Vol.1, No.1, Juni **2026**,
hal. 27 - 33

JOVIIM

e-ISSN : -
p-ISSN : -

Optimization of 30° Angle Paddle Blade Design on Horizontal Mixer Machine 10 kg Capacity against Motor Load Reduction and Increased Stirring Efficiency.

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Abstract

This study aims to optimize the design of a 30 ° angled paddle blade for a 10 kg horizontal mixer to reduce the motor's workload and improve the efficiency of bread dough mixing. Problems with the previous machine included a high motor power rating (4.85 kW), a relatively long mixing time (60 minutes), the use of materials that did not meet food-grade standards, and a lack of protection for the transmission system. The design method used the French Method, which includes needs identification, concept design, detailed design, and performance evaluation. The drive system uses a 6.5 HP gasoline engine with a 1:20 WPA 60 gearbox and a belt-pulley transmission at 60–80 rpm. The drum and online mixer are made of SUS 304 stainless steel. Test results showed a reduction in motor load from 4.85 kW to 2.45 kW (49.48% power efficiency) and a reduction in mixing time from 60 minutes to 35 minutes (a 41.67% increase in productivity). Furthermore, the addition of a transmission guard enhances operator safety. Research shows that optimizing the paddle blade angle to 30° significantly improves energy efficiency, mechanical load stability, and machine productivity.

Keywords: energy efficiency; horizontal mixer; design optimization; 30° paddle blade; SUS 304

1. Introduction

The horizontal mixer is the primary equipment in the bread dough processing industry, where mixing quality is largely determined by the mixer's design, rotation speed, and the dough's rheological characteristics [1-4]. A suboptimal blade design can increase mechanical resistance, thereby increasing torque and motor power.

In the existing engine, the motor power load is 4.85 kW, and the mixing time is up to 60 minutes. In addition, the safety and hygiene aspects have not fully met the standards for the design of food industry machinery. High motor loads indicate an uneven shear-force distribution and less effective material flow patterns.

Several studies have discussed the design and fabrication of dough mixer machines, focusing on machine capacity, transmission systems, and operational performance [4-7]. However, limited studies quantitatively evaluate the effect of paddle blade geometry, particularly blade inclination angle, on motor power consumption and mixing efficiency. Therefore, optimizing the 30° paddle blade angle is an important engineering approach to improving mixer performance. A 30° blade inclination angle was chosen based on engineering considerations, as it is expected to generate a balanced axial–radial flow pattern, improve dough circulation, and reduce mechanical resistance during mixing.

The angle of inclination of the wind blades affects the axial–radial flow pattern and the distribution of shear forces during the mixing process [8], [9]. Therefore, optimizing the paddle blade angle is a technical approach to reducing system resistance and improving the machine's operational efficiency.

The novelty of this study lies in the implementation of a 30° inclined paddle blade on a 10 kg horizontal dough mixer and the quantitative evaluation of its effects on motor power consumption, torque reduction, and mixing efficiency. Unlike previous studies that mainly focused on machine fabrication and capacity improvement, this research demonstrates that blade-angle optimization can simultaneously improve energy efficiency, productivity, hygiene compliance, and operational safety.

2. Methods and Materials

2.1 Design Method

This study employs the French Method as a systematic approach to machine design and development. The method begins by identifying technical needs to determine functional specifications and design limitations. Furthermore, concept design was conducted to develop alternative solutions that meet engine performance requirements. The next stage is detailed design, which includes determining component dimensions, selecting suitable materials, and planning the transmission system. The final stage is evaluation and performance testing to ensure that the resulting design meets the design objectives technically, efficiently, and safely in operation [6], [10].

2.2 Machine Specification

The technical specifications of the developed horizontal mixer machine include:

1. Capacity: 10 kg
2. Petrol engine: 6.5 HP (≈ 4.85 kW)
3. Transmission: WPA 60 (1:20 ratio)
4. Working rotation: 60–80 rpm
5. Blade & tube material: SUS 304 stainless steel
6. Transmission system: Belt-pulley + protector (safety guard)

The belt-pulley transmission system is designed based on V-belt transmission planning [7] and slip analysis for specific workloads [11].

2.3 Test Parameters

Variable and parameter testing is designed to quantitatively analyze the effect of paddle blade angle on the horizontal machine performance of the mixer, including:

1. The independent variable in this study was the rotational speed of the mixer shaft, which was varied at 60 rpm, 70 rpm, and 80 rpm.
2. The measured variables in this study include motor power (kW) as an indicator of the load of the working system and mixing time (minutes) as a parameter of process efficiency.
3. The workload is kept constant in the form of bread dough with a mass of 10 kg to ensure the consistency of the test conditions.
4. As a comparison, a paddle blade with an angle of 0° was used to analyze the difference in performance compared to the 30° angle paddle blade design developed.

