PJET, Vol. 4, No. 1, July 2026: 1-14

Poly Journal of Engineering and Technology

journal homepage: https://journals.bdu.edu.et/index.php/PJET/index

Original Article

Design and Analysis of Manually and Electrically Operated Dough Mixer Machine for Small Scale Application

Geta Kidanemariam[1], Nigatu Abebe[2]

[1]Faculty of Mechanical and Industrial Engineering, Bahir Dar Institute of Technology Bahir Dar University, Ethiopia

[2]Debre Birhan City Administration, North Shewa, Ethiopia

ABSTRACT

The traditional practice of manually kneading dough in developing countries is labor-intensive and time-consuming. This research proposes a hybrid dough mixer machine designed to enhance efficiency and affordability in dough preparation for traditional products like Injera /local Ethiopian bread/ and Bread. By integrating both manual and electric operations, the machine aims to improve accessibility for small and medium-sized house hold, restaurant and hotel in lower-income communities. The hybrid design features a 3 hp electric motor combined with a pulley and belt system for automated mixing, and a hand crank for manual operation. The machine has a batch mixing capacity of 15 kg, with an overall working capacity of 66 kg per hour. Comprehensive design analyses were performed on critical components including the aluminum cylinder, pulleys, hand crank lever, stainless steel helix blade, shaft, bearings, and main frame. This hybrid dough mixer machine offers a practical solution by combining functionality and cost-efficiency, presenting a viable alternative to imported models. It addresses the diverse needs of users by providing both manual and electric options, thus improving dough preparation in resource-limited environments. It is recommended to evaluate with practical application and promote to the end-users. The research successfully developed a versatile and cost-effective dough mixer machine capable of operating both manually and electrically. The technology is easy for manufacturing, operations, maintenance and after promotions in different areas it could be as one appropriate technology which can minimize women work load in rural and urban areas.

***Keyword**: Conceptual Design, Dough, Efficiency, Hybrid system, Kneading*

DOI : https://doi.org/10.20372/pjet.v4i1.2753

Corresponding Author: Geta Kidanemariam

***Email**:* getakimariam@gmail.com

1 Introduction

A dough mixer is a device used to mix water and flour into dough in homes and large bakery industries [1,2,3] The mixing machine is used to make high-quality products and save the time spent on dough preparation [4,5]. But the machine is not used by all people except larger institutions. In our country, water and flour are traditionally mixed by hand, which is a difficult job for women due to various household chores. Due to the expense and accessibility of the machine, the dough kneading machine is not available to lower income societies. Mixing dough is still very troublesome and time-consuming. The importance of dough mixing, knowing the requirements of each type of flour when mixing and achieving the right quality in relation to the final dough properties are still current problems. Although for small and medium productions, manual dough mixing is still common in developing countries due to economic reasons [7]. Manual mixing is very slow and laborious with little or no guarantee of end product homogeneity. For this reason, design of dough mixing machine is prepared for the solution of minimizing the challenges of traditional kneading activities. Conventional dough mixers such as blade; Hook, tape and pin types are mainly used in industry [8]. Mixing is an important step in the production of all types of bread, as the properties of the mixed dough are critical to successful baking [6].

Most machines available on the market are electrically powered [9]. The efficiency parameters of a mixer are influenced by the order in which the various ingredients are introduced into the mixer, the type of mixer, and the nature and magnitude of the forces on the shaft and the direction in which they act and are used to improve mixing quality, to reduce stirring resistance, to reduce shaft and blade failure and power consumption. Despite so many batter mixers on the market, many small and medium-sized manufactures in developing countries still use the traditional method of hand batter mixing for reasons of economy. The challenge of making inexpensive kneaders had led to the development of mega dough kneaders, which gained popularity in high-intensity bakeries. However, the cost of dough mixing still remained unaffordable for small and medium-sized bakeries. The high cost of electric dough mixers makes them unaffordable for many lower-income households, leading to the continued reliance on manual methods in homes, restaurants, and hotels [8]. And the current dough mixer machine is not comfortable to move place to place [10][11][12]. This research aims to address these issues by designing and analysing an affordable, efficient dough mixing machine.

