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# Design And Fabrication of Roller Type Pelletizing Machine Equipped With A Steam Injector For Production of Buoyant Fish Feed

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***Abstract*** - *Besides as a reservoir for irrigation, the Gajah Mungkur reservoir located at Wonogiri Central Java is also used for fish floating cage sites by local fishermen. According to the fisherman, they have faced the problem of costly fish pellets in recent years, which causes high operational costs. Thus, the benefit margin becomes that reduces the income of the fisherman. A 75 kg/h roller-type pelletizing machine has been designed and fabricated in the present work to encounter a problem. The present work aims to design and fabricate a compact and low-cost roller-type fish pellet machine for the fisherman group located in the Gajah Mungkur reservoir. The uniqueness of the machine is that the machine is equipped with a steam boiler and steam injector. The machine is built from several components, i.e., hopper, roller, die, transmission gear, electric motor, steam injector, boiler, LPG burner, and safety devices. The machine works well during the test and can produce cylindrical feed fish pellets having a diameter of 2 mm and length of 4 mm*

**Keywords -** *roller; fish; pellet, steam; injector.*

## I. INTRODUCTION

Gajah Mungkur reservoir, located in Wonogiri, Central Java, Indonesia, has been built for farming irrigation nearby. Besides, the reservoir has become a tourism place, especially culinary tourism. Many floating restaurants can be found there which offer various fish-based menus to the visitor. Local fisherman cultivates fish itself in the floating cage built in the reservoir. According to the fisherman, they also make fish pellets using the manual pelletizing machine. They found that the capacity production is very low, and they cannot produce floating pellets. A directly sinking pellet makes the feed ratio is very poor. Hence more pellet is required for the particular weight of fish obtained. A measure of efficiency in converting feed into increased body mass is called Feed Conversion Ratio (FCR) (Li *et al*., 2014). The problem of low FCR could be overcome to increase margin benefit by using a good pellet quality.

Common pelletizing machines used in producing fish pellets are roller compression type and screw type pelletizing machines. Okolie *et al*. (2019) developed a simple single unit fish feed pelletizer at a lost cost for peasant farmers. The machine consists of a hopper, screw conveyor, barrel, dies, drive system, and heater. The throughput capacity of 17 kg/h, machine efficiency of 73.33%, and a pelletizing efficiency of 90.90% was obtained. A higher capacity pelletizing machine was designed and constructed by Olusegun *et al*. (2017). The machine has a capacity of 113.1 kg/h and can produce fish pellets with 4 mm and 6 mm diameter. A single screw pelletizing machine was also used by Cian *et al*. to optimize the effect of moisture content and die temperature on the physical properties of fish pellets based on vegetable meals.

Meanwhile, twin screw pelletizing machines have been designed and fabricated by Liu *et al*., 2021. The extruder is equipped with a cooling die. Two mash pellets (with and without wheat flour) are made under die's temperature of 138ºC by high and low moisture content.

Several factors have to be considered in producing fish pellets, such as pellet formulation and process parameters. Pellet quality is affected by feed formulation (Martin *et at*., 2019). Formulations with high rapeseed press cake /rapeseed peel contents increased the extrusion die pressure and caused greater longitudinal expansion but simultaneously reduced the sectional expansion, bulk density, sinking velocity, and specific hardness. Yasni *et al.* investigated the effect of varying the concentration of protein, vitamins, fats, and carbohydrate concentrations on the swelling, leaching, and floating properties. They obtained fish feed of formulation of 50% exhibit the desired swelling, leaching, and surface morphology with the swelling rate of 10.20%, the absorbance of 0.023 for leaching test, and with few pores on the surface of the fish feed. Skoien *et al.* 2016 found that pellet size is positively correlated with increased diffusion, and on the other hand, pellet density plays a less important role. Both the size and density of pellets had a significant impact on the settling rate. The binder type may also affect the floatability of the fish pellet. Considering the right polysaccharides as binders for on-farm floating feed, Orire & Emine, 2019 recommended using Cassava. The bulk density of low-starch content floating feed pellet decreased as increasing cassava content in formulations. The floatability of the pellet reached 100 % when the cassava content was≥ 54.3 g/kg (Ma *et al*.)

Besides feed formulation, process temperature also has a significant effect on pre-gelatinized taro-broken rice pellet quality. Die head temperature had significant effects on the physical properties of the pellets, such as moisture content (MC), expansion ratio (ER), floatability (F), pellet durability index (PDI), and water absorption index (WAI). The MC, ER, F, PDI, and WAI values significant increased by 7.0, 3.5, 103.6, 0.1, and 13.5%, respectively (de Cruz *et al*., 2015). The surface of the extruded pre-gelatinized taro-broken rice pellets became coarser when the die temperature was elevated from 125 to 170 °C (Kamarudin *et al*., 2018). Besides temperature, other process parameters, i.e., moisture content, could affect the expansion property, affecting the floatability of extruded feed (Draganovic *et al.*, 2011; Singh and Muthukumarappan, 2016).

