

The Impact of Screw Pitch Types on Screw Feeder Performance on Floating Fish Feed Machine

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Abstract - One of the important parts of the floating pellet machine, a tool often used in Indonesia to produce fish feed, is the screw press. The largest contributor to the overall production cost in fish farming is fish feed. Floating pellet machines usually require two motors and have large machine dimensions due to the use of two constant-pitch screw feeders. The purpose of this study was to optimize the performance of the floating fish feed machine with one screw press and one drive motor, with the screw feeder selected as the variable-pitch type. The simulation method was used to compare the mass flow rate produced by each screw pitch and the pressure value parameters on the screw. Based on the results of the study, by using the same fish feed machine base, changing the screw pitch type from the constant type to the variable type, provides an increase in the quality of the fish feed produced to be denser and not easily destroyed, and its buoyancy increases.

Keywords: Screw Press, constant pitch screw, variable pitch screw, mass flow rate, pressure, fish feed.

I. INTRODUCTION

Pellet machines are important in increasing production efficiency in the animal feed industry, especially fish feed. The screw design, which moves the material through the machine until it forms pellets, is a crucial aspect of making pellet machines. Optimal screw design plays an important role in producing sufficient pressure and a stable mass flow rate, which will ultimately affect the quality of the pellets produced [1,2,4,5,7,8,9,10]. Other factors that influence the quality of fish feed pellets are the speed of the screw feeder and the moisture content of the material and the physical properties of the feed material.[6-9].

The impact of various types of screw pitch on the performance of the pellet machine screw feeder is very important in determining the efficiency and effectiveness of production. Screw pitch affects pressure and mass flow rate that is the two main aspects of screw feeder performance [3-10].

Smaller screw pitch types (closer threads) tend to produce higher pressure because the material is compacted more strongly as it moves along the screw. This greater pressure is important for forming pellets with good density and mechanical strength. However, a pitch that is too small can increase friction and heat, potentially damaging the raw material or causing blockages [2,4].

A larger pitch allows material to flow faster through the screw, resulting in a higher mass flow rate [1]. This can increase production capacity, but if the pitch is too large, the resulting pressure can be too low, so the pellets formed may not have the desired consistency or strength. Therefore, the selection of the right pitch must be adjusted to specific needs, such as the type of raw material, material properties, and desired pellet quality. The optimal pitch will provide a balance between sufficient pressure to produce quality pellets and an efficient mass flow rate to increase production capacity. This study aims to identify the best configuration to achieve optimal performance in a pellet machine by providing variations in the type of screw feeder with different types of screw pitches as shown in Figure 1 and Figure 2.

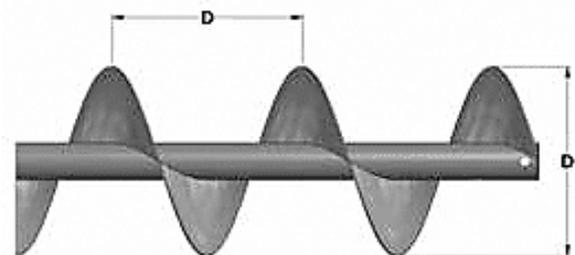


Figure1: Constant pitch screw feeder

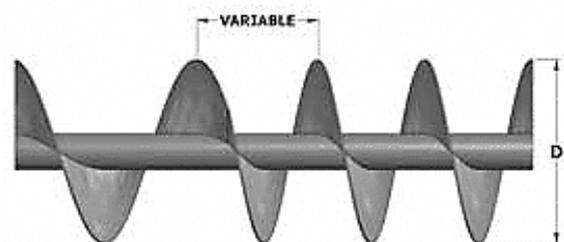
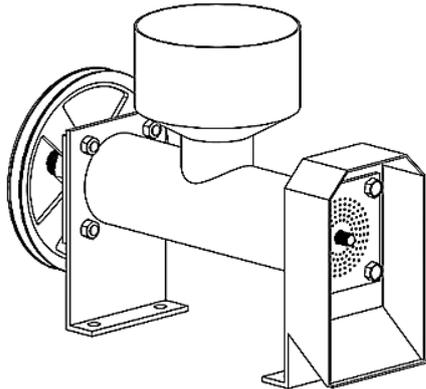