2 Material and methods

The research follows the standard procedures for the product development, starting the problem identification and customer requirements through semi structural questioner and observations and concept generation to design and analysis. Based on the customer requirements the dough mixer machine has to be considered the following parameters:

- The power source of the machine is both electric power and human power
- The capacity of the machine is 60kg/hours
- The total size of the machine is height 1050mm, width 580mm and depth 380mm
- The cost of the machine is maximally 24842.4 birr

- The machine is easy to move from place to place
- The efficiency of the machine is 86%
- Have a great strength and Easy to maintaining and operating
- Long life and Spare part existence

2.1. Conceptual design:

Main function of the mixer

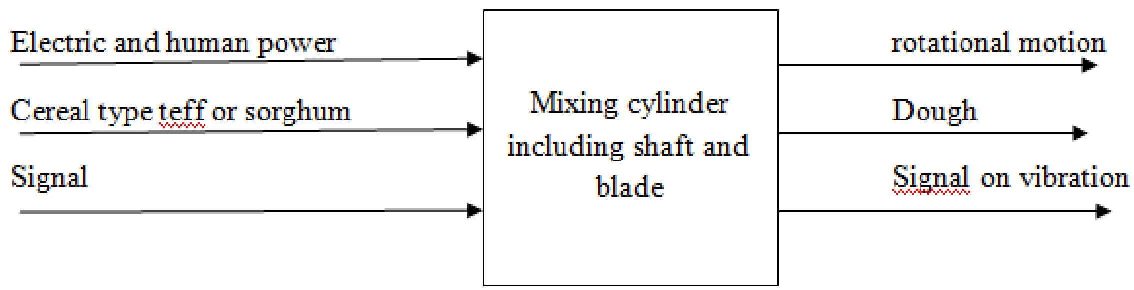

Figure 1. Main function of the dough mixer

2.2. Sub-function of the mixer

Table 1. Sub function of the mixer

Sub function	Option			Final choice
Power source	Human power	Electric power	Solar power	Both human and electric power
Mixing container	cylindrical	rectangular	trapezoid	Combination of Cylindrical & rectangular
Mixer	Helical blade or spiral blade	Wire Whisk	Flat Beater (Paddle)	Helical blade or spiral blade
Power transmission	Pulley	belt	Shaft	Pulley, belt, and shaft
Cereal type	Teff	sorghum	Weight	teff and sorghum

2.3. Concept generation

Based on the above product design and development method identify the dough kneading process is how much very challenging practices in the house hold, restaurant and hotels. Because of that the researcher to think the necessity of dough mixing machines by low costs and optional power source. Based on the sub functions with different options four independent concepts were generated as depicted on the Figure 2.

