

FUTA JEET

Vol 11 Issues 1&2

December 2017

# Journal of Engineering and Engineering Technology

ISSN 1598-0271



School of Engineering and Engineering Technology,  
The Federal University of Technology, Akure, Nigeria





## Development of a Small-Scale Motorized Dough Kneading Machine

Owolabi, H. A.<sup>1</sup>, Omidiji, B. V.<sup>1</sup>, Oke, A. O.<sup>1</sup>, Morakinyo, A. T.<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, ObafemiAwolowo University, Ile-Ife, Nigeria.

<sup>2</sup>Department of Food Science and Technology, ObafemiAwolowo University, Ile-Ife, Nigeria.

### A B S T R A C T

#### Key words:

Dough, kneading machine, roller gap, kneading time, kneading efficiency.

*Dough kneading is an essential operation which enhances development of gluten that gives bread its structure. Manual dough kneading is laborious, energy sapping, and time consuming, even at a small-scale level of production. The study focussed on the development of a motorized dough kneading machine for small-scale use. The machine consists of driver and driven shafts which suspended rollers and conveyor belt, gears, pulleys, work-table, variable-speed electric motor and supporting frame. The experimental design adopted for the machine evaluation was 3 x 3 x 4 factorial design. The result showed that the maximum kneading efficiency and capacity were found to be 87% and 38.57 kg/h respectively which occurred at 3.0 mm roller gap. The optimum kneading time associated with 3.0 mm roller gap is 14.0 s. In this study, it is inferred that the developed motorized dough kneading machine is useful for small and medium-scale bakeries, needed to produce final baked products.*

### 1. Introduction

The common recipes of conventional bread are water, oil, salt, yeast and ascorbic acid, mixed together with the wheat flour in appropriate matrix inside a mixer to form dough (Gisslen, 2004; Dahiru et al., 2007). Dough can be kneaded by hand, dough hook or with a mixer. In the processing of making dough, kneading is done manually or mechanically at small-scale level instead of mixing, by massaging, pummelling and stretching of the mixture to facilitate structural development and homogenous of ingredients. Kneading of dough enhances development of gluten, the protein found mainly in wheat flour. Kneading incorporated air and breaks the air pocket to form viscous-elastic material. This mechanical operation stretches the gluten into sheets that trap the CO<sub>2</sub> as the dough expands (Hwang and Gunasekaran, 2001).

It also helps to equalize temperature throughout the dough mass and cause the subdivision of gas bubbles formed during fermentation to give uniformity and fineness to the grains (Dahiru et al., 2007 and Kordylas, 1990). The smaller the air pockets, the finer the bread texture (Gisslen, 2004). The existence of the dough kneading machine has been developed in ancient Rome since 18th century, with many modifications through patent after patent into the present century as science and technology

advances. The Deliry-Desboves dough kneader, also of French origin, consists essentially of a cast iron trough or basin, with two helical blades rotating on a vertical axis, which also form part of the mechanism, which shear and aerate the dough (Rumble, 2012). The steel roller mills were invented in Swaziland and are in use in the United States (Pyler, 1988). Many previous researchers had reported on development and modifications of dough mixers, with emphasis on two major factors such as speed and time that influences the mixing efficiency. Zounis and Quail (1997) predicted the optimum mixing time using two empirical dough mixers (farinograph and mixograph).

They reported that there is no significant difference between bread qualities once the optimum mixing time and speed are maintained. However, Hwang and Gunasekaran (2001) reported that the optimum mixing time is relative to the flour composition, bread recipes, mixer type and speed. Industrial revolution led to numerous inventions and improvement in bread making and mechanized dough mixing machines for large-scale bread production.

In Nigeria, large-scale bakeries adopted conventional dough mixers such as: vertical bowl and planetary mixers with a dough hook or a spiral blade. These mixers are powered with electric motors of higher capacities and more importantly, due to irregular supply of electricity, size and high power consumption, such equipment could not be acquired by the small-scale bakers.