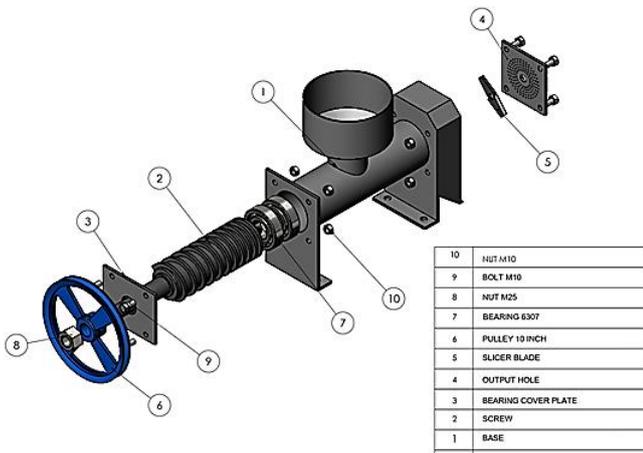
Figure 2: Variable pitch screw feeder

II. METHODOLOGY

The research was carried out utilizing the Ansys 2023 simulation program. The parameters to be examined are the amount of pressure on the screw pitch and the mass flow rate for each type of screw feeder. Figures 2 through 7 and Tables 1–2 illustrate the specifications of the floating pellet machine, the driving motor, and the specifics of the screw feeder.



(a)



(b)

Figure 3: Design of the floating pellet machine (a) assembly view, (b) explode view