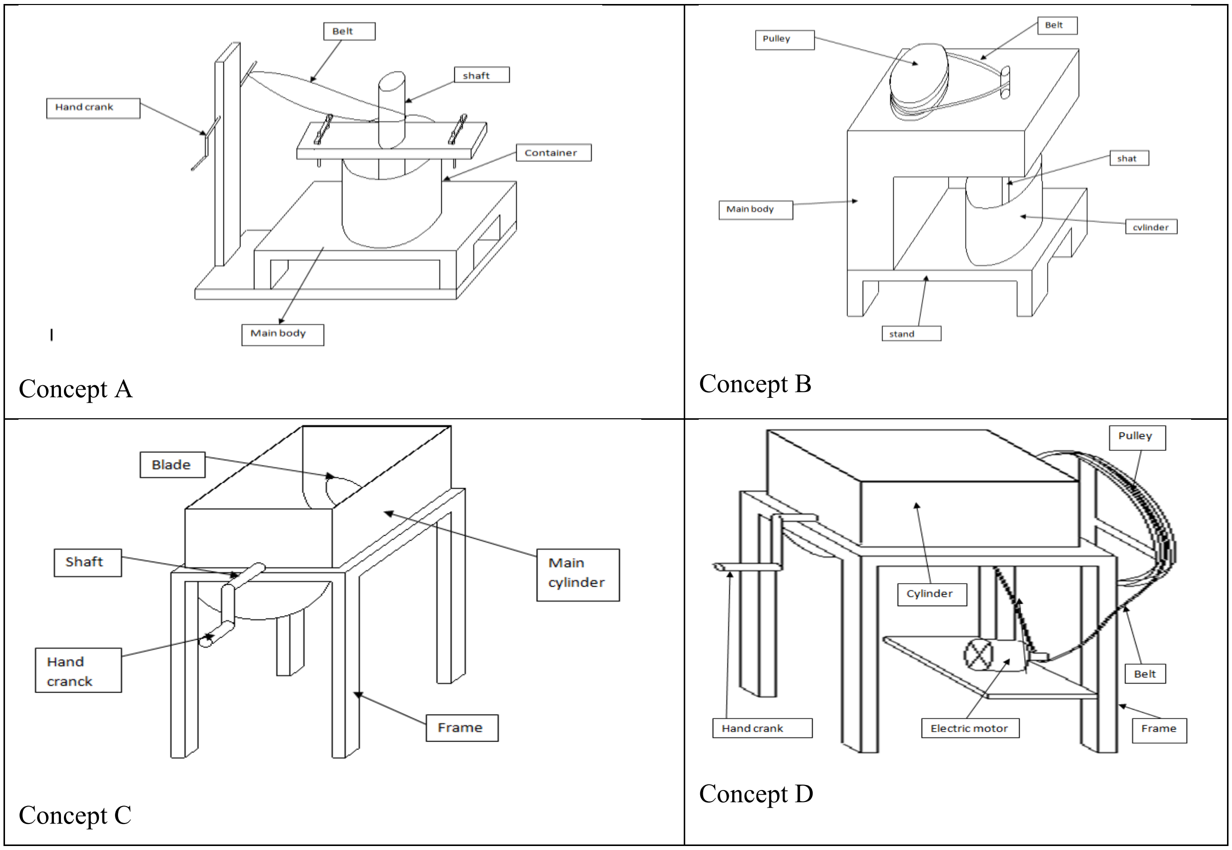

Figure 2. Concept alternatives

The design concepts were evaluated on the criteria of cost, Acceptance of machine in both urban and rural area, Optional power source, and Easy to operate. These criteria (objectives) for evaluation are ranked equally and hence have equal weight. The scores are tabulated in Table 3-1.

Table 2. Concept scoring for selection of concepts

	criteria for evaluation				
Concept	Cost	Acceptance of mixer	Optional power source	Easy to operate	Total
score concept "A"	4	2	3	3	12
score concept "B"	3	3	4	5	15
score concept "C’’	4	2	3	3	12
score concept "D"	2	5	5	4	16

Based on the above selection criteria concept “D” is scored the highest value and therefore stands to be the best for consideration. The design is more acceptable for both urban and rural areas house hold, restaurant and hotels. It is easy to maintain and operate by skilled and unskilled persons. Because of the design concept ‘’D’’ is the best option.

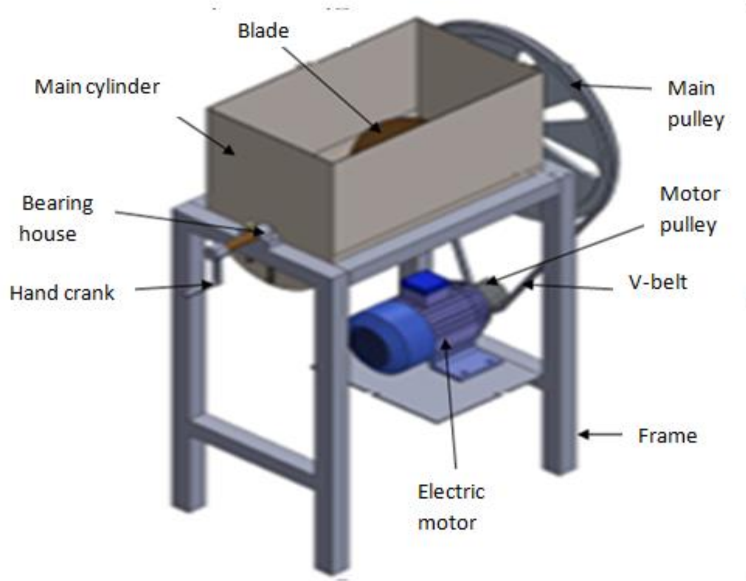

Figure 3. Isometric drawing of dough mixer machine

2.4. Working principle

The two fundamental mechanisms are used to operate a dough mixer machine. Both manually operated and electric operating systems fall under this category. Both methods of mixing involve adding flour and water to the cylinder's main chamber first. The dough is then prepared by rotating a hand crack when using human strength and by using an electric powers source and a belt and pulley system. The blades mix the flour in both mechanisms as they revolve around a shaft, the helical shape of the blade helps two rotate in both side at opposite directions, this will facilitate to push the mixed dough towards the centre of the cylinder. After that, the ingredients are combined to create uniform dough.

