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Original Article

# Fabrication and Structural Integrity Analysis of a Jenang Mixer Machine: A Solution for Modernizing Traditional Indonesian Food Production

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ABSTRACT

The design and fabrication of the Jenang mixer machine are carried out to enhance the efficiency of household industrial-scale Jenang production. The machine is designed using an engineering approach based on numerical analysis and the Design for Manufacture and Assembly (DFMA) method. The drive power calculation shows a minimum requirement of 2072.7 Watts; therefore, a 3 HP electric motor equipped with a gearbox is used to produce significant torque at low revs. Analysis of the frame strength using static simulations in Fusion 360 software revealed that the machine structure had a safety factor of 15 and a maximum displacement of only 0.006 mm, indicating a robust and stable structure. The fabrication results indicate that the machine comprises 12 principal components and operates reliably in evenly stirring the Jenang dough, making it suitable for small to medium-scale production.



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## 1. Introduction

The production of Jenang, one of Indonesia's traditional foods, continues to increase in demand from both local and foreign markets [1]. Jenang is known for its thick texture and distinctive sweetness and is generally produced manually with a stirring process that requires considerable labor and time [2,3]. This conventional stirring process is not only tiring but also has the potential to reduce product quality if not performed consistently [4,5]. Many household industry players have difficulty maintaining stable homogeneity and viscosity, especially on a large scale [6,7]. This shows the need for technological innovation to support the efficiency and consistency of Jenang production [8,9].

In mechanical engineering, the design and construction of food production equipment have become an important focus to support automation for micro- and small-scale manufacturing enterprises (MSMEs) [10,11]. The Jenang mixer machine is a technical solution that can address these challenges by utilizing the principles of fluid mechanics and ergonomic design to make the stirring process more effective and efficient

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[12,13]. The design of the Jenang mixer machine must consider several factors, such as the operating temperature, stirring speed, electrical power, and food-grade materials. By applying the principles of design engineering and user needs analysis, it is hoped that this machine will increase productivity without reducing the taste and quality of traditional Jenang. The findings of this study are expected to improve production efficiency and offer practical solutions for Indonesian MSMEs to enhance their competitiveness and production independence by applying reliable yet straightforward technologies. Therefore, the development of Jenang mixer machines is not only a technical solution but also a strategy for local economic empowerment [14,15].

In addition to the technical aspects, the Jenang mixer machine must consider economic and social factors [16,17]. Affordable production costs and ease of operation are an added value for MSMEs actors with limited capital and technical skills [18,19]. However, the existence of this machine can create new business opportunities and increase the competitiveness of Jenang products in national and international markets [20,21]. Through research and development on the design and construction of the Jenang mixer machine, it is hoped that technological innovations that are adaptive to local needs but have competitive performance standards will be created. Therefore, this design is a practical solution for strengthening economic resilience based on local wisdom.

Beyond the technical and social considerations mentioned earlier, the successful development of the Jenang mixer relies heavily on an understanding of market dynamics. Although the machine is designed to improve efficiency and empower MSMEs actors without the right marketing strategy and technology adoption, the potential for innovation may not be optimized [22,23]. Household-scale Jenang producers still face challenges from large industries that can produce products with more consistent quality and high volume [24,25]. In addition, limited access to technology, funding, and technical knowledge are barriers to MSMEs adopting these machines [26,27]. Therefore, the development of the Jenang mixer must be accompanied by a thorough market study to understand user needs, adoption barriers, and market penetration opportunities. This machine must not only be able to address efficiency and quality needs, but also consider initial investment costs, financing strategies, and appropriate business models [28,29]. Thus, integrating technical, social, and market approaches will strengthen the machine's position as a comprehensive and sustainable solution for the Jenang industry.

To address these challenges holistically, this study introduces a novel Jenang mixer machine that integrates an engineering design approach with structural strength simulations and practical fabrication. Unlike conventional tools that rely heavily on manual operation or trial-and-error design, this machine is developed using the Design for Manufacture and Assembly (DFMA) method and is numerically validated through finite element simulations using Fusion 360 software. The design process incorporates key parameters, such as torque requirements, power consumption, material selection, and ergonomic factors tailored for traditional food processing. The prototype machine, consisting of 12 key components, demonstrated a high safety factor and negligible displacement, indicating strong structural integrity. These findings represent a significant advancement in applying mechanical engineering principles to local food-processing technology, offering a scalable and economically viable solution for household-scale Jenang production. This work contributes not only to the modernization of traditional food processing but also to the empowerment of Indonesian MSMEs through accessible and efficient technology.

