Performance Evaluation of a Small-Scale Mechanical Fish Feeder

S. A. Fasoyin, W. A. Akinfiresoye, L. A. S. Agbetoye, L. A. Olutayo, and O. Adetuyi

Abstract **— The performance evaluation of an existing mechanical fish feeder was carried out. Floating feeds of sizes 2 mm, 4 mm, and 6 mm at constant moisture content of 13 % were fed into the feeder. The feeder was powered by a 3-phase, 1.5 kW reducing gear electric motor at speed 40 rpm, 50 rpm, 60 rpm, 70 rpm and 80 rpm machine. It was observed that the horizontal screw conveyor effectively transported the material from the hopper to the discharged point. The results obtained from the tests showed an optimal performance of the machine at speed 50 rpm with dispensing efficiency of 93.1 % for 2 mm feed size, while the throughput was 75.76 kg/h at motor speed of 80 rpm also for the 2 mm fish feed size. The ANOVA at $p \leq 0.05$ showed that machine speed has significant effect on its dispensing efficiency and the throughput capacity. The cost of production of the mechanical fish feeder was ₦262,300 which made it affordable for young entrepreneurs.**

Keywords **— Dispensing efficiency, Mechanical fish feeder, and Throughput capacity.**

I. Introduction

Nigeria enjoys exclusive fishing rights of over 256,000 km of the adjoining Atlantic Ocean (80 km coastline x 320 km) termed 'Exclusive Economic Zone' [1]. Nigeria Fishing Industry is classified into Artisanal fishery and Industrial fishery. Artisanal fishery is carried out in Coastal and brackish waters as well as inland in lakes and rivers while industrial fishery is carried out in deep coastal water as well as deep sea water and includes shrimping [2]. Currently, Tilapia type of fish farming represents more than 75% of world Tilapia production [3], [4]. Many fish farmers focus on Catfish, as they can have a high market value of two to three times that of Tilapia [5]. [6], [7] observed that in developing countries like Nigeria, millions of people live in small scale fishing communities. Specifically in Nigeria, fish farming is projected to exceed 150 million metric tons by the year 2010 [7]. Related to economic aspect, especially for highly invested aquaculture project, the control of fish feeding will also determine the survivor of the fish farming sector. The objective of feeding fish is to provide the nutritional requirements for good health, optimum growth, optimum yield, and minimum waste according to [8]. Feeding frequency is thus an essential consideration in fish farming because overfeeding and underfeeding are common problems faced. The former wastes feed and degrade water quality while the latter results in poor growth which eventually leads to low productivity [9]. Feed delivery in the correct form, at the right time and appropriate amount is expedient to increase and maintain a successful aquaculture production. Traditional method of hand feeding fish in pond, cage or even small lake is laborious, time consuming, and wastages of the feed is inevitable [10], [11]. [12] developed and tested a demand fish feeder, fabricated with Fiber Reinforced Plastic material. [13] developed an automatic fish feeder which had the capability of sensing uneaten feed. [14] designed an automatic fish feeder using PIC microcontroller. While several automatic fish feeders are available in developed nations, they are scarce in Nigeria and other developing countries, and its unavailability is mainly attributable to the cost of importation [15], [16]. Therefore, this study is to bridge the gap observed in Nigeria.

II. Methodology

A. Machine Description

The Mechanical Fish Feeder (MFF) has the frame, hopper, metering chamber, feeding chamber, conveyor screw augers, electric motor, covering net and the adjustable screen. Pelletized fish feed is loaded into the hopper weekly. The screw auger below the orifice of the hopper conveys the feeds from the hopper and meter it into the feeding chamber at a pre-determined feeding rate. The feed chamber also has another screw auger that conveys the pelletized feed from the inlet end of the feeding chamber to the outlet end of the chamber. Below this chamber is an adjustable screen of sizes 3 mm, 4 mm, and 6 mm where the feed is dispensed through into the pond while the auger is rotating. At the extreme end of the feeding chamber is an 8 mm hole on the three screens where all the feed is totally dispensed that escapes from dropping through the designated screen. The rotation of the screw auger is powered by a 3-phase, 1.5 kW reducing gear electric motor with maximum speed of 1420 rpm. The operational chart of the feeder is shown in Fig. 1.