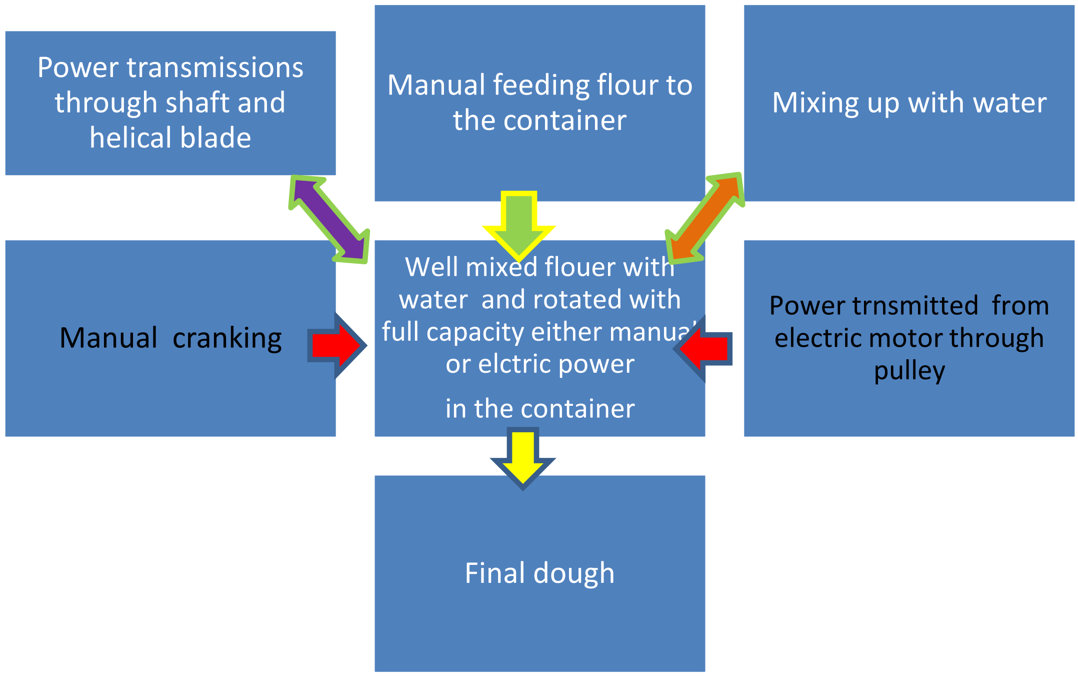

Figure 4. Working principal flow chart for the dough mixing operations

3. Result and Discussions

3.1. Selection of Motor Power

For this design, the researcher to select an electric motor as energy source by considering the following factors: Dough mixer machine has one distinct part that required a power source, in order to drive shaft and blade to produce quality dough.

3.2. Design Parameters

1) Producing quality dough.
2) Capacity of 66 kg/hr.

Now, using the above parameters the researcher can select the power requirement as follows;

- In order to produce dough having a capacity of 66kg/hr, the researcher to select 20mm diameter shaft for having the power requirement of 1.5 KW – 2.5 KW.

Then take the average power required $\frac{1.5+2.5}{2}$ KW = 2 KW

In order to transfer the power from the motor to the pulley the researcher to use a V-belt efficiency of 76 - 90%. We assume that the belt efficiency as 90% for the maximum belt efficiency. (Source: Norton, Machine design).

Then, the maximum power required by the dough mixer machine can be determined by using the belt efficiency and total power required.

$$P\ Max = \frac{Total\ Power}{BeltEfficiency} = \frac{2KW}{0.90} = 2.22\ \text{KW}$$

Therefore, the maximum power required for the motor power is 2.22 KW.

The motor power specification is based on the horse power. So, change those powers (KW) in to the unit of horse power. The designed motor horse power is 2.97 hp, so take a standard motor horse power having 3 hp. Since a 3 hp motor power is greater than the maximum power required by the machine, so the selection of motor power is safe.

3.3. Design Volume of main cylindrical part

The main cylindrical component is a critical part of the dough mixer, as it is where the primary mixing of water and flour occurs. This cylindrical chamber facilitates the thorough blending of ingredients, ensuring a homogeneous dough mixture. For this purpose, the cylindrical part is constructed from Aluminum 3003. This material is selected for its excellent resistance to oxidation and corrosive attacks from most corrosive substances, making it highly durable in various environments. Additionally, Aluminum 3003 is known for its minimal reactivity with food ingredients, ensuring that there are no adverse reactions that could affect the quality of the dough or pose health risks. The choice of Aluminum 3003 also contributes to the overall efficiency and longevity of the dough mixer. Its lightweight nature reduces the load on the mixer's drive system, enhancing energy efficiency and ease of handling.

