr., which is lower than the 1CSS by Tiough *et al's* (2020) which had a throughput of 16.5kg/hr.

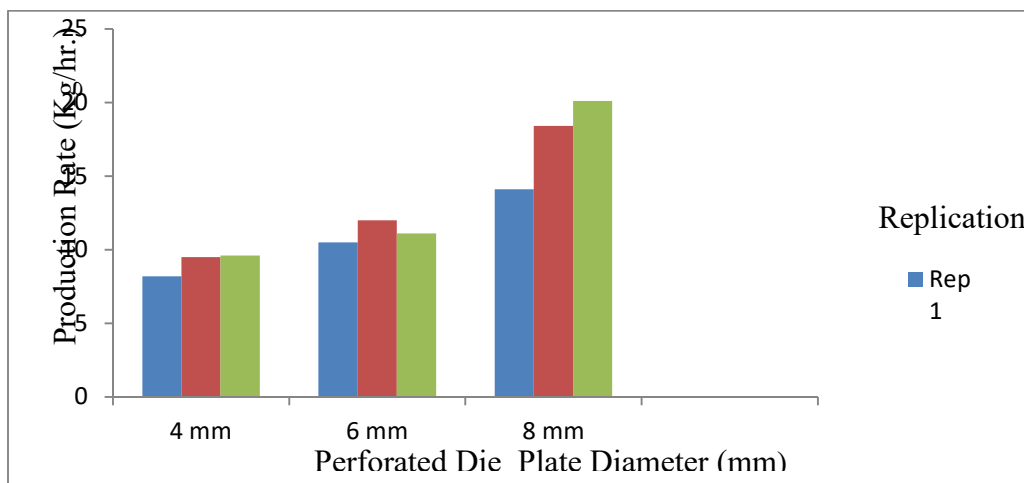


Figure 3: Two chain and sprocket system showing the production rate of the machine

DISCUSSION OF RESULTS

The two chains and sprocket system (2CSS) fish feed pelletizing machine is similar in all ramifications to the one chain and sprocket system (1CSS) fish feed pelleting machine earlier produced by Tiough, Obahi and Afaor (2020), except that it uses two chains and sprockets instead of one chain and sprocket. The machine is operated through the manual rotation of the handle which turns the shaft that compresses the molten feed through the die. This 2CSS machine is used by local small-scale fish farmers. There is no much cost difference between the 1CSS and 2CSS except in the addition of the second chain as additional cost in the 2CSS. The cost of the 2CSS machine is still less than seventy

thousand naira (₦70,000) which is affordable by the farmers.

The efficiency of the 2CSS manual fish feed pelletizing machine was evaluated using three different diameter die plates to determine the pelleting efficiency and throughput capacity. The efficiency of the 2CSS is 79%, which is lower than the machine produced by Ojomo *et al's* (2010), which used an electric motor and had efficiency of 87.6% and the one CSS machine produced by Tiough *et al's* (2020) which had an efficiency of 85%.

Similarly, the production rate or throughput evaluation of the 2CSS machine showed that the 2CSS machine had a throughput capacity of 12.6kg/hr which is higher than the throughput capacity of the



fish feed machine produced by Burmamu, Aliyu and Tya (2015), which had a throughput capacity of 9kg/hr. The production rate of the 2CSS machine is also less than that of the earlier CSS machine produced by Tiough *et al's* (2020) which had a production rate of 16.5kg/hr.

CONCLUSION

The performance of a hand-driven, two chains and sprocket system fish feed pelletizing machine is evaluated in the study. In order to give fish farmers variety of sizes of fish feeds, three interchangeable die plates were used with hole diameter sizes of 4mm, 6mm and 8mm. The performance of the machine through evaluation showed that this 2CSS machine had an efficiency of 79% and a production rate of 12.6kg/hr. The machine is therefore considered to be adequate for use by local small-scale fish farmers for production of fish feeds on their farms. The machine is also cheap and easily affordable by small-scale fish farmers. It will avail the farmers the opportunity to formulate and pelletize their fish feeds according to their desired nutrient formulation. The 2CSS fish feed pelletizing machine can also be used to pelletize feeds for other animals whose feeds need pelletizing. Since the machine does not use gasoline or electricity, it becomes cheaper for rural farmers who may not be lucky to have electricity and where gasoline may be scarce.

RECOMMENDATIONS

1. Local entrepreneurs are encouraged to produce this machine in large quantities to make them available to fish farmers.
2. The 2CSS machine is recommend for small-scale fish farmers so as to produce their fish feed and reduce cost of fish feed purchase from

commercial feed seller, so as to maximize profit.

3. This machine is recommended to small-scale fish farmers who are in rural areas where electricity is scarce or un-steady and where access to gasoline may also be difficult since it can be operated by manual winding of the handle.

REFERENCE

- Atoyebe, G. Y. (2007). Modification and Testing of a Worm Fish Meal Machine, Department of Mechanical Engineering Project Work, University of Ilorin, Nigeria.
- Burmamu, B. R., Aliyu, B. & Tya, T.S.K. (2015). Development of a manually operated fish feed pelletizing machine. *International Journal of Research in Engineering & Advanced Technology*, 2 (6), 23-32.
- Kaankuka, T. K. & 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.
- Odesola, I. F., R. A. Kazeem, and N. C. Ehumad. 2016. Design and construction of a feed extruder. *International Journal of Scientific & Engineering Research*, 7(8): 1378–1386.
- Ojomo A. O., Agbetoye L. A. S., & Ologunagba F. O. (2010). Performance evaluation of a fish feed pelletizing machine. *Journal of Engineering and Applied Sciences*, 5 (9), 88 – 97.
- Olusegun, H. D. & Adekunle, A. S. (2009). Design, construction and testing of a wormlike pellet fish meal processing machine. *International Journal of Engineering*, 3 (1), 31-44.



- Olusegun, H. D., Adekunle, A. S., Ohijeagbon, I. O., Akande, K. A. & Mohammad, B. G. (2017). Design, fabrication and evaluation of fish meal pelletizing machine, *Journal of Science and Technology*, 37(1), 51-63.
- Tiough, D. M., Obahi & Aafor (2020). Fabrication and performance evaluation of a manual fish feed pelletizer. *Journal of Information, Education, Science and Technology*.