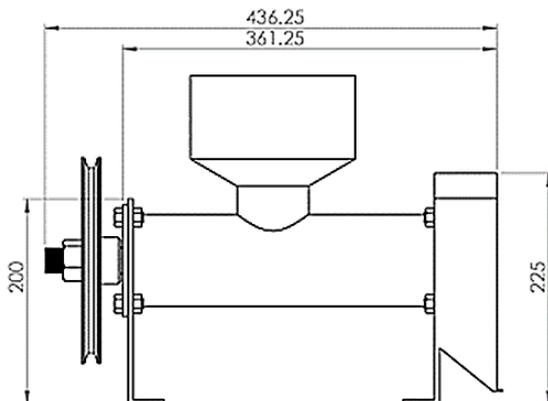


Figure 4: Front view and the dimensions of the floating pellet machine

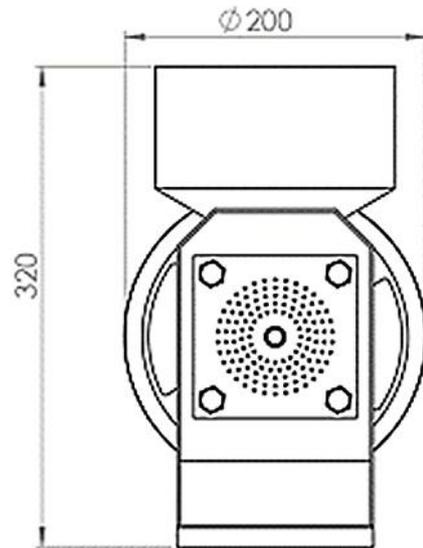


Figure 5: Side view and the dimensions of the floating pellet machine

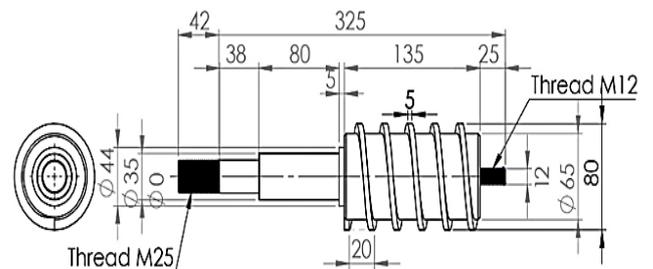


Figure 6: Screw Feeder with a constant pitch screw type

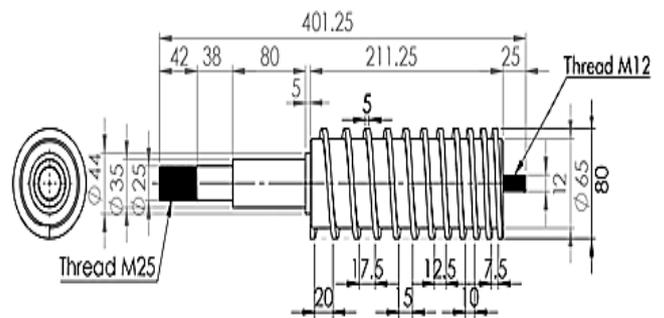


Figure 7: Screw Feeder with a variable pitch screw type

Table 1: Pellet Machine Screw Specifications

No	Screw Design	Material	Diameter	Screw Length	Pitch Gap
1	Constant Pitch Screw	Low Carbon Steel (ST-40)	8 cm	32,50 cm	2,00cm
2	Variable Pitch Screw	Low Carbon Steel (ST-40)	8 cm	40,12 cm	(2,00; 1,75; 1,50; 1,25; 1,00; 0,75)cm

Table 2: Engine Specifications for Floating Pellet Machine

Engine Specifications	
a Type	Paus GX 200
b Model	OHV, 4-Stroke, Cylinder, Air-Cooled
c Dimension (mm)	340 x 400 x 340
d Bore x Stroke (mm)	68 x 45
e Output power	6,5 hp / 6500 rpm
f Torque	Net torque: 12,4 Nm (9.1 lbs ft)
g Starting system	Recoil
h Fuel type	Gasoline

In General Setup, the Solver type used is Pressure-Based with Absolute Velocity Formulation, then the conditions used are Steady and Gravitational Acceleration points to the Y axis with a value of 9.81 m/s².

In the cell zone condition properties, the simulation is run using frame motion with rotation axis direction towards the Y axis -1. Then the rotation speed that is run is 23.4695 rad/s. In the boundary condition inlet properties, all external pressure is considered 0 with the Direction Specification Method Normal to Boundary. Then Prevent Reverse Flow is activated to prevent flow that does not match the extrusion direction. While in the boundary condition outlet, gauge pressure is considered 0 with the pressure profile multiplier conditioned at a value of 1. Prevent Reverse Flow is also still activated.

In boundary condition walls, wall motion is set with stationary wall to illustrate the absence of wall movement in the simulation. Shear condition is considered “no slip” while for Roughness Models and Sand-Grain Roughness is set to Standard with a Roughness Constant of 0.5 and Thermal Conditions using Heat Flux. For reference value and solution method used, can be seen in Figure 8 to Figure 10.