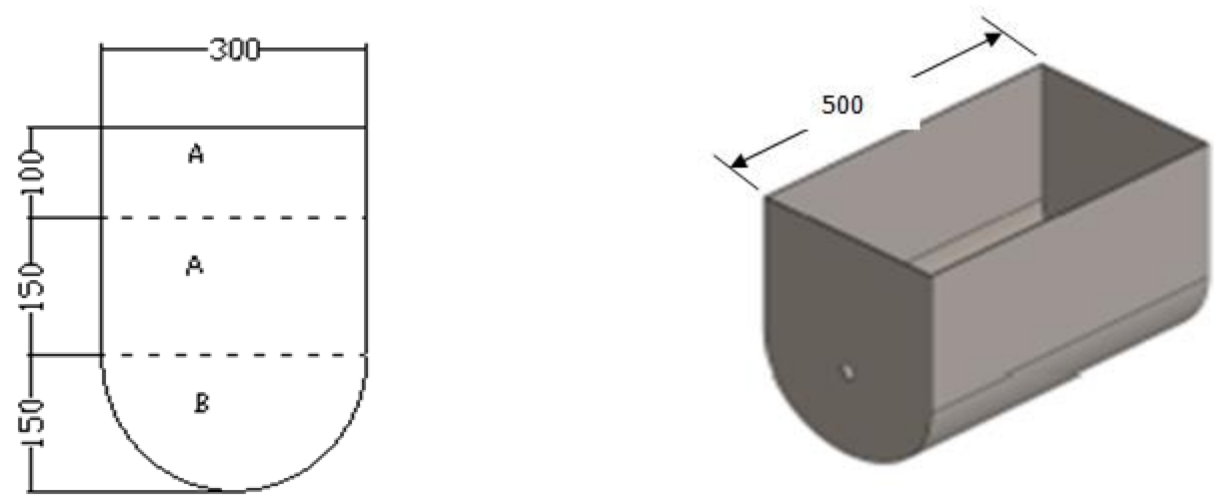

Figure 5. Main Cylindrical Part

Since the cylinder is not fully a circular or rectangular Figure 5, so the volume is obtained by subtracting the rectangular volume from total volume.

Then rectangular volume:

$V = l \times A$

$V_{AA} = l \times w \times h$

$= 300 \times 500 \times 150$

$= 0.0225\ m^3$

Circular volume: $-V_B$

$$\frac{1}{2}\left(\frac{\pi d^2}{4}\right) h \times w$$

$$\frac{1}{2}\left(\frac{\pi \times 0.3^2}{4}\right)0.15 \times 0.5$$

$=0.0026494 \text{ m}^3$

Total Volume of the cylinder

$$V_T = VAA + VB$$

$$=0.0225 \text{ m}^3 + 0.0026494 \text{ m}^3$$

$$=0.0251494 \text{ m}^3$$

But: density of flour selected based on the variety of different cereals the main choice of our peoples. Because of that density of the flour is listed below [13, 14, 15,]

Table 3. Bulk density of flour

No.	Flour type	Bulk density of flour
1	Teff	0.55 kg/mm^3 or 550kg/m^3
2	Sorghum	0.54 kg/mm^3 or 540kg/m^3
3	Wheat	0.59 kg/mm^3 or 590kg/m^3
4	Corn	0.72 kg/mm^3 or 720kg/m^3

Based on the above table 3 select the major and indigenous cereal crops in Ethiopia that is Teff flour density.

Mass (m) = volume (v) x density (ρ)

$= 0.0251494 \text{ m}^3 \text{x } 550\text{kg/m}^3 = 13.83\text{Kg} \approx 15\text{kg}$

$=15\text{Kg} \times 9.81\text{m/s}^2 = 147.15\text{N}$

Since the mass (m) falls within the accepted limits of 15 kg for a house hold consumption, then the design size is acceptable. The force applied on the handle (shaft) in the container is determined using the formulas(equ.1-4) and obtained as 122. 65N power.

Design of main cylindrical parts considering the circumferential or hoop stress on main cylindrical part is calculated based on [14].

δ_t = Pi x d/2t -- (1)

Where:

δ_t = thickness of sheet

Pi = is the intensity of internal pressure

d = the internal diameter of main cylindrical part, and

t = wall thickness of main cylindrical part $\delta_t \leq$ 5Mpa

But Pi = pressure due to (centrifugal force + weight of mixture)

Pi =Pc + P_w--- (2)

Where:

Pc = pressure due to centrifugal force

P_w= pressure due to weight of mixture

Centrifugal Force on Mixture

F_c= mrω ^{2} --- (3)

Where m= mass of mixture, in kg

r = radius of main cylindrical part

ω = the angular velocity in rad/s

ω = 2πN/60--- (4)

Power (P) = $\frac{2\pi NT}{60}$ and Torque (T) = Force (F) x radius (r)

T= F x r = 170N x 0.15m= 25.5Nm

P= $\frac{2\pi NT}{60}$ but P= $\frac{Work\ done\ (W)}{Time\ (t)}$ $= \frac{F\ x\ L}{t}$ $= \frac{170N\ x\ 0.72m}{1min}$ = 122.4Nm/min