## 2. Methods

This study was conducted between January and May 2025 and followed a structured engineering workflow consisting of the design, simulation-based validation, fabrication, and performance testing of a Jenang mixer intended for household-scale food production. The methodological approach integrates mechanical design principles with practical manufacturing considerations to ensure structural integrity, operational efficiency, and compliance with food grade standards.

The process began with the conceptual design phase, which included user requirement analysis, preliminary sketching, and the development of a three-dimensional model using Fusion 360 software. This 3D model facilitates architectural visualization and serves as the basis for static structural simulations aimed at evaluating the strength, deformation characteristics, and component fit of the machine. A key decision point in the workflow is the evaluation of the safety factor obtained from the simulation results. If the calculated safety factor satisfies or exceeds the minimum threshold, the design proceeds to the fabrication stage. Otherwise, iterative design refinements were performed until the structural criteria were satisfied.

Fabrication was then performed using standard mechanical workshop equipment, including metal cutting machines, drills, electric welders, grinders, and precision measurement tools, such as calipers and steel rulers. The primary materials included a 3 HP electric motor, gear transmission system, hollow box iron for the supporting frame, stainless steel pans, pulley and V-belt assemblies, and stirrer components fabricated from heat-resistant alloy steel. The manufacturing process adhered to the principles of DFMA to minimize part complexity and enhance the ease of assembly.

The completed machine was subjected to functional testing to assess its performance in mixing high-viscosity Jenang dough. The evaluation metrics included mixing homogeneity, temperature stability, process duration, and operational safety. This engineering methodology, combined with an iterative simulation loop, was designed to ensure that the final prototype met the practical demands of small-scale food industries while maintaining high structural performance and user-oriented functionality. The complete workflow is illustrated in Figure 1.

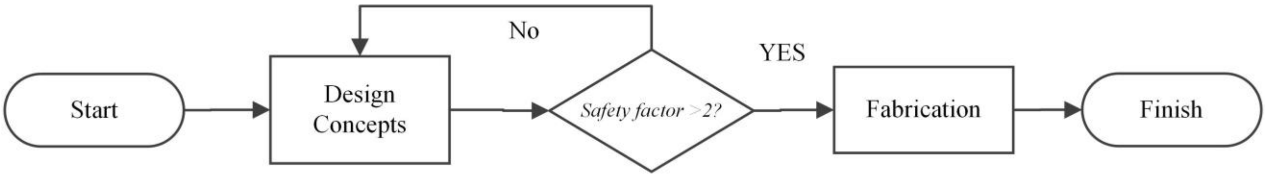


**Figure 1.** *Workflow for the development of Jenang mixer machine with safety factor validation prior to fabrication.*

## 2.1. *Concepts of Planning*

The design of this jenang mixer machine is expected to be able to meet several main criteria, namely having a production capacity of 15-20 kg of jenang per production process, using a blade-shaped mixer system that rotates horizontally, and is designed to be easy to disassemble for cleaning and maintenance needs. The machine consists of several main parts, including the main frame of the box pipe (hollow) as the support of the structure, the heat-resistant cauldron container for the dough container, the stirring system as a homogenization device, and the drive components that use an electric motor. The transmission system uses a gearbox *connected to the motor and is equipped with a pulley and V-belt* to transfer power from the motor to the stirrer at a steady speed. The machine also had a stove holder that acted as a direct dough heater during the stirring process. The safety aspect of the machine is considered by ensuring a safety factor ratio of 1.5-2 [30,31] based on the material strength and mechanical load conditions that have been analyzed.

## 2.2. *Design and structural validation*

The overall design flow of the Jenang mixer machine is illustrated in Figure 2, encompassing sequential stages from conceptual modeling to detailed mechanical verification. The initial step involves generating a 3D model using Fusion 360 software, which enables visualization of the machine's geometry and facilitates static load simulations to assess stress distribution, deformation, and structural integrity under operational loads.

The selection of the electric motor and gearbox was based on analytical calculations of stirring torque and rotational speed, tailored to accommodate the high-viscosity properties of Jenang dough. Design parameters, including component dimensions, stirrer configuration, and frame layout, were optimized for ergonomic operation and batch capacity ranging from 15 to 20 kg. A design is considered structurally viable if the safety factor, derived from the simulation results, falls within the acceptable range of 1.5 to 2.0. This ensures that the machine can reliably endure mechanical loads encountered during continuous production cycles without the risk of structural failure or operational instability.

