

Optimization of Pellet Press Design by Converting a Dual-Roller into a Three-Roller Mechanism to Improve Production Efficiency

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Abstract - The pelletizing process plays a critical role in both feed and biomass industries, as it determines product quality, density, and overall production efficiency. Conventional pellet presses equipped with dual-roller mechanisms typically suffer from limitations in pressure distribution, production capacity, and pellet shape uniformity. This study aims to design and optimize a pellet press by modifying the roller configuration from a dual-roller to a three-roller system in order to enhance pelletizing efficiency. The research methodology includes mechanical design through analytical calculations and numerical analysis using CAD-based modeling. The results indicate that the addition of a third roller increases the effective compression area by 250% and boosts the average production capacity by approximately 260% compared with the dual-roller system. These findings demonstrate that the three-roller modification significantly improves pelletizing performance in terms of mechanical efficiency and product quality, achieving a break-even point (BEP) within only a single day of operation.

Keywords: Pellet press design; production efficiency; break-even point (BEP); roller configuration; mechanical optimization; sustainable manufacturing.

I. INTRODUCTION

The rapid growth of the livestock industry demands feed production approaches that are not only efficient but also environmentally sustainable. The adoption of sustainable manufacturing practices is increasingly critical, as rising global feed demand must be aligned with efforts to reduce carbon footprints, improve energy efficiency, and ensure responsible resource utilization [1]. Feed pellets, as an innovation in feed processing, have been shown to enhance nutritional efficiency, reduce material losses, and improve the overall quality of feed products [2]. This positions the pelleting process as an essential component of green manufacturing, capable of converting local raw materials, agricultural residues, and biomass into high-value products [3].

Pellet production involves processing materials such as corn, soybean meal, wheat, straw, fishmeal, and various agricultural biomass into compact and uniform forms through mechanical compaction [4]. Current industrial trends highlight that pelletizing equipment is expected not only to produce high-quality pellets, but also to comply with principles of energy efficiency, waste minimization, and process optimization as part of sustainable manufacturing practices [5]. In this context, pellet presses play a vital role in transforming raw resources into value-added products while maintaining environmental considerations [6].

However, many pellet presses still employ the conventional dual-roller design that has long been used in both feed and biomass industries. While functional, this design faces several limitations, including low production capacity, inconsistency in pellet quality, high energy consumption, and inefficiencies in processing fibrous or moisture-sensitive materials [7–9]. Such constraints directly contribute to higher energy consumption per unit output, increased wear rates of mechanical components, and reduced process stability—conditions that contradict the principles of green manufacturing.

In response to industrial demands for more energy-efficient, reliable, and sustainable production processes, design optimization of pellet presses is required to enhance efficiency without increasing environmental burdens [10]. One promising technical approach is the conversion of the dual-roller mechanism into a three-roller configuration, which can increase compression force, enlarge the working zone, and improve material flow during pelleting [11]. The addition of a third roller is projected to enhance pellet density and uniformity, reduce specific energy consumption, and extend the service life of mechanical components through improved load distribution [12].

Thus, optimizing pellet press design through the addition of a third roller is intended not only to enhance production capacity and product quality, but also to support the realization of green manufacturing practices by reducing energy consumption, improving process efficiency, and

enabling broader utilization of locally sourced materials [14–16]. This study aims to analyze the performance of the three-roller mechanism and evaluate the resulting improvements in production efficiency as a strategic step toward a more sustainable, economical, and competitive pelleting system.



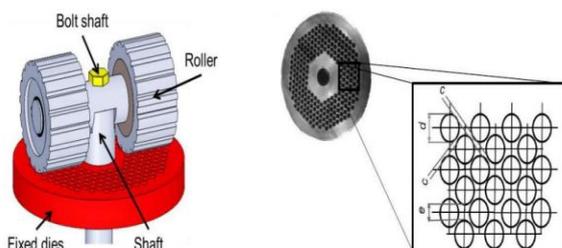
(a)



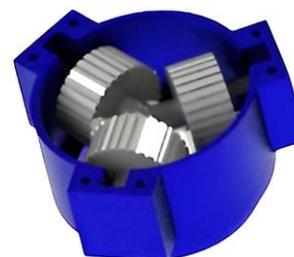
(b)

Figure 1: (a) The dual-roller pellet machine powered by an 8 HP diesel engine; (b) the dual-roller configuration inside the pellet machine [13]

The dual-roller pellet machine to be modified is presented in Figure 1. The geometry of the rollers and die in the initial configuration, along with the redesigned three-roller configuration—including the modified roller shafts—is shown in Figure 2.



(a)



(b)



(c)

Figure 2: (a) The dual-roller type mounted on the shaft and die; (b) the three-roller design; and (c) the shaft design for the three-roller configuration

The specifications of the pellet machine targeted for roller modification are presented in Table 1. The specifications of commercially available dual-roller and three-roller pellet machines with the same type of drive system are presented in Table 2.

Table 1: Machine Specifications

Machine Specifications	Notes
Power	5.67 kW (8HP)
Torque	20.8 Nm (2600rpm)
Mass	72 kg
Transmission	Pulley, V-belt, Gearbox
Large Pulley Diameter	120 mm
Small Pulley Diameter	75 mm
Motor Type	Electric/Diesel Engine

Table 2: Commercially Available 2-Roller and 3-Roller Pellet Machines

Type	Price (Rp)	Production Capacity (kg/h)
Dual-roller type with an 8 HP engine drive	8,300,000–8,800,000	90-120
Three-roller type with an 8 HP engine drive	9,840,000–10,000,000	300-350

II. METHODOLOGY

This study employs an engineering experimental approach to design and optimize a pellet press equipped with a three-roller system. The primary objective is to enhance pelletizing efficiency and product quality compared with the conventional dual-roller configuration. The dimensions of the hopper and rollers remain unchanged, while the number of rollers is increased from two to three, requiring corresponding modifications to the roller shaft.