Then N= $\frac{60P}{2\pi T} = \frac{60\ x\ 122.4}{2\ \pi\ x\ 30}$ = 38.98rpm

ω = 2πN/60 where N= 38.98rpm

ω =$\frac{2\pi N}{60} = \frac{2\pi\ x\ 38.98}{60}$ = 4.079rad/sec

Now $F_c = mr\omega^2$

= 15kg x 0.15m x (4.079rad/sec) ^{2} =37.44N

Since F_c is acting on the circumference of main cylindrical part

Area on which F_c acts:

Area of cylinder (Ac) = 2πrh in my design: --- (5)

Height = length of main cylindrical part

h= L = 500mm = 0.5m

w = diameter = 300 = 0.3

d = depth =400 =0.4

Area AA $_{rectangle}$ = L×W 1.6 ×0.25 =0.4m^2

Area B $_{cylindrical}$ = 0.235 × 0.15 = 0.035 m^2

Area B $_{Total}$ = 0.4m^2 + 0.035 m^2=0.75 m^2

Ac = 2π x0.15mx 0.5m = 0.47m^2

Pc = F_c= /Ac = $\frac{37.44N}{0.47}$ = 79.66Pa

P_w=ρgh-- (6)

Where: P = pressure

ρ = density of mixture,

h= height of mixture, and

g = gravity

P_w = 550Kg/m^3 x 9.81m/s^2 x 0.5m = 2687.75N/m^2

Pi = p_c + P_w

Pi = 175.53N/m^2 + 2687.75N N/m^2 = 2873.28 N/m^2

δ_t = Pi x d/2t but δ_t= ≤ 5MPa use δ_t = 600kpa

$t = Pi \times d / 2\delta t \quad d= 2r$

$t= \frac{2873.28pa \times 0.3m}{2 \times 300kpa} = 0.0012m$

t= 1.44mm use 2mm thick plate.

Weight of cylinder

Mass=volume × density

Volume =Area $_{cylinder}$ × thickness $_{cylinder}$

= 0.75 m^2 × 0.001m

= 0.0075 m^3

0.0075m^3 × 2700=2.025kg

2.025kg×9.81m/s^2= 19.865N

1.1. Design of pulley

In dough mixing machines, pulleys are crucial for transferring rotational motion from the motor to the mixing components. They enable speed adjustments by varying their sizes, allowing for different mixing speeds, and efficiently distribute power while reducing motor load and minimizing vibrations. Typically made from aluminum due to its lightweight, corrosion-resistant, and durable properties, aluminum pulleys ensure smooth and reliable performance. Their resistance to oxidation and minimal reactivity with food ingredients make them ideal for use in food processing equipment, enhancing both the efficiency and longevity of the dough mixer.

3.4. Design of Hand Crank Lever

In dough mixing machines, a hand crank is used to manually rotate the mixing components, allowing for precise control over the mixing process, especially in scenarios where power assistance is limited or for small batch adjustments. Made from mild steel 1090, the hand crank offers strength, durability, and resistance to wear and deformation under manual force. Mild steel 1090 are selected for its excellent machinability and ability to withstand mechanical stresses, ensuring reliable operation and longevity of the hand crank in the dough mixing process.

3.5. Design of Blade

The helix blade is a specialized attachment used in some dough mixers to enhance the efficiency and effectiveness of dough preparation. Its spiral or helical design is particularly effective in kneading dough, aiding in the development of gluten to achieve the desired texture and elasticity for bread and other baked goods. This design ensures uniform mixing, thoroughly blending ingredients to prevent overworking or under-mixing. Additionally, the helix blade helps reduce heat generation during the mixing process, which is crucial for maintaining dough quality and preventing overheating that could impact the final product. The helix blade has two opposite motions in one crank, i.e the clockwise direction starts from one side to the centre and anti-clockwise blade is from the centre to the end of the shaft. Its versatility allows it to handle a wide range of dough consistencies, from soft and sticky to stiff and heavy, thereby catering to various baking needs. Overall, the helix blade increases mixing efficiency, reducing the time needed to achieve the ideal dough consistency compared to others.

Determine the Number of Turns in the Helix:

The total coverage area of the helix is given as 460 mm. This can be interpreted as the total length of the helix along the shaft.