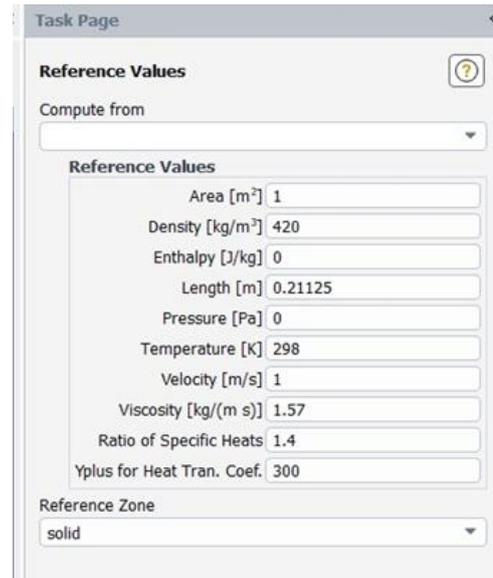


Figure 9: Reference valuefor variable pit screw feeder

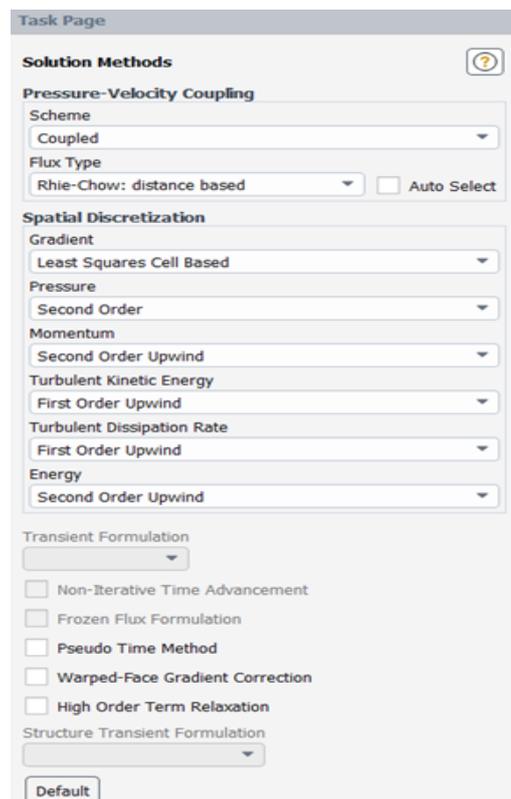


Figure 10: Solution Method

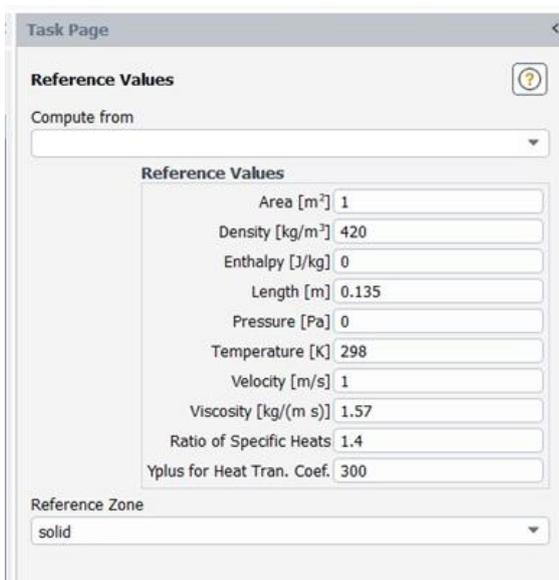


Figure 8: Reference valuefor constant pit screw feeder

Residual Monitors: the iteration used is 1000 by activating Print to Console and also Plot. Then in the Equations settings, all checklists are activated. For properties initialization, initialization methods use hybrid initialization. The settings for run calculation used in this simulation are using 1000 iterations and reporting interval 1. The variation of the simulated pellet machine is also given by the size of the dies or the output hole of the pellet mixture. The variations available are dies with a diameter of 2 mm, 3 mm, and 4 mm.

III. RESULTS AND DISCUSSION

The pellet extrusion simulation process begins with the flow of dough that is fed through the hopper. Then the dough is flowed to the screw section to stir the dough and the flow of pellet dough comes out through the die hole. The simulation carried out with the direction of dough flow can be seen in Figures 11 and 12.

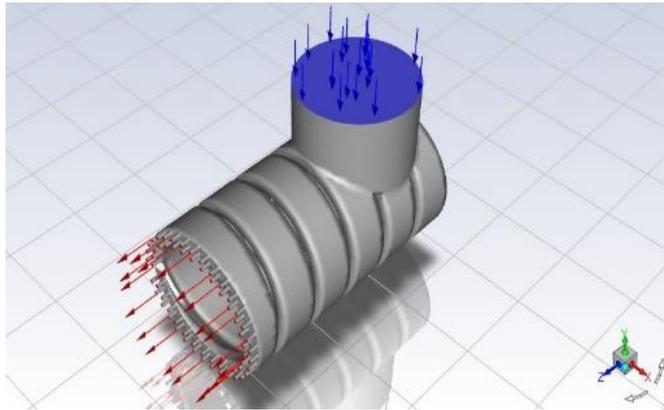


Figure 11: Screw Feeder with a constant pitch screw type

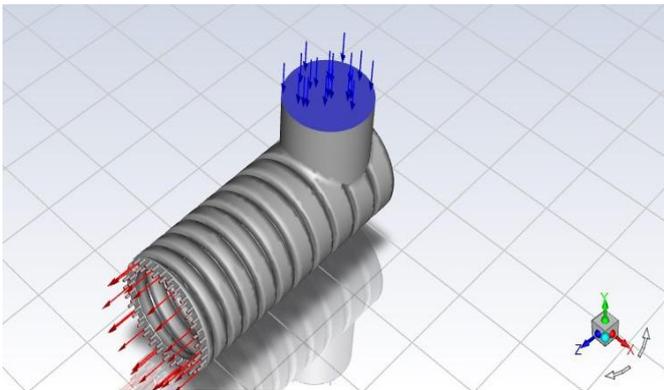


Figure 12: Screw Feeder with a variable pitch screw type

The simulation results of the pellet production process using a screw feeder can be seen in Figures 12 to 17.