2.4 Basic of Calculation

Based on working torque:

$$P = T.\omega \tag{1}$$

$$\omega = \frac{2.\ \pi.n}{60} \tag{2}$$

where:
P = power (W)
T = torque (Nm)

ω = angular velocity (rad/s)

The relationship between power and torque in a rotational system follows the operating principles of chemical engineering and fluid mechanics, as described in the classic literature on unit operations [12].

3. Result and Discussion

3.1 Results of Machine Realization

It has total dimensions of 675 mm × 756 mm × 1118 mm, including all mechanical elements and supporting structures. The results of the horizontal bread dough mixer machine design are shown in **Figure 1**. The paddle blade design with a 30° angular inclination is shown in **Figure 2**.

Figure 1 shows the final result of the development of the horizontal bread dough mixer machine in the form of an overall assembly.

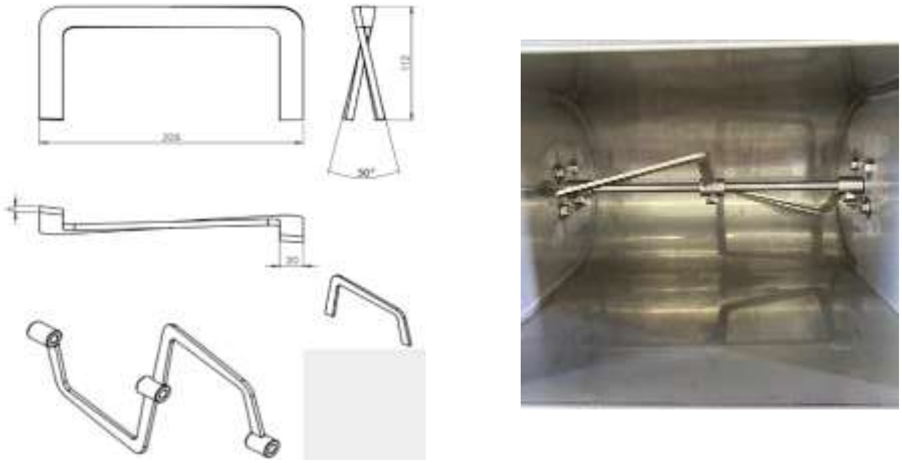

Figure 1. Paddle Blade Design with 30° Angular Tilt

3.2 Power and Torque Models

Lowering the Motor Load

Initial power: 4.85 kW

Power after optimization: 2.45 kW

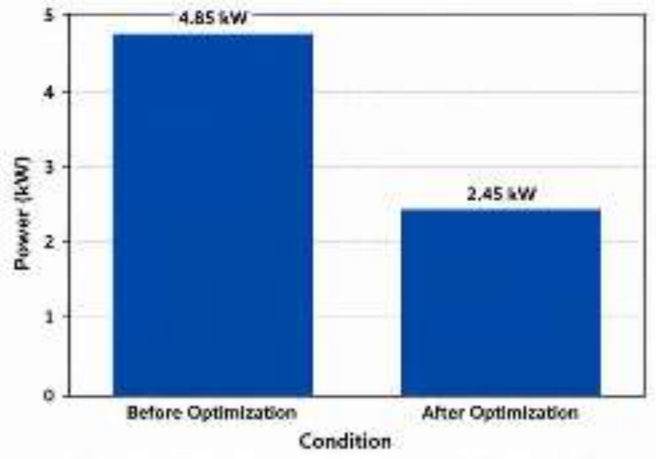

Figure 3. Comparison of Motor Power Consumption

Power efficiency:

$$\eta = \frac{4.85 - 2.45}{4.85} \times 100\% = 49.48\%$$

This decrease occurs because the 30° angle yields a more continuous material flow pattern and reduces the drag force during mixing. The motor power ratio is shown in **Figure 3**.

The relationship of power and torque is formulated:

$$P = T \cdot \omega$$

Angular velocity is calculated from:

$$\omega = \frac{2\pi N}{60}$$

With a working rotation of 70 rpm (60–80 rpm on average):

$$\omega = \frac{2\pi(70)}{60} = 7.33\ Rad/s$$

Torque Calculation

Before optimization:

$$T_1 = \frac{4850}{7.33} = 661.66\ Nm$$

After optimization:

$$T_2 = \frac{2450}{7.33} = 334.38\ Nm$$

Torque drop = 49.5%

This means that a 30° angle mechanically lowers the resistance by almost half.