To find the number of turns (n), use the formula:

Total Length of Helix=Number of Turns × Pitch

Rearranging for the number of turns:

$$n = \frac{total\ length\ of\ helix}{pitch}\ n = \frac{460mm}{200mm} = 2.3$$

Calculate the Length of the Helix Blade:

The length of the helix blade can be determined by using the length of one complete turn of the helix. The length of one turn is essentially the helical path, which can be calculated using the formula for the helix [14,15]:

$length\ of\ one\ turn = \sqrt{pitch^2 + (circumference\ of\ shaft)^2}$..............................(12)

Where the circumference of the shaft is:

Circumference = π × D = π × 20 mm ≈ 62.83 mm

$$length\ of\ one\ turn = \sqrt{200^2 + (62.83)^2}$$

$$length\ of\ one\ turn = \sqrt{40000 + 3944.4}$$

$$= \sqrt{43944.4} \approx 209.6\text{mm}$$

Calculate the Total Length of Helix Blade:

Multiply the length of one turn by the number of turns:

Total Length of Helix Blade = Length of One Turn × n

Total Length of Helix Blade=209.6 mm×2.3≈482.1 mm

So, the total length of the helix blade is approximately 482.1 mm

a. Torque Acting on the Helix Blade

Convert twisting angle to radians: Twisting angle (radians) = $30° \times \frac{\pi}{180°}$ = 0.5236 radians

Polar moment of inertia J for a solid circular shaft:

$$J = \frac{\pi}{32} d^4 = \frac{\pi}{32} (0.02)^4 \approx 1.57 \times 10^{-9}\ m^4$$

Calculate the torque T: $T = \frac{\theta JG}{L}$

Substitute the values' $T = \frac{0.5236 \times 1.57\times 10^{-9} \times 77\times 10^9}{0.46}$

$$T = \frac{0.5236 \times 1.5 \times 77}{0.46}$$

$$T = \frac{8{,}352.57}{0.46} \approx 18.2\ N\ m$$

b. Twisting Moment

The twisting moment is equivalent to the calculated torque:

Twisting Moment=18.2 Nm

c. Bending Moment

Given:

Maximum bending moment at point C: Mc=14.52 Nm

d. Weight of the Helix Blade

Given:

- Width of helix blade: 100 mm = 0.1 m
- Length of helix blade: 482.1 mm = 0.46 m
- Thickness of helix blade: 6 mm = 0.006 m
- Density of Stainless Steel 304L: ≈ 8000 kg/m³

e. Calculate the volume:

Volume =Length × Width × Thickness

$= 0.4821 \times 0.1 \times 0.006 = 0.00028926 m^3$

Calculate the weight:

Mass = Volume × Density

$= 0.00028926 m^3 \times 8000 kg/m^3 = 2.31408 kg$

Weight = Mass × gravity

$= 2.31408 kg \times 9.81 m/s^2 = 22.70$

The frame designed using mild steel, with the given dimensions and applied loads, is well within the safety limits for bending, and shear stresses. The calculated stresses are significantly lower than the design limits, providing ample safety margins. The factor of safety of 3 ensures additional reliability. The dimensions and material properties are appropriate for the intended application, making the frame design robust and functional.

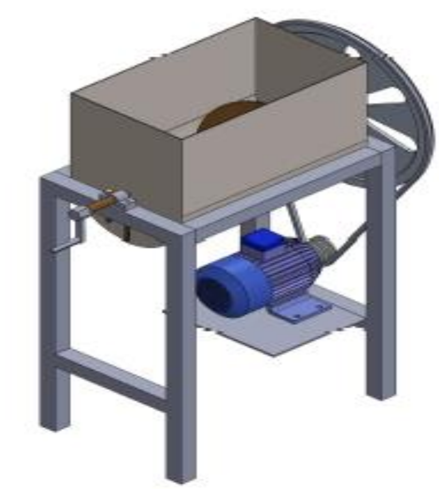

Figure 6. Final products of dough mixer machine

The designed dough mixer machine effectively combines manual and electric operation modes, offering versatility and cost efficiency. The detailed design and critical analysis ensure reliable performance, and the machine's specifications suggest it is well-suited for its intended application. This approach not only makes the machine affordable but also makes it a viable alternative to imported models.

4. Conclusion

In the Ethiopian context, dough mixing is a very challenging and time-consuming activity. The fundamental problem of dough mixing activity in Ethiopia is the traditional hand kneading to make dough, which requires a lot of energy from domestic workers. At this point, the process of kneading is very laborious and time-consuming. Because the kneading work of women in the household is still a traditional way. This activity is loaded dominantly as women's' deities.

So, the main focus of this study is to solve and minimize the challenge of women in the house hold activities by the design and analysis of a dough mixer. Dough mixing machine is used for kneading large dough. As you know in Ethiopian context there is no enough electric power in both urban and rural areas.

Because of that this research is focus on the solution of the challenges of traditional dough mixing by substituting dough mixing machine. This machine is using both electric power for electric accessible area and using human power for electric off grid area.