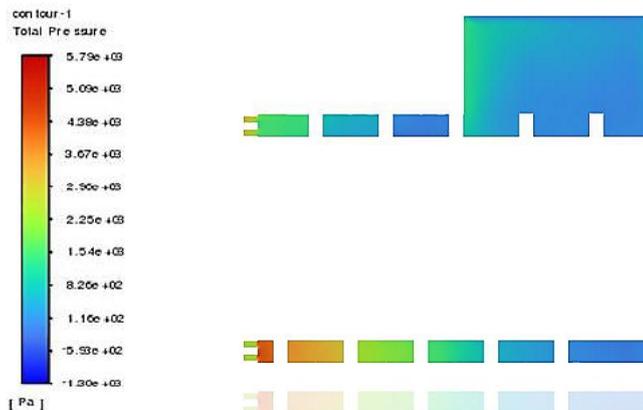


Figure12: Pressure on constant pitch screw with die diameter 2 mm

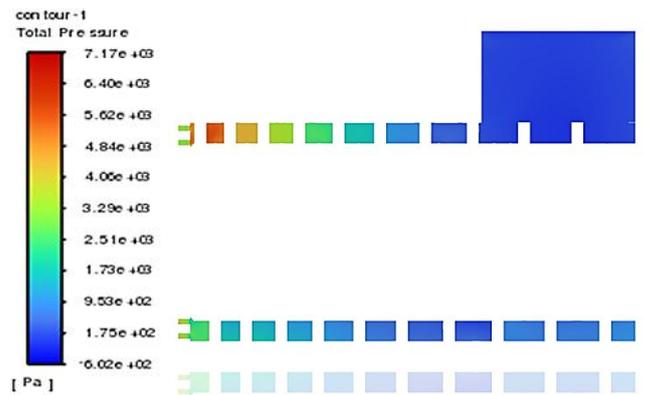


Figure13: Pressure on variable pitch screw with die diameter 2 mm

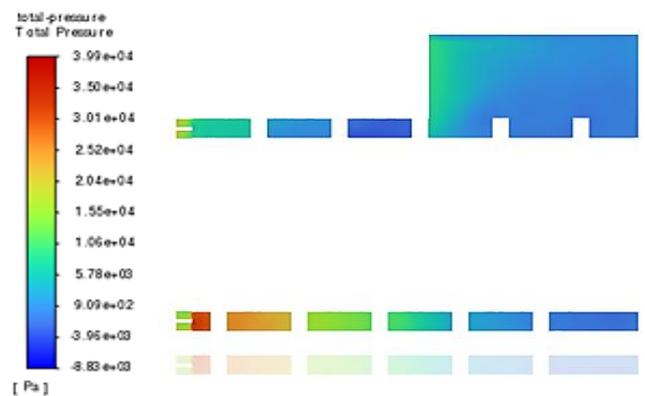


Figure 14: Pressure on constant pitch screw with die diameter 3 mm

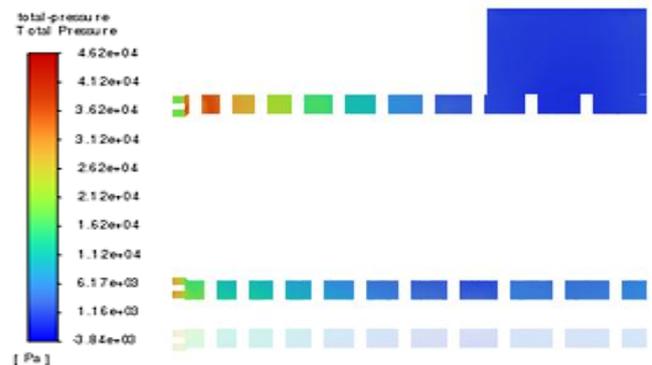


Figure 15: Pressure on variable pitch screw with die diameter 3 mm

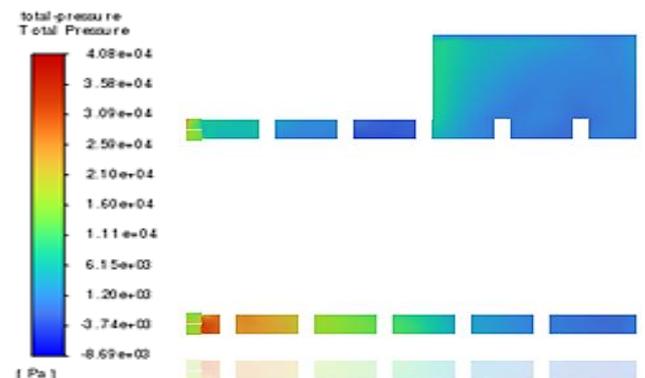


Figure 16: Pressure on constant pitch screw with die diameter 4 mm

IV. CONCLUSION

From the simulation results, the highest pressure occurs in the variable-pitch screw with a die diameter of 2 mm, which is 1936.44 Pa. The highest mass flow rate is found in the variable-pitch screw with a die diameter of 4 mm, with a value of 97.49 kg/hour.

Changing the type of screw pitch from a constant type to a variable type affects the increase in pressure and mass flow rate, which affects the quality of the pellets due to the increase in pellet density. The next thing that needs to be studied is how the effect of the increase in temperature occurs, which has the potential to damage the pellets produced because the feed material burns due to high heat.

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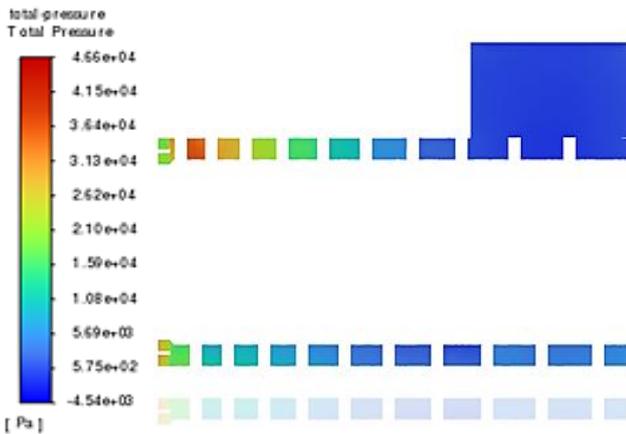


Figure 17: Pressure on variable pitch screw with die diameter 4 mm