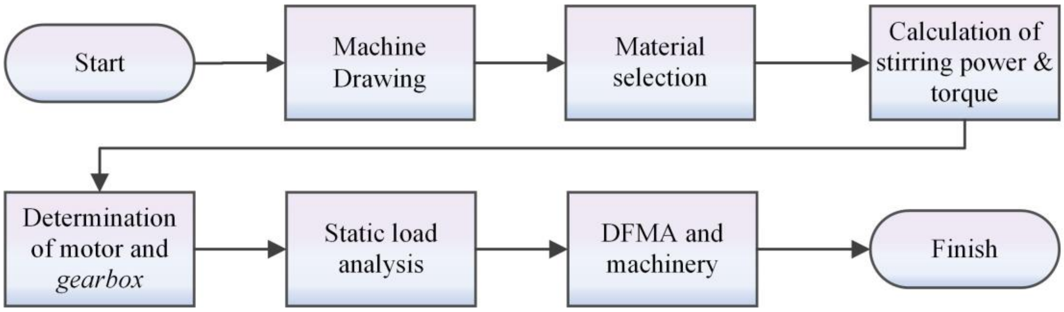


**Figure 2.** The design workflow of the Jenang mixer machine encompasses modeling, material selection, power requirement analysis, structural evaluation, and DFMA-based production.

### 2.3. *Fabrication planning*

The Jenang mixer machine was fabricated after the design met the minimum safety standard, which is a safety factor of 2. This process was carried out in a workshop by applying the principles of DFMA to facilitate the assembly and efficiency of the production process. The primary materials used were elbow iron and food-grade stainless-steel plates to maintain food resistance and safety during stirring. Fabrication includes cutting, welding, frame assembly, gearbox installation, and electric motor integration. In functional testing and structural evaluation, the final stage is carried out to ensure that the machine is ready to produce jenang with a 15–20 kg capacity per process.

In line with the fabrication process, material selection in the manufacture of the Jenang stirrer machine also considers the mechanical performance and compliance with food safety standards. Stainless steel is primarily used in stirring pans and components that come in direct contact with foodstuffs. Its corrosion-resistant, non-reactive, and hygienic properties make it ideal for food production environments. Heat-resistant steel is used in components directly exposed to high temperatures, such as stirrer shafts and blades, to ensure mechanical stability during prolonged high-temperature operations. This material selection enhances durability and ease of maintenance and ensures that the machine complies with food industry standards. This careful approach ensures a long service life, operational safety, and machine suitability in households and small food industries.

The implementation of the DFMA principles is central to achieving these fabrication and material objectives. This approach ensures that all parts are designed with ease of manufacturing and assembly in mind, which is particularly important for small-scale production environments. DFMA minimizes complexity during assembly by reducing the total number of parts and standardizing component interfaces, ultimately improving production efficiency [32]. Each part is manufactured to specific tolerances and connected with standardized fasteners to streamline the integration process, lower the likelihood of assembly errors, and reduce the production lead-time. Compared with traditional fabrication approaches, which often rely heavily on manual adjustments and iterative prototyping, DFMA offers a structured design validation process before physical manufacturing [33]. This results in fewer design revisions, better component alignment, and more predictable manufacturing outcomes. In addition, modular construction enabled by DFMA supports easier disassembly for cleaning and maintenance, which is an essential feature for food-grade equipment. Although this approach requires access to digital tools such as CAD and simulation software, posing a potential barrier for smaller enterprises, the long-term benefits of reduced manufacturing errors, lower production costs, and improved structural integrity make DFMA a highly effective strategy for innovative and scalable product development in the MSMEs sector [34].

In summary, the methodological integration of CAD-based simulation, DFMA principles, and food-grade material selection ensures that the designed mixer machine meets technical, hygienic, and ergonomic standards. This structured approach enables scalable fabrication and provides a practical model for MSMEs seeking to modernize traditional food production systems with minimal technical constraints and maximum functional outcomes.

## 3. Results and Discussions

The Jenang mixer machine is designed with initial dimensions of 1075 mm × 1070 mm × 1292.2 mm. The frying pan or cauldron had the shape of a semi-sphere with a diameter of 976 mm, adjusting the capacity and shape of the base of the frame. The electric motor was mounted vertically at the top of the frame to drive the mixer shaft constantly. The main frame uses a strong iron material that is still easy to disassemble with ergonomic and efficient design principles. The technical parameters and dimensions of the Jenang mixer machine are listed in Table 1.