In the future, Ethiopia has strived to strength the dough mixing machine is to reduce the stress on women and to increase quality of dough and reduce contaminations. Because of that this electrically and manually operated dough mixer machine is highly important to the rural and urban areas of North Shewa zone, Amhara region, where the study initiated and surveyed as a research background.

The design and analysis of the both manually and electrically operated dough mixer demonstrate that it effectively meets both operational and safety requirements for mixing teff and sorghum flour. The mixer is capable of handling up to 60 kg/hour with a 15 kg batch capacity, and it can be operated using either a 3 hp electric motor or manual force with 170 N requirements.

The study successfully developed a versatile and cost-effective dough mixer machine capable of operating both manually and electrically. The design integrates essential mechanical components such as pulleys, belts, and shafts to ensure efficient power transfer and operation. The technology is easy for manufacturing, operations, maintenance and after promotions in different areas it could be as one appropriate technology which can minimize women work load in rural and urban areas.

Funding: There are no funding/funders to this research work.

Credit Authorship Contribution statement: ***Nigatu Abebe***: Investigation, writing original draft.

Geta Kidanemariam Gelaw: Supervision, Writing-review and editing

Declaration of Conflicts of Interest: The Authors declare that they have no competing interest.

REFERENCE

[1] C. M. Rosell and C. Collar, (2009). Effect of temperature and consistency on wheat dough performance," *Int. J. Food Sci. Technol.*, vol. 44, no. 3, pp. 493–502, doi: 10.1111/j.1365-2621.2008.01758.x.

[2] D. Marsh and S. P. Cauvain, (2007). Mixing and dough processing, *Technol. Breadmaking*, pp. 93–140, , doi: 10.1007/0-387-38565-7_4.

[3] W. Ajibola, I. Gbenga, W. A. Ajibola, and G. W. Ibrahim, (2020). Design and Fabrication of a Flour Mixing Machine, *Adv. Eng. Des. Technol.*, vol. 2, no. December, pp. 89–94, , doi: 10.37933/nipes.a/2.2020.8.

[4] A. Marzec, J. Kowalska, E. Domian, S. Galus, A. Ciurzyńska, and H. Kowalska, (2021). Characteristics of dough rheology and the structural, mechanical, and sensory properties of sponge cakes with sweeteners, *Molecules*, vol. 26, no. 21, , doi: 10.3390/molecules26216638.

[5] O. Oluseyi, A. Adebola, T. Olutoyin, and A. Olajumoke, (2020). Design and Fabrication of an Improved Industrial Impeller Dough Mixer, pp. 36–43, , doi: 10.9790/1813-0911013643.

[6] V. E. Munsey, (1952). Baking Science and Technology, *J. AOAC Int.*, vol. 35, no. 3, pp. 811–811, , doi: 10.1093/jaoac/35.3.811.

[7] B. O.-I. J. of E. and Technology and undefined (2015). Design of Power Driven Dough Mixing Machine, *Citeseer*, vol. 5, no. 2, pp. 76–79, 2015,

[8] C. H. Hwang and S. Gunasekaran, (2001). Determining wheat dough mixing characteristics from power consumption profile of a conventional mixer, *Cereal Chem.*, vol. 78, no. 1, pp. 88–92, , doi: 10.1094/CCHEM.2001.78.1.88.

[9] K. Ange and P. Dovi, (2019). Evaluation of Dough Mixing Properties of Sorghum Genotypes using a Micro-Scale Screening Method and Properties of Maize Prolamin Co-Protein Blends, no. October, 2019.

[10] E. D. Stoica and E. G. Constantin, (2015). Process Study on the Work of a Dough Kneader with a Planetary Motion of the Kneading Arm, no. 1, pp. 40–45,.

[11] L. Abu-Farah, T. B. Goudoulas, S. Hooshyar, and N. Germann, (2019). Numerical and experimental investigation of dough kneading in a three-dimensional spiral kneader, *Phys. Fluids*, vol. 31, no. 11, , doi: 10.1063/1.5122261.

[12] E. B. Bennion, G. S. T. Bamford, and A. J. Bent, (1997). Bakery machinery and plant, *Technol. Cake Mak.*, pp. 321–352, doi: 10.1007/978-1-4757-6690-5_26.

[13] Fadeyibi A, Aina SJ, Busari RA, Alabi KP, and Yisa MG, 2021. Optimization of Operation Parameters of a Developed Dough Mixer, *LAUTECH J. Eng. Technol.*, vol. 14, no. 2, pp. 36–48,.

[14] Shigley's, Mechanical Engineering Design, 8th Ed.optimizing its constructional and operational parameters. vol. 21, no. 2, pp. 220–225,

[15] Khurmi, R.S. (2003). Machine Design. S. Chard Company Ltd., India.