Correspondence:

E-mail address:

As a result of this, there is an urgent need to develop a kneading machine of higher economy comparative advantage over mixer, running with lower capacity of electric motor which can be propelled using two-stroke engine, even at the rural area for our small-scale bakers. In this work, a small-scale dough kneading machine was developed to eliminate drudgery non-homogenous mixture and un-hygienic handling of dough using rolling pins, bottles and trays associated with small-scale dough production in Nigeria.

2.0 Materials and Methods

Materials for the components of the dough kneading machine are selected based on food compatibility, availability, sustainability for working conditions in service, and cost. Some of the important properties of the materials that influenced their selection are strength, durability, and weight, resistance to corrosion, machinability, and weldability factor.

2.1 Design calculations of working components

(a) Shaft design

The shaft design and analysis are as shown below. The diameter of a solid shaft without axial loading is determined by the formula (Khurmi and Gupta, 2003; Hall et al., 1983; Dixon and Poli, 1995):

$$d^3 = \frac{16}{\pi \sigma_s} \sqrt{(k_b \cdot M_b)^2 + (k_t \cdot M_t)^2} \quad (1)$$

Where d is shaft diameter (m),  $k_b$  is combined shock and fatigue factor of bending moment,  $k_t$  is combined shock and fatigue factor of torsion moment,  $M_b$  is bending moment(N-m),  $M_t$  is torsion moment (N-m), and  $\sigma_s$  is the allowable combined shear stress for bending and torsion moment for mild steel.

The loads on the upper shaft are due to weights of the gear and roller. Mass of the driven gear is 3.7 kg.

1 kgf = 1 kg x 9.81 m/s<sup>2</sup> = 9.81 kg- m/s<sup>2</sup> = 9.81 N (Khurmi and Gupta, 2005)

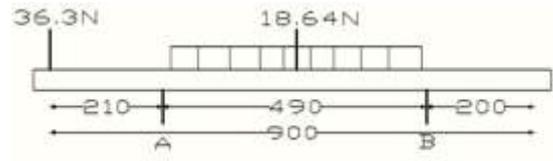
Weight of the gear = 36.30 N

Mass of the roller was estimated using the density of the galvanized steel (7850 kg/m<sup>3</sup>) and the mass of the roller is 4.09 x 10<sup>-03</sup> kg/mm

Weight of the roller = 18.64 N

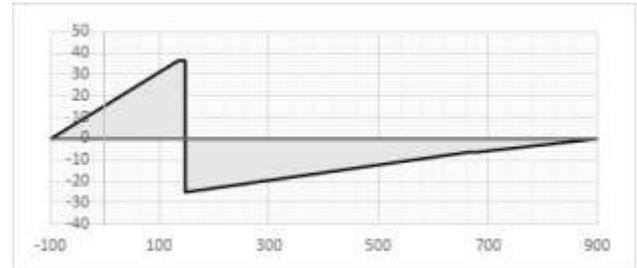
Sum of clockwise moments = Sum of anticlockwise moment

$R_a = 61.18N, R_b = -6.24N$

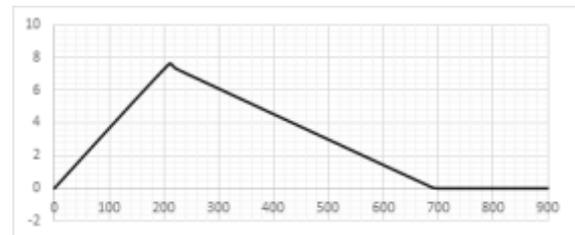


(a)

Maximum bending moment  $M_b = 7.62 Nm$



(b)



(c)

Fig. 1: Loading, shear force and bending moment diagrams for the upper shaft (a- Loading, b-Shear force, c-Bending moment).

The weight on the lower shaft is due to the weight of the gear, pulley and the roller.