The results of the comparison before and after optimization are shown in **Figure 4**.

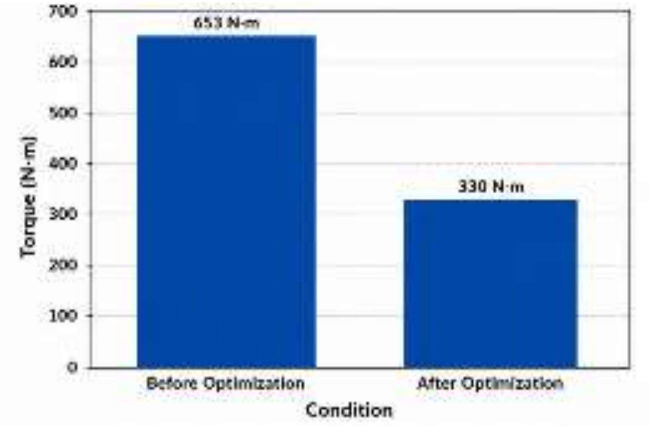

Figure 4. Comparison of Required Torque

3.3 Energy Efficiency Analysis

The mixing time was reduced from 60 minutes to 35 minutes (a 41.67% increase in productivity), as shown in **Figure 5**. The decrease in power and process time indicates that the specific energy per cycle becomes lower.

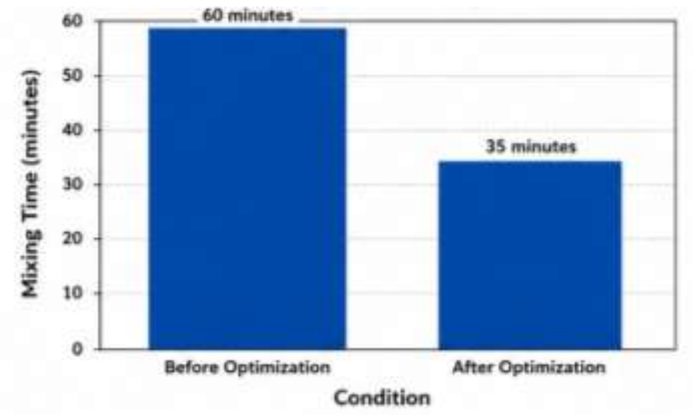

Figure 5. Comparison of Mixing Process Duration

Time efficiency:

$$\eta_T = \frac{60 - 35}{60} \times 100\% = 41.67\%$$

These results show that the system's mechanical load has decreased significantly, productivity has increased, and energy consumption per mixing cycle has decreased and become more stable [6].

3.4 Mechanical Analysis

Based on the analysis of fluid mechanics and rotational dynamics, the use of a paddle blade angle of 30° results in a more even distribution of shear force across the mixing plane. The geometric angle can improve the flow pattern toward more axial and radial components, thereby reducing the occurrence of material reinforcement and stagnant zones. This condition reduces the system's mechanical resistance, thereby directly reducing peak torque during stirring. Theoretically, the relationship between power and torque is given by equation 1, where a decrease in resistance reduces the torque and motor power required.

The test results showed that the 30° angle reduced the load torque by up to ±49.5%, with implications for dynamic load stability and a decrease in motor working current. Thus, the motor work is lighter, and the energy consumption per mixing cycle is significantly reduced. The distribution of shear forces and axial–radial flow patterns in agitation systems is influenced by the geometry of the blades, which directly affects the power and torque requirements of the system [13].

3.5 Safety and Hygiene Aspects

The safety and hygiene of the machine are improved by selecting SUS 304 stainless steel, which offers high corrosion resistance, is nonreactive with food, and meets food-grade material standards [6], [14]. This material also has a relatively smooth surface that facilitates the cleaning process and minimizes microbiological contamination.

In addition, the belt-pulley transmission system is equipped with a safety guard to prevent direct contact between the operator and rotating components [12], [15]. The implementation of this transmission protector aligns with the principle of occupational safety in industrial machinery design, namely, eliminating potential mechanical hazards and reducing the risk of work accidents [11].