From the simulation results, it can be seen that the pressure produced by the variable screw is more even compared to the constant screw. Data on the pressure produced and also the mass flow rate of each simulation variation can be seen in Table 3.

Table 3: The magnitude of pressure and mass flow rate of the simulation results for both types of screw pitch

No	Pitch Screw Type	Diameter Dies (mm)	Pressure (Pa)	Mass Flow Rate (kg/jam)
1	Constant	2	1849,42	45,10
		3	1756,28	47,12
		4	1671,04	52,41
		2	1936,44	85,21
2	Variable	3	1892,64	90,13
		4	1852,31	97,49

From the simulation data, it can be seen that the pressure produced by the variable pitch screw produces the highest pressure compared to the constant pitch screw, which is 1936.44 Pa for a dies diameter of 2 mm, 1892.64 Pa for a dies diameter of 3 mm, and 1852.31 Pa for a dies diameter of 4 mm. Higher pressure on the variable pitch screw allows the density level of the pellets produced to be higher compared to the constant pitch screw.

The mass flow rate value produced from both screws is inversely proportional to the pressure value on the screw due to the influence of the variation of the die diameter. The larger the diameter of the dies applied, the greater the mass flow rate value produced. And the mass flow rate value of the variable pitch screw is higher than the constant pitch screw, namely 85.21 kg/hour for a die diameter of 2 mm, 90.13 kg/hour for a die diameter of 3 mm, and 102.49 kg/hour for a die diameter of 4 mm.

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