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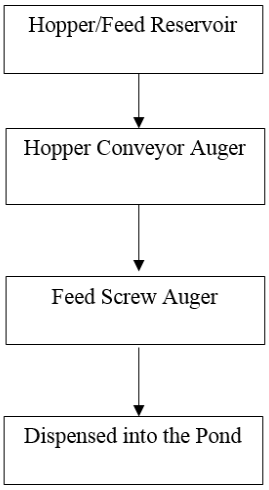

Fig. 1. Flow chart of machine operation.

B. Design Drawing

The MFF was designed using Inventor 19, the isometric and pictorial view is as shown in Fig. 2 and 3.

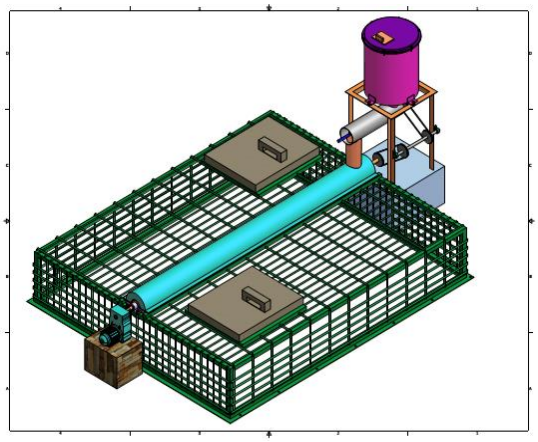

Fig. 2. Isometric view of the fish feeder.

Fig. 3. Pictorial view of fish feeder.

C. Experimental Design

The performance test of the MFF was carried out on a 2.2 m deep artificial pond of Rufus Giwa Polytechnic with water at temperature of 30 ºC. Pelletized Fish Feed (PFF) of sizes 2 mm, 4 mm, and 6 mm were bought from Onyearugbulem market in Akure, Nigeria. PFF was oven dried to a moisture content of 13 % and weighed to 5 kg in four places according to their sizes using electronic digital weighing scale. The PFF were fed into the machine under the four electric Motor Speed (MS) of 40 rpm, 50 rpm, 60 rpm,70 rpm, and 80 rpm. A 3×4 factorial design was used for both the independent variables of PFF sizes and the speed of MFF. Data obtained were analysed using descriptive statistical method, IBM SPSS version 23. ANOVA at significance level of $p \leq 0.05$ were carried out to ascertain the level of significance of the effect of the MS on the sizes of the fish feed.

D. Test Parameters

The performance parameters evaluated are the Dispense Efficiency (DE) and the Throughput Capacity (TC). The following parameters were also determined during the experiment:

a) Input feed (I_f): The actual weight of fish feed before feed in the machine measured with digital weighing balance.

b) Dispensing Efficiency (DE): The dispensing efficiency of the machine calculated at each speed was determined using (1):

$$D = \frac{\text{Wtd}}{\text{If}} \times 100 \quad (1)$$

where W_{td} is the total weight of feed dispensed and I_f is the input feed

c) Throughput Capacity (TC): This is the amount of feed delivered per unit time as calculated in (2):

$$TC = \frac{I_f}{T}(kg/h) \quad (2)$$

where T is the time taken in hours.

III. Results and Discussion

The results of the experiment is as discussed below.