- a. Mass of gear: the mass of the driving gear is 1.7kg  
Weight of the gear = 16.67 N
- b. Mass of the pulley was determined by weighing to be 3.4kg  
Weight of the pulley = 33.4 N
- c. The mass and weight of the lower roller is the same as that of the upper roller.

Sum of clockwise moments = Sum of anticlockwise moment

$R_a = 9.958N$

$R_b = 58.752N$

Maximum bending moment  $M_b = 10.85 Nm$

**Torsional Moment,  $M_t = \frac{FX 60}{2\pi N}$**

Therefore,  $M_t = 9550 \times 1.5/65 Nm$

$= 220.38 Nm$

The required shaft diameter is determined by employing the formula in eqn. (1)

$d^3 = 1.999 \times 10^{-5} m$

$d = 27.14 mm$

Therefore the minimum diameter for the shaft should be 27 mm, but 30 mm shaft was used

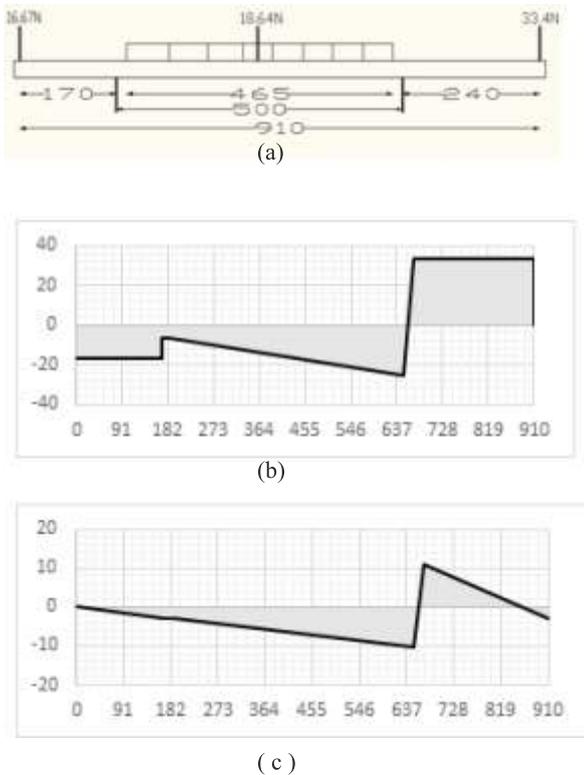


Fig.2: Loading, shear force and bending moment diagrams for the lower shaft(a- Loading, b-Shear force, c-Bending moment)

#### (b) Power Requirement

The kneading power i.e., power required to drive the shaft is given below (Morakinyo et al., 2014);

$$P = \frac{2\pi NT}{60} \quad (3)$$

Where T is Torque (Nm) and N= speed of electric motor (Speeds of a 3-phase, 50 Hz induction variable speed electric motor used for this design ranges between 50 -100 rev/min.)

Hence, taken N = 75.0 rev/min, T = 220.38 Nm, P = 1.7 kW. Therefore, 2.0 kW of variable speed electric motor was selected.

#### (c) Roller Design

The rollers exert forces on the dough as it passes through the gap between them. The rotation of the rollers was in opposite direction with the help of two spur gears which enhances kneading action on dough. Also the distance between the roller surfaces could be varied to allow for different thickness of dough to be fed into the machine. The design of the rollers is analogous to the design of two parallel cylinders in contact under the action of uniformly distributed stress between the two contacting surfaces.

The maximum pressure between the rollers is determined by (Dahiru et al., 2007);

$$p_0 = \frac{2P}{A} \quad (5)$$

Where;

$$A = \pi bL \text{ (m}^2\text{)}$$

$$P = \text{radial load of roller, (N)}$$

$$L = \text{length of contact surface, (m)}$$

$$b = \text{width of rectangular contact surface, (m)}$$

The maximum pressure between the rollers will result from the minimum thickness of the dough.

$$L = \sqrt{r\delta} \quad (6)$$

$\delta$  = minimum reduction obtained

r = radius of the material

Therefore,

$$A = \pi \times 0.465 \times 0.01063$$

$$= 1.6 \times 10^{-2} \text{ m}^2$$

$$P_0 = 18.64 / 1.6 \times 10^{-2}$$

$$= 1165 \text{ N/m}^2$$

Due to the varying mass of dough to be kneaded, the maximum pressure obtained in the roller design can knead dough of 1.5 kg with maximum of 4mm roller gap, and at the maximum speed of 100 rpm, as presented in section 3.1.