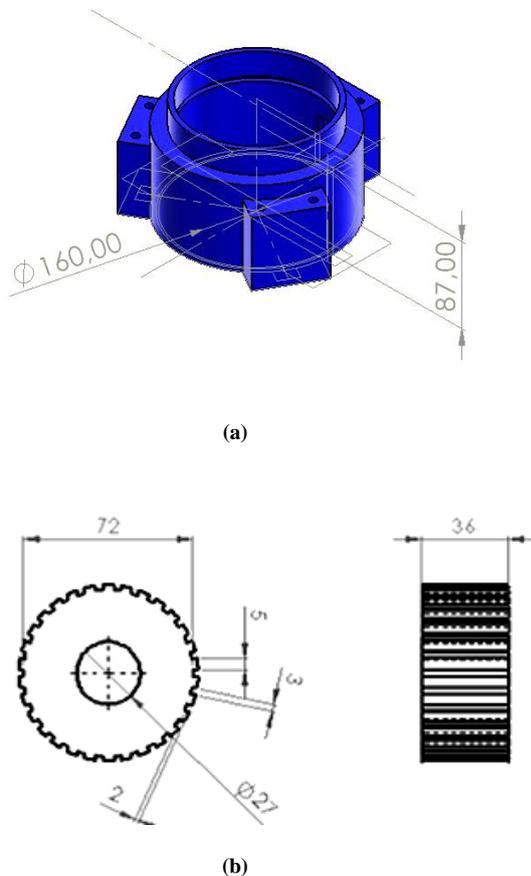


Figure 3: Dimensions in mm of (a) the hopper and (b) the roller

The research procedure consists of mechanical design development, analytical calculations, numerical analysis, prototype fabrication, and performance testing. The machine design was carried out using CAD-based software. Figure 3 illustrates the design of the hopper and roller used in this study.

The prototype was constructed using carbon steel for the frame and alloy steel for the roller components. Performance tests were conducted by comparing the dual-roller and three-roller machines using a feed mixture composed of fine rice bran and soybean meal/corn with a moisture content of 10–12%. The evaluated parameters included production capacity, pellet shape uniformity, and pellet density.

The experimental data were analyzed quantitatively to determine the performance improvements resulting from the addition of the third roller. The optimization results were then used to recommend the most efficient operational configuration for the three-roller system.

III. RESULTS AND DISCUSSIONS

The modified configuration, converting the dual-roller system into a three-roller design and incorporating an electric motor as an alternative to the conventional 8 HP diesel engine, is presented in Figure 4.



Figure 4: Configuration of the rollers connected to an electric motor as an alternative drive system

The analysis of the effects of roller number modification on the load-bearing capability of the machine configuration, as well as the adequacy of the drive power, is presented in Table 3.

Table 3: Specifications of the Three-Roller Pellet Machine

Parameter	The effects of roller modification
Hopper Volume	0.00175m ³
Product Mass in Hopper	0.84 kg
Roller Contact Area on the Die	0.0054 m ²
Average Pelleting Shear Stress (τ)	30,900 N/m ²
Roller Compaction Force (Pelleting Force)	500.58 N
Motor Power Requirement	4.9 kW (6.6 HP)
Transmitted Power ($f_c=1.2$)	5.88 kW (7.9 HP)

The original 8 HP drive motor remains sufficient to serve as the primary power source for the pellet machine after modifying the roller configuration from two to three rollers.

The effects of changing the number of rollers on the hourly pellet production capacity, based on the experimental results, are presented in Table 4. The increase in the number of rollers demonstrates a substantial improvement in production capacity.

Table 4: Changes in Production Capacity

Parameter	2 Rollers	3 Rollers	Increase %
Capacity (kg/h)	72	187	260
Compression Area (Die Hole)	24	60	250

With the local market price of feed pellets at approximately Rp 6,000 per kilogram, the profit value and break-even point (BEP) can be calculated as presented in Table 5.

Table 5: Changes in the Economic Value of the Produced Product

Roller Type	Roller Capacity (kg/h)	Profit (Rp/h) @Rp.6.000/kg
2 Rollers	72	432,000
3 Rollers	187	1,122,000

The production capacity of the dual-roller machine is 72 kg/h, which is still below the commercial standard of 90–120 kg/h. Three-roller machines available in the market are reported to achieve a production capacity of 300–350 kg/h. In relative terms, the claimed production capacity ratio between dual-roller and three-roller machines is approximately 1:3. The modification conducted in this study demonstrates a production capacity ratio of 1:2.6.

The cost of modifying the roller configuration—including material expenses and machining services—amounted to Rp 2,585,000. Accordingly, the break-even point (BEP) can be calculated from the modification costs and the economic value of the resulting product. The BEP obtained is:

$$\text{BEP} = \text{Rp } 2,585,000 / \text{Rp } 1,122,000 \text{ per hour}$$

$$\text{BEP} = 2.4 \text{ hours}$$

With a typical machine operating schedule of 3–5 hours per day under low-duty conditions ($f_c = 1.2$), the BEP for converting the dual-roller system to a three-roller configuration is achieved within a single day of operation.

IV. CONCLUSION

The modification of the pellet machine’s roller configuration resulted in a significant performance improvement, increasing production capacity to 2.6 times that of the original system. The modification did not require changes to the existing drive motor, as the installed power

remained adequate, thereby contributing to improved energy efficiency. The break-even point (BEP) can be achieved within a single day of operation, indicating a highly favorable economic outcome.

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