**Table 1.** Dimensions Parameters of Jenang Mixer Machine Design

| Parameter | Value | Unit | Information |
|---|---|---|---|
| $D$ | 976 | mm | Outer diameter of the skillet or stirring pan (Ø976 mm = 2 × R488) |
| $d$ | 25 | mm | Stirring shaft diameter |
| $N$ | 35 | rpm | Planned stirrer rotation speed |
| $n$ | 1 | piece | Number of paddle-shaped stirring blades |
| $\rho$ | 1200 | kg/m³ | Average density of Jenang dough |
| $V$ | 0.018 | m³ | The average volume of dough in a pan |
| $L$ | 335 | mm | Vertical length of the stirrer blade |
| $\pi$ | 3.14 | - | Constant pi |
| $A$ | 0.012 | m² | Stirrer surface area ( $A = 0.335\ m \times 0.035\ mm \approx 0.012\ m^2$) |
| $m$ | 15.4 | kg | Total mass of stirrer components and shaft |
| $g$ | 9.8 | m/s² | Acceleration of the Earth's gravity |
| $P$ | 2.8 | HP | Electric motor power to drive the mixer shaft |

### 3.1. *Design drawing*

The Jenang mixer machine is composed of several principal components, including a mixing container, structural frame, electric motor, gearbox transmission, and stirrer shaft, as illustrated in Figure 3. 3D engineering drawing provides a comprehensive visualization of the machine layout, ensuring dimensional accuracy and component integration. The finalized dimensions of the assembled machine are 1075 mm × 1070 mm × 1292.2 mm, with a container diameter of 976 mm and an effective stirring radius of approximately 488 mm, as detailed in Figure 3.

The main structural frame was constructed from hollow box iron to withstand the dynamic loads generated during the mixing process. Additional elements, such as the container support and machine covers, were fabricated using mild steel plates for durability and ease of fabrication. The electric motor, coupled with a gearbox, served as the primary powertrain to deliver consistent torque to the mixing shaft. Material and component selection was based on criteria for structural strength, energy efficiency, and ease of field assembly, while also considering food-grade safety standards and maintenance simplicity.