A. Effect of Machine Speed (MS) on Dispensing Efficiency (DE)

Fig. 4 shows the effect of MS on DE for different PFF sizes of 2 mm, 4 mm and 6 mm. It was generally observed that there was an increase in the DE for all the sizes of the PFF when the MS increased from 40 rpm to 50 rpm. Nevertheless, a further increase in MS leads to a decrease in the DE. For example, at MS of 40 rpm for the 2 mm PFF, the DE was 86.2%, but when the MS was increased to 50 rpm, the DE rose to 92.2% . A further increase of the MS led to a decrease in DE. Specifically, at MS of 60 rpm, 70 rpm and 80 rpm; the DE were 79.5%, 78.2% and 76.1% for 2 mm PFF. This was the trend for PFF of sizes 4 mm and 6 mm for other MS.

At a higher speed, it is difficult to control the dispension rate as equally observed by [12] in their work on the demand cap fish feeder. This was the reason why the dispensing efficiency (DE) was higher at a lower machine speed (MS). The machine also was able to dispense the PFF with smaller sizes quickly when compared with the higher ones.

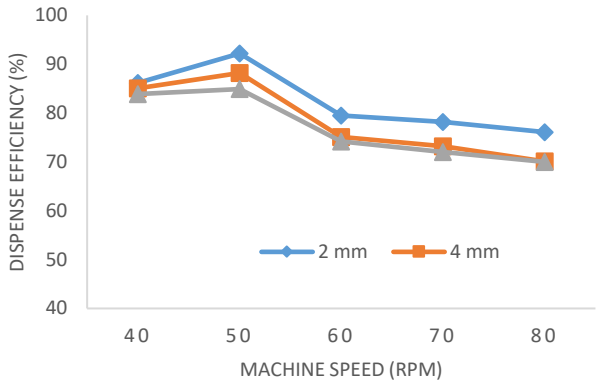

Fig. 4. Effect of machine speed on dispensing efficiency.

B. Effect of Machine Speed on its Throughput Capacity (TC)

As shown in Fig. 5, the TC of the machine increases as the MS increases for all the sizes of the fish feed under investigation. For PFF of 2 mm, the TC were 42.13 kg/h, 58.92 kg/h, 70.10 kg/h, 74.20 kg/h and 75.76 kg/h for speed 40 rpm, 50 rpm, 60 rpm, 70 rpm and 80 rpm respectively. This was the same trend for PFF of 4 mm and 6 mm at the same MS.

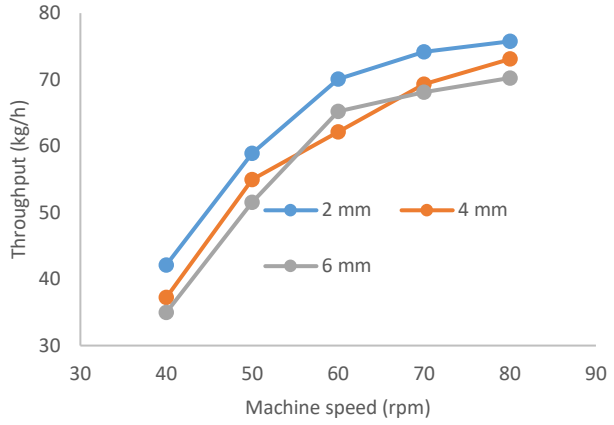

Fig. 5. Effect of machine speeds on throughput capacity.

The higher the machine speed, the higher the throughput capacity. This was the same observation by [14] in their work on automatic fish feeding system.

The Analysis of Variance (ANOVA) carried out on the experiment as shown in Table 1 revealed that the machine speed has significant effect on the dispensing effciency and throughput capacity since p-value is 0.013 which is < 0.05.

TABLE 1: ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1471.64	3	490.54	4.85	0.013	3.23
Within Groups	1616.08	16	101.00			
Total	3087.72	19				

IV. Conclusion

The performance evaluation of an existing fish feeder was carried out and its highest dispensing efficiency and throughput capacity were 93.1% and 75.76 kg/h, respectively for 2 mm fish size at machine speed of 50 rpm and 80 rpm respectively. The analysis of variance at $p \leq 0.05$ showed that the machine speed has significance effects on its dispensing efficiency and througput capacity.

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