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Mechanical Analysis in the Improvement of a Fish Feed Pelletizer

Ohene Kwame Oduro

Abstract

This study presents the redesign and performance analysis of a fish feed pelletizer, emphasizing aspects of strength of materials, machine design analysis, dynamics of machinery, and fluid dynamics. The project involved reinforcing the machine's structural elements, optimizing its power transmission system, and assessing its dynamic behavior under operational loads. Analytical evaluations included shaft stress checks using the Tresca criterion, compression pressure estimation, motor power selection, and belt-pulley transmission analysis. Fluid dynamics calculations were made to evaluate the throughput of the system. Dynamic improvements such as vibration damping and speed regulation were also incorporated. Results indicate that the modified pelletizer, powered by a 3 HP motor and fitted with a belt-tensioning mechanism, achieves safe stress levels, improved durability, and consistent pellet production, making it more efficient and reliable for small- and medium-scale aquaculture operations.

Keywords: Fish feed pelletizer, Strength of materials, Machine design, Dynamics of machinery, Power transmission

1 Introduction

Pelletizers are widely used in aquaculture for efficient feed production. A pelletizer transforms feed mixtures into durable pellets through pressing and extrusion. However, existing machines often suffer from structural weaknesses, power inefficiencies, and dynamic instabilities, which reduce their effectiveness. This study focuses on improving the strength, durability, and dynamic performance of a fish feed pelletizer by applying principles of strength of materials and dynamics of machinery. Specific objectives include reinforcing load-bearing members, optimizing shaft and power transmission design, and mitigating vibration effects for smoother operation.

2 Methodology

2.1 Strength of Materials Analysis

The shaft and frame were subjected to strength checks. The shaft torque from the 3 HP motor was calculated as 15.26 Nm. Using the Tresca yield criterion, shear stress was 28.3 MPa, significantly lower than the yield strength (125 MPa), confirming safety. The frame was strengthened with welded angle bars and treated with anti-rust coatings to prevent corrosion and fatigue.

2.2 Machine Design Calculations

Parameter	Value	Notes
Pressing Force (F)	1200 N	Based on experimental observation
Roller Speed (N2)	490 RPM	From pulley ratio
Tangential Velocity (v)	1.8 m/s	$v = \omega \times r$
Power Requirement (P)	2.16 kW ≈ 2.9 HP	$P = F \times v$
Selected Motor	3 HP	Standard, with margin
Compression Pressure (Pc)	0.95 MPa	Based on die hole area
Belt Length (L)	1.14 m	Open-belt drive equation
Angle of Wrap (θ)	158.6°	Ensures adequate grip

2.3 Dynamics of Machinery

The operating roller speed of 490 RPM provided stable torque transfer. Rubber dampers minimized vibration transmission, reducing structural fatigue. Pellet hammer and cutter geometry were optimized for uniform cutting, reducing torque fluctuations.

2.4 Fluid Dynamics Perspective.

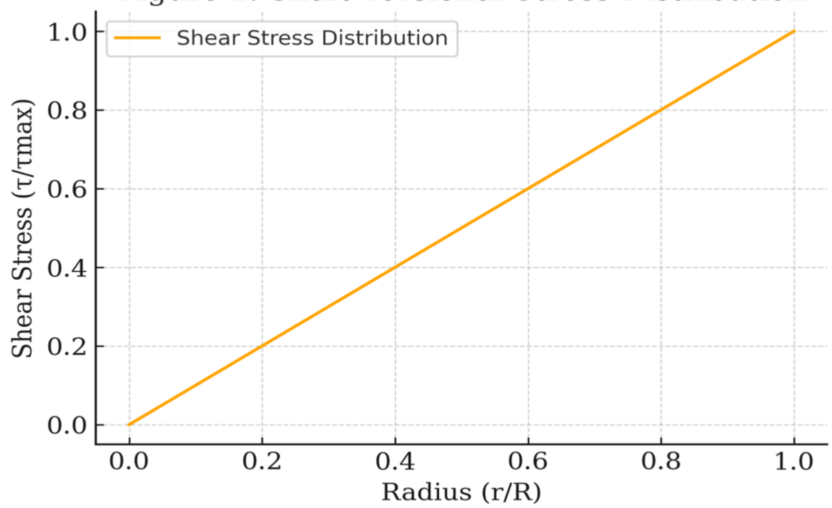
From a fluid dynamics standpoint, the feed mixture is compressed and extruded through multiple die holes, each with a diameter of 6 mm. With 100 holes, the total die opening area was calculated as 1.257×10^{-3} m². At a roller tangential velocity of 1.8 m/s, the theoretical volumetric throughput was approximately 2.26×10^{-3} m³/s (≈ 2.26 L/s or 136 L/min). The compression pressure was estimated at 0.95 MPa, which is adequate for forming durable pellets without overloading the machine. Flow uniformity and consistent extrusion depend on maintaining proper feed conditioning, die geometry, and steady roller speed.

3 Results and Discussion

3.1 Shaft Stress Analysis

The shaft shear stress was calculated as: τ = 16T/(π d^3). For torque T = 15.26 Nm and shaft diameter d = 20 mm, τ = 28.3 MPa. This is below the Tresca limit (125 MPa), confirming safe operation.

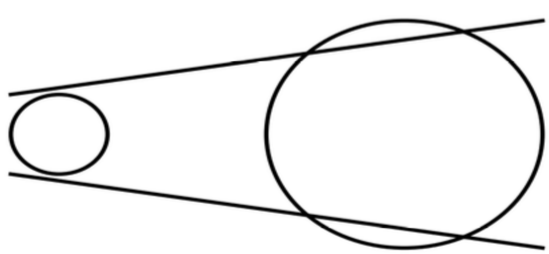
Figure 1: Shaft Torsional Stress Distribution



3.2 Belt-Pulley Transmission

The belt drive was optimized for speed reduction and torque transfer. For D1=0.07 m, D2=0.20 m, and motor speed N1=1400 RPM, the driven pulley speed N2 = (D1/D2) × N1 = 490 RPM. The calculated wrap angle of 158.6° ensures adequate grip.

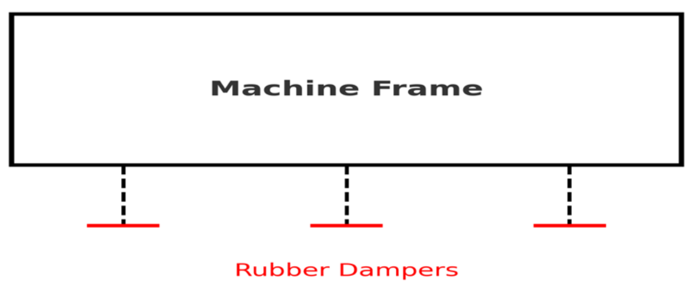
Figure 2: Belt-Pulley Transmission System



3.3 Dynamic Improvements

Vibration damping reduced oscillations during operation. Uniform pellet output was achieved due to consistent torque delivery and cutter design.

Figure 3: Vibration Damping in Machine Frame



4 Conclusion

The improved fish feed pelletizer demonstrates robust performance by integrating strength of materials analysis and machinery dynamics into its redesign. The shaft and frame remain structurally safe, the belt-pulley transmission ensures efficient power delivery, and vibration damping improves machine stability. These improvements make the pelletizer more durable, efficient, and reliable for aquaculture feed production. Future work should include fatigue testing, real-time vibration monitoring, and sensor integration.

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