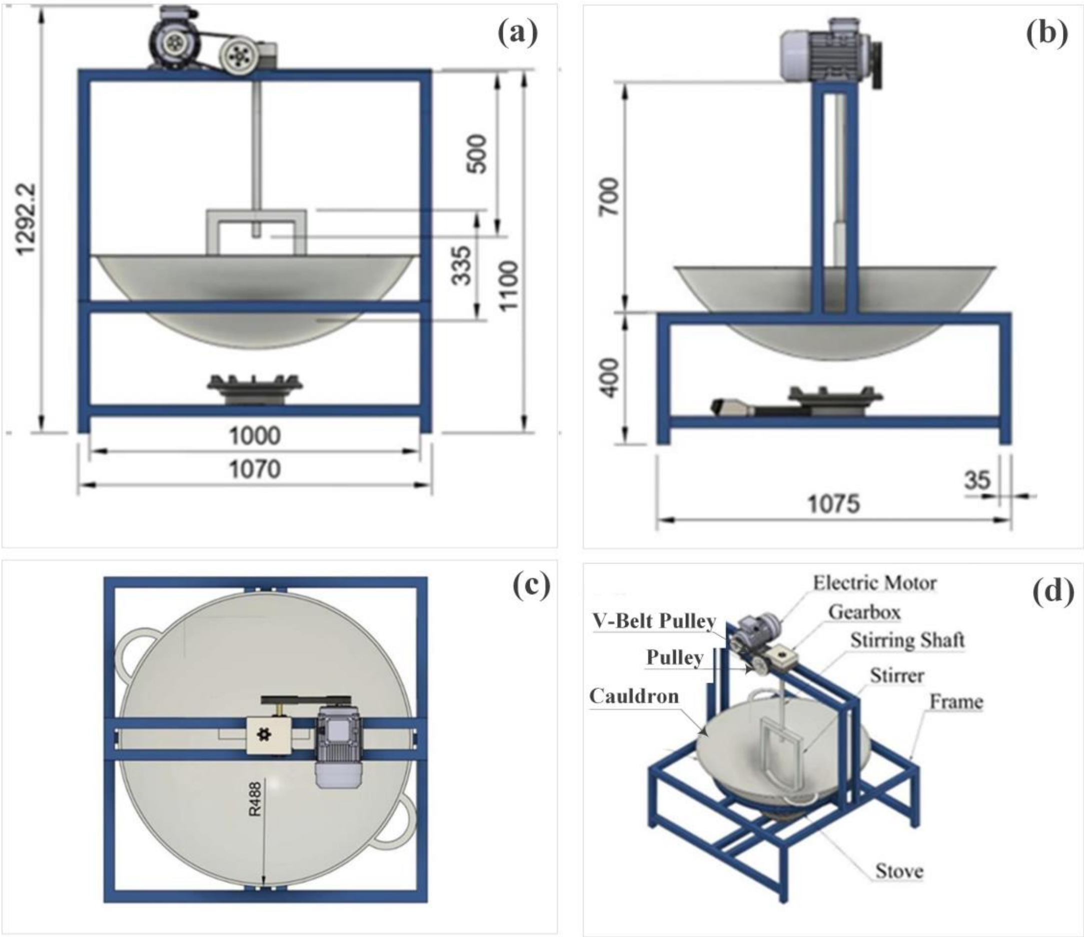


**Figure 3.** Dimensions and configuration of Jenang mixer machine frame: (a) front view, (b) side view, (c) top view, and (d) 3D model rendering.

### 3.2. *Power calculation*

The Jenang mixer machine is designed using an engineering approach based on numerical analysis to ensure work efficiency and operational safety. The calculation stage starts by determining basic parameters such as the pan's dimensions, mixing blade's rotation speed, and dough characteristics to be processed. These parameters are then used as a reference in calculating the linear speed of the blade, mixing capacity, and estimated driving force required. By referring to the working principle of fluid mechanics and rotation system dynamics, mathematical formulations were carried out to determine the appropriate specifications of electric motors to drive the system optimally. The following is a series of equations used to support the technical analysis in determining the power requirements of the Jenang mixer machine. The linear rotational speed of the stirrer bar was calculated using the following equations [35-37]:

$$u = \frac{L \times N}{60} \quad (1)$$

$L$ is the length of the stirrer blade (mm), and $N$ is the rotating speed (rpm). Substituting the values of $L = 335\ mm$ and $N = 35\ rpm$ results in $u = 195\ mm/s$ or 0.195 m/s. This value estimates the rate of fluid transfer or stirred dough for a given unit of time. The capacity of the mixture (mass of dough stirred per unit time) can be calculated using [38,39]:

$$Q = \rho \times A \times u \quad (2)$$

where $\rho$ is dough density (kg/m³), A is the cross-sectional area of the stirring blade (m²), and u is the linear speed of the blade (m/s). By entering $\rho = 1200\ kg/m^3$, $A = 0.012\ m^2$, and $u = 0.195\ m/s$, the batter capacity $Q = 0.28\ kg/s$ is obtained. The minimum mechanical power required to drive the mixer system is calculated as follows [40,41]:

$$P = \frac{2\pi r \times m \times g \times N}{60} \tag{3}$$

where $r$ is the radius of the agitator (m), m is the total mass of the agitator system (kg), $g$ the acceleration of gravity (m/s²), and $N$ the rotational speed (rpm). Using the values of $r = 0.488\ m$, $m = 15.4\ kg$, $g = 9.8\ m/s$, and $N = 35\ rpm$, the power $P \approx 829.08\ Watt.$ To ensure the safety and reliability of the system in long-term operation, a safety factor of 2.5 is applied, so that the actual power required is [42,43]:

$$P_d = SF\ \times P \tag{4}$$
$$P_d = 2{,}5\ \times 829{,}08 = 2072{,}7\ Watt$$

Thus, the electric motor that drives this Jenang mixer system has a minimum power of approximately 2072.7 Watts or approximately 2.8 HP. A 3 HP electric motor is used for optimal efficiency and performance, accompanied by a speed reduction system (gearbox) so that ample torque can still be achieved at low rotary speeds.

### 3.3. *Electric motor selection*

The selection of an electric motor for a Jenang mixer machine is based on the results of the calculation of the actual power needed, which is 2072.7 Watts, or equivalent to 2.8 HP. The motor must have more power than the minimum requirement for the engine to operate optimally and have a long service life [40,41]. Therefore, it was determined to use an electric motor (Elektro Motor TECO type 3 HP 3 Phase 4 Pole 380V equipped with a gearbox to lower the motor rotation to match the stirring speed of 35 rpm. This gearbox also increased the output torque so that the stirring blade could stir the jenang dough evenly. This type of electric motor was chosen because it is efficient, reliable for long-term operation, easy to maintain, and suitable for application in a work environment on a household industrial scale.