Since fish feed pellets face major threats to their stability before reaching the target in the aquatic medium (Wood, 1993; Fagbenro & Jaunccy, 1995), it is important to produce a fish pellet with good floating ability before reaching the bed of the cage. The present work aims to design and fabricate a compact and low-cost roller-type fish pellet machine for the fisherman group located in the Gajah Mungkur reservoir. The uniqueness of the machine is that the machine is equipped with a steam boiler and steam injector. There is no similar work has been reported so far. Thus the present work is a novel concept in a roller type pelletizing machine

## II. MATERIALS & METHODS

### A. *Design and fabrication*

In the present work, a roller-type pelletizing machine is designed and fabricated in a local workshop in Yogyakarta. The machine is attended to produce a fish pellet of 75 kg/h. The main components of the machine are roller, die, hopper, electric motor, boiler, burner, steam injector, and safety devices.

#### *a) Calculation of shaft power*

Shaft power to rotate the roller during the process is calculated using Eq. (1). Where T is the required torque (Nm), N is the rotational speed of the roller (rpm).

$$P_{sh} = \frac{2\times\pi\times N\times T}{60} \quad \text{(Watt)} \qquad (1)$$

According to Olusegun *et al*. (2017), the required torque to pelletize fish pellet using roller type was 32, 7 Nm. The rotational speed of the roller is selected to be 350 rpm in the present work. Thus the shaft torque becomes:

$$P_{sh} = \frac{2\times\pi\times 350\times 32.7}{60} = 1200\ W$$

#### *b) Selection of electric motor*

The electric motor's power output is calculated using Eq. (2), where $\eta_m$ is the mechanical efficiency of the transmission.

$$P_m = \frac{P_{sh}}{\eta_m} \qquad (2)$$

Taking into account the mechanical efficiency of 85%, the required motor's power becomes

$$P_m = \frac{1200}{0.85} = 1412\ W = 1.8\ HP$$

Thus, the electric motor used in the present work has a power output of 2 HP

#### *c) Design of the hopper*

Fig. 1 shows the variables that have to be considered in designing hopper. The hopper has a geometry of reverse truncated cone. The diameter of the hopper discharge is denoted by d, and ϴ notifies the slope angle between the hopper wall and vertical axis.

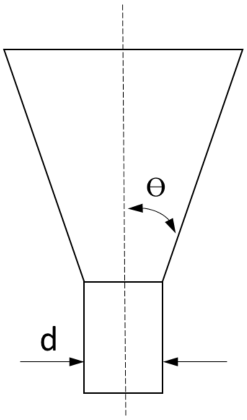


**Fig. 1. The hopper variables**

The smallest diameter of the hopper discharge is calculated using Eq. (3), which is given in Amos et al. (2000).

$$d = \left(2 + \frac{\theta}{60}\right) \times \frac{CAS}{\rho\times g} \qquad (3)$$

Where CAS is the critical stress on the hopper wall (Pa), $\rho$ is the particulate density (kg/m$^3$), and g is the gravitational force (9.81 m/s$^2$). The critical stress is taken from Freeman (2009), i,e, 1300 Pa. Slope angle is taken to be 25º based on the series of curves developed by Thomas (1997). The particulate density of the material is 2.5 kg/m2 in the present work. Thus the smallest hopper diameter becomes

$$d = \left(2 + \frac{25}{60}\right) \times \frac{1300}{2.5\times 9.81} = 0.128\ m$$

Hence, the hopper outlet discharge diameter is designed to be 128 mm

### B. *Testing of the machine*

After the machine has been fabricated, it is tested to produce fish pellets at the workstation of the Gajah Mungkur reservoir. Besides producing pellet, the training of the operator is also conducted.

## III.RESULTS & DISCUSSION

Fig. 2 shows a photograph of the roller-type pellet machine. The machine has several components, i.e., hopper, roller, die, transmission gear, electric motor, steam injector, boiler, LPG burner, and safety devices. The performance of the machine is tested to pelletize a feed fish. The machine works well during the test and can produce cylindrical feed fish pellets. Fig. 3 and Fig. 4 display the photographs of the pelletizing process and the produced pellet having a diameter of 2 mm and length of 4 mm


**Fig. 2. Roller type fish pellet machine**

**Fig. 3. Fish feed pelletizing**

**Fig. 4. Feed fish pellet**

From the test, it can be observed that the operator has to care about operating producer of the machine, especially in checking the pressure of the boiler and the cleaning of the steam injector. Steam injector hole has to be checked regularly to prevent blocking from the pellet dough. Besides, the die hole has also to be prevented from blocking. This blocking may reduce the quality of the pellet and may decline the capacity of the machine. To maintain the machine's optimum performance, the operator should have a good knowledge regarding operation and maintenance.

## IV. CONCLUSIONS

A low-cost and compact roller-type pellet machine with steam injection is designed and fabricated successfully in the present work. The machine has a capacity of 75 kg/h at optimum operating conditions. To maintain the machine's optimum performance, the operator should have a good knowledge regarding operation and maintenance.

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