4. Conclusion

Based on the results of the planning, testing, and analysis that have been carried out, it can be concluded that:

1. The optimization *of the 30° angled paddle blade* can reduce the load of the motor by 49.48%.
2. The stirring time is reduced by 41.67% so that it increases the productivity of the machine.
3. Energy consumption becomes more efficient and stable during the operation process.
4. The use of SUS 304 material improves hygiene and food safety standards.
5. The addition of transmission protectors improves the operator's work safety.

Overall, the design optimization not only improves technical efficiency but also enhances the machine's safety and operational aspects. Future studies are recommended to evaluate long-term performance and investigate the effects of different blade geometries and operating parameters on mixing efficiency.

Acknowledgement

The author would like to thank all parties who have provided support in implementing this research, including data collection, facility provision, and funding. It is hoped that the results of this research can contribute to the development of machinery technology, especially in the small- and medium-scale food processing industry.

Bibliography

[1] M. A. Rizza *et al.*, "The Effect of Mixing Time and Rotation Speed on the Consistency of Dough Viscosity in a Horizontal Mixer," *J. Mech. Eng. Sci. Technol.*, 2024, [Online]. Available: https://api.semanticscholar.org/CorpusID:274497727

[2] V. ChidanandD., "Assessment of Dough Rheological Characteristics with Mixing Time," 2020. [Online]. Available: https://api.semanticscholar.org/CorpusID:227036057

[3] I. Kovalenko, "Study of Effect of Technological Parameters of a Continuous Mixer on the Quality of Wheat Flour Dough".

[4] F. P. Adji, U. Ridhani, and M. Ikhsan, "Rancang bangun mixer untuk adonan roti," vol. 5, no. 1, pp. 8–16, 2023.

[5] B. Y. P. Nainggolan and H. Nainggolan, "RANCANG BANGUN MESIN PENGADUK ADONAN DONAT UNTUK USAHA MIKRO BERKAPASITAS 4 KG/JAM)," *J. Teknol. MESIN UDA*, vol. 2, no. 2, pp. 136–147, 2021.

[6] R. Nur and M. A. Suyuti, *PERANCANGAN MESIN-MESIN INDUSTRI*, 1st ed. Yogyakarta:

DEEPUBLISH, 2018.

[7] J. D. Siburian, "ANALISA SLIP TRANSMISI PULLEYdanV-BELT PADA BEBAN TERTENTU DENGAN MENGGUNAKAN MOTOR BERDAYA SEPEREMPAT HP," UNIVERSITAS ISLAM RIAU, 2019.

[8] H. Xu, J. Guo, S. Xu, and K. Wang, "The Influence and Optimization of Mixing Characteristics of Feed Based on Response Surface Methodology of Stirring Paddle Structure," pp. 1–24, 2025.

[9] B. Jadidi, M. Ebrahimi, F. Ein-Mozaffari, and A. Lohi, "Effect of the Mixer Design Parameters on the Performance of a Twin Paddle Blender: A DEM Study," *Processes*, vol. 11, no. 3, 2023, doi: 10.3390/pr11030733.

[10] Z. M. Nasution, D. Y. Sari, R. A. Nabawi, and R. Rifelino, "Metode Perancangan Produk Dalam Teknik Mesin," *J. Vokasi Mek.*, vol. 4, no. 3, pp. 20–29, 2022, doi: 10.24036/vomek.v4i3.389.

[11] D. D. Firdaus, A. E. Purkuncoro, and S. T. Mt, "Perancangan transmisi pembangkit listrik tenaga mikrohidro," no. mm, pp. 1–4.

[12] D. C. Prieve, *Unit Operations of Chemical Engineering*, 1st ed. Pittsburgh: Department of Chemical Engineering Carnegie Mellon University, 2017.

[13] M. Zlokarnik, "Buchbesprechung: Handbook of Industrial Mixing– Science and Practice. Von E. L. Paul, V. A. Atiemo-Obeng, S. M. Kresta," *Chemie Ing. Tech. - CHEM-ING-TECH*, vol. 76, pp. 1576–1578, 2004, doi: 10.1002/cite.200490408.

[14] S. E. Perangin-angin, A. Hamsi, M. Sabri, and I. Isranuri, "KOMPONEN-KOMPONEN DAN PERALATAN BANTU MIXER KAPASITAS 6,9 LITER PUTARAN 280 RPM," no. 2, pp. 93–107, 2015.

[15] D. R. Hartana, R. Muhfidin, and A. Jehatu, "MEKANISASI PROSES PENGADUKAN ISI ADONAN BAKPIA UNTUK MENINGKATKAN PRODUKTIVITAS ' UKM BAKPIA SRIMPI ,'" vol. 6, no. 2, pp. 355–359, 2023.