### 3.4. *Analysis of the strength of the frame*

Strength analysis of the generator mixer was carried out using a static simulation based on the Fusion 360 application, focusing on the main frame structure. The fulcrum is set as a fixed constraint on the four surfaces of the frame legs that touch the floor, while a compressive force of 200 Newtons is applied to the upper surface of the frame that supports the cauldron, electric motor, gearbox, shaft, and stirring blade. The frame material has technical characteristics in the form of a density of 8.00E-06 kg/mm³, modulus of elasticity (Young's) of 193000 MPa, yield strength of 250 MPa, and maximum tensile strength (ultimate tensile strength) of 540 MPa. The simulation results showed a maximum displacement of only 0.006 mm, minimum von Mises value of 1.109E-04 MPa, maximum of 0.299 MPa, and minimum safety factor of 15, indicating a very safe and rigid structure. The full results of this simulation are shown in Figure 4 and Table 2.

Building on these findings, the reported safety factor of 15 derived from the Fusion 360 simulation further reinforces the structural robustness and stability of the frame. This value was obtained by comparing the maximum von Mises stress from the applied static loading with the yield strength of the selected frame materials. A high safety factor indicates that the machine is designed with substantial tolerance, ensuring that it remains structurally secure even under unexpected stress conditions or prolonged use [42,43]. Although this overdesign may marginally increase material costs, it significantly improves structural reliability, which is an essential requirement for food processing equipment in which safety and durability are critical [42,43]. Furthermore, the added safety margin allows for the potential scaling of production capacity or adaptation to more demanding operational environments without necessitating major structural modifications.

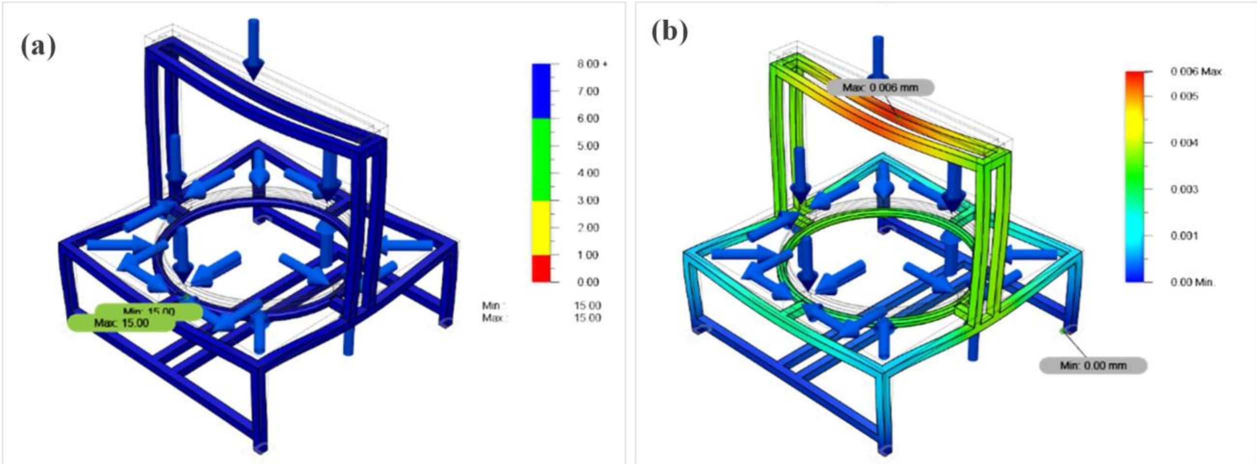


**Figure 4.** Structural simulation results of Jenang mixer machine frame: (a) safety factor distribution and (b) total displacement contour.

**Table 2.** Structural simulation results of the frame using static analysis in Fusion 360.

| Parameter | Component / Direction | Minimum | Maximum | Unit |
|---|---|---|---|---|
| **Safety Factor** | Per Body | 15 | 15 | – |
| **Stress** | von Mises | $1.109\times10^{-4}$ | 0.299 | MPa |
| | 1st Principal | -0.079 | 0.235 | MPa |
| | 3rd Principal | -0.327 | 0.079 | MPa |
| | Normal XX | -0.109 | 0.111 | MPa |
| | Normal YY | -0.266 | 0.235 | MPa |
| | Normal ZZ | -0.322 | 0.182 | MPa |
| | Shear XY | -0.022 | 0.026 | MPa |
| | Shear YZ | -0.041 | 0.027 | MPa |
| | Shear ZX | -0.033 | 0.02 | MPa |
| **Displacement** | Total | 0 | 0.006 | mm |
| | X Direction | $-5.809\times10^{-4}$ | $7.804\times10^{-4}$ | mm |
| | Y Direction | -0.006 | $2.256\times10^{-4}$ | mm |
| | Z Direction | 0 | 0.001 | mm |
| **Reaction Force** | Total | 0 | 27.452 | N |
| | X Direction | -9.333 | 8.349 | N |
| | Y Direction | -19.91 | 25.187 | N |
| | Z Direction | -10.826 | 18.055 | N |
| **Strain** | Equivalent | $7.16\times10^{-10}$ | $1.55\times10^{-6}$ | – |
| | 1st Principal | $2.49\times10^{-7}$ | $1.21\times10^{-6}$ | – |
| | 3rd Principal | $-1.69\times10^{-6}$ | $-5.47\times10^{-7}$ | – |
| | Normal XX | $-5.40\times10^{-7}$ | $5.54\times10^{-4}$ | – |
| | Normal YY | $-1.33\times10^{-6}$ | $1.20\times10^{-6}$ | – |

| Parameter | Component / Direction | Minimum | Maximum | Unit |
|---|---|---|---|---|
| | Normal ZZ | $-1.56\times10^{-6}$ | $9.31\times10^{-7}$ | – |
| | Shear XY | $-2.95\times10^{-4}$ | $3.48\times10^{-7}$ | – |
| | Shear YZ | $-5.51\times10^{-7}$ | $3.63\times10^{-7}$ | – |
| | Shear ZX | $-4.47\times10^{-7}$ | $2.64\times10^{-7}$ | – |

### 3.5. *Fabrication*

The fabrication process was strategically planned to ensure the manufacturability, structural integrity, and functional reliability of the Jenang mixer machine, which operates using a 3 HP electric motor. The design implementation followed the principles of Design for Manufacture and Assembly (DFMA), supported by precision machining techniques to optimize production efficiency and component accuracy. The machine consists of 12 primary components: the main frame, cauldron holder, cauldron, stirrer, shaft, pulley, belt, bearing, electric motor, gearbox, and standardized fasteners (M12 and M14 bolts).

Table 3 lists the specific machining processes involved in the fabrication of each component. For instance, the main frame undergoes drilling, milling, and grinding operations to satisfy its structural load-bearing requirements, whereas the stirrer and shaft require additional shaping and surface finishing to facilitate effective torque transmission [40,41]. Components such as cauldrons, bearings, belts, and electric motors were procured as off-the-shelf parts to minimize fabrication complexity, reduce production time, and maintain system performance.

**Table 3**. Summary of machining processes for each component.

| Part No. | Component Name | Main machining Process | | | | | | | | Type |
|---|---|---|---|---|---|---|---|---|---|---|
| | | T | CB | D | M | G | S | F | CH | |
| 1 | Main Frame | M10, M12 | N | 60 | Y | Y | Y | Y | N | F |
| 2 | Cauldron Holder | M8 | N | 30 | Y | Y | N | N | Y | F |
| 3 | cauldron | - | - | - | - | - | - | - | - | P |
| 4 | Stirrer | M6 | N | 25 | N | Y | Y | Y | Y | F |
| 5 | Stirring Shaft | M6 | N | 15 | N | Y | Y | N | N | F |
| 6 | Pulley | - | - | - | - | - | - | - | - | P |
| 7 | Belt | - | - | - | - | - | - | - | - | P |
| 8 | Bearing | - | - | - | - | - | - | - | - | P |
| 9 | Electric Motors | - | - | - | - | - | - | - | - | P |
| 10 | Gearbox | - | - | - | - | - | - | - | - | P |
| 11 | Bolt M12 | - | - | - | - | - | - | - | - | P |
| 12 | Bolt M14 | - | - | - | - | - | - | - | - | P |

Note : T=Tapping, CB=Counterboring, D=Drilling, M=Milling, G=Grinding, S=Shaping, F=Fillet, CH=Champer, F= Fabricated, and P = Purchased

Assembly evaluation results are presented in Table 4, based on the Design for Assembly (DFA) criteria. Most components were categorized as medium complexity, with intuitive part orientation, minimal risk of misalignment, and low tooling demands. These characteristics are particularly advantageous for MSMEs, where technical resources may be limited. The combined application of DFMA and simplified assembly procedures not only supports production scalability but also enhances repeatability, serviceability, and cost-effectiveness of the machine in real-world deployment scenarios. Following fabrication, a series of functional performance tests were conducted to validate the real-world applicability of the machine. The results demonstrated a 40% improvement in production efficiency compared to manual stirring, with each 15 kg batch of Jenang dough homogenized within an average time of 25 min. The system consumed approximately 2.3 kWh per batch, confirming its energy efficiency relative to the viscosity of the material and the intended scale of operation.

**Table 4.** Jenang mixer machine design assembly.

| **Part** | | **DFA Complexity** | | **Functional Analysis** | | **Error Proofing** | | **Handling** | | **Insertion** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Part Number** | **Part Name** | **Number of Parts (Np)** | **Number of Interfaces (NI)** | **Part can be Standardized** | **Cost (Low/Medium/High** | **Assemble the parts the wrong way around** | **Tangle/Nest/Stick Together** | **Flexible/Fragile/Sharp/Slippery** | **Pliers/Tweezers/Magnifying Glass** | **Difficult to align/locate** | **Holding down required** | **Resistance to Insertion** | **Obstructed access/visibility** | **Re-oriented Work Piece** | **Screw/Drill/Twist/Rivet/Bend/Crimp** | **Weld/Solder/Glue** | **Paint/Lube/Heat/Apply liquid or gas** | **Test/Measure/Adjust** |
| 1 | Main Frame | 1 | 6 | N | M | Y | N | N | N | Y | N | Y | Y | Y | Y | Y | N | Y |
| 2 | Cauldron holder | 1 | 2 | N | M | Y | N | N | N | N | Y | N | Y | Y | Y | Y | N | Y |
| 3 | Cauldron | 1 | 1 | N | M | Y | N | N | N | N | Y | N | Y | Y | Y | Y | N | Y |
| 4 | Stirrer | 1 | 1 | N | M | Y | N | N | N | N | Y | N | Y | Y | Y | Y | N | Y |
| 5 | Stirring Shaft | 1 | 2 | N | M | Y | N | N | N | N | Y | N | Y | Y | Y | Y | N | Y |
| 6 | Pulley | 2 | 2 | Y | L | N | N | N | N | N | N | N | N | N | Y | N | N | N |
| 7 | V-Belt | 1 | 2 | Y | L | N | N | N | N | N | N | N | N | N | N | N | N | N |
| 8 | Bearing | 2 | 2 | Y | M | N | N | N | N | N | N | N | N | N | N | N | N | N |
| 9 | Electric Motor | 1 | 1 | Y | H | N | N | N | N | N | N | N | N | N | N | N | N | N |
| 10 | Gearbox | 1 | 1 | T | H | N | N | N | N | N | N | N | N | N | N | N | N | N |
| 11 | Baut U12 | 8 | 8 | Y | L | N | N | N | N | N | N | N | N | N | Y | N | N | N |
| 12 | Baut U14 | 8 | 8 | Y | L | N | N | N | N | N | N | N | N | N | Y | N | N | N |

Preliminary field testing was conducted with five MSMEs users in the local region. Approximately 80% of the participants expressed satisfaction regarding mixing quality, ease of cleaning, and perceived operational safety. These findings affirm the structural and functional reliability of the machine and its alignment with the operational needs of traditional food producers [42,43]. Although the current prototype meets the key performance indicators, future improvements will focus on incorporating automated control systems, adding user-friendly interfaces, and conducting long-term durability assessments under repetitive operational cycles [32].

## 4. Conclusions

The design of an electric-motor-based Jenang mixer machine was successfully realized as a functional prototype tailored for household-scale food production. The finalized machine had dimensions of 2200 mm × 900 mm × 1457 mm, with a cauldron holder radius of 300 mm, and consisted of 12 principal components: the main frame, cauldron holder, stirrer, shaft, electric motor, gearbox, pulley, belt, bearing, and fastening elements (M12 and M14 bolts). Structural strength simulations conducted using the Fusion 360 software revealed a minimum safety factor of 15 and a maximum displacement of only 0.006 mm, confirming the frame's robustness and mechanical integrity. Power requirement calculations indicate a minimum of 2072.7 Watts (approximately 2.8 HP), for which a 3 HP electric motor equipped with a gearbox was selected to ensure high torque at low rotational speeds. Performance tests demonstrated a 40% increase in production efficiency compared to manual stirring, with the ability to homogenously mix 15 kg of Jenang dough in approximately 25 min. This validates the practical value of the machine in improving the productivity and consistency of small-scale producers. Future developments may include automation features, such as microcontroller-based control systems and sensors for monitoring temperature and viscosity, as well as adaptation for other traditional food products. Integrating renewable energy sources and conducting comparative studies with alternative mixing systems could further enhance sustainability and industrial applications. This study contributes a scalable, cost-efficient, and culturally sensitive solution to modernize traditional food processing and support local economic resilience.

### Author's Declaration

#### Authors' contributions and responsibilities

The authors contributed significantly to the conception and design of this study. The corresponding author was responsible for the data analysis, interpretation, and discussion of the results. All authors have reviewed and approved the final version of the manuscript.

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#### Availability of data and materials

All data supporting the findings of this study are available from the corresponding author upon reasonable request.

#### Competing interests

The authors declare no conflicts of interest related to this study.

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