#### (d) Belt Drive

Following are the various factors upon which the selection of a belt drive depends (Khurmi and Gupta, 2005): speed of the driving and driven shafts, speed reduction ratio, power to be transmitted, centre distance between the shafts, positive drive requirements, shafts layout, space available, and service conditions.

Factors of power adjustment include speed ratio; shaft distance; type of drive unit (electric motor); service environment (wet, dusty); and pulley-belt arrangement (open). The pulley diameter also determines the size of belt used. Two belts of different sizes are used: one connecting the electric motor to the lower shaft and the second belt is used to transmit motion from the lower shaft to the conveyor shaft; both are V-belts and A-type of belt.

The choice of A-type belt is its capability of transmitting power ranging from 0.1 kW to 3 kW, which is within the range of design capacity.

2.2 Description of working components of the dough kneading machine

The exploded view of the machine with part list of components and orthographic projection of the machine are presented in Figure 3 and 4.

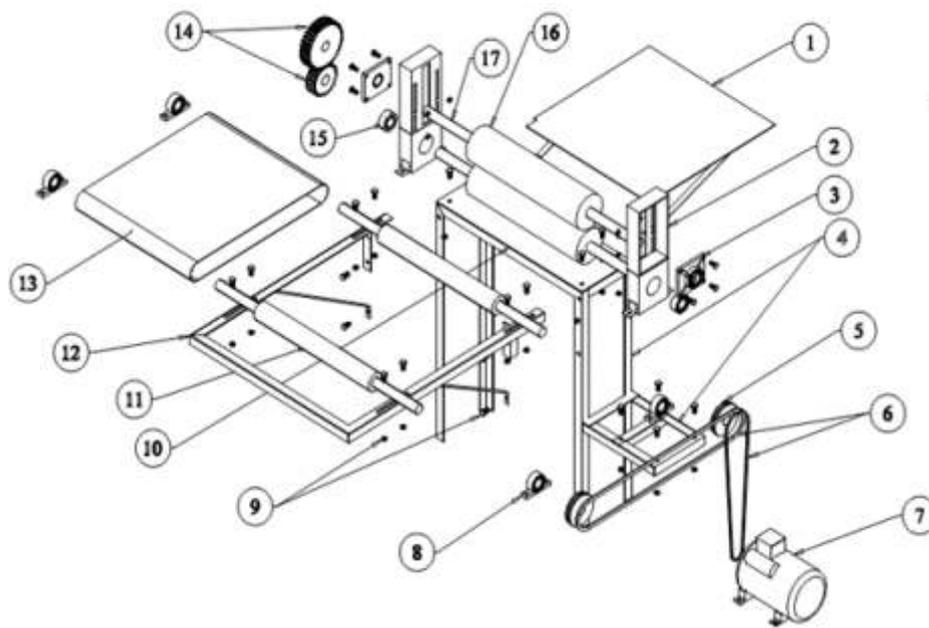
(a) Body Frame/Support

The frame provides mounting points to all other components of the machine. The kneading machine frame was constructed with angle iron and while some members of the frame were welded, others

were fastened using bolts and nuts. Only the temporary joints that are fastened with bolt and nuts are shown in the exploded drawing.

(b) The Working Table

The work table provides a platform on which the rolled dough is fed. The design consideration was such it could withstand the handling load of the dough while been fed in between the rollers during kneading. The exploded drawing and part list containing information on machine parts, and materials used are presented in Figure 3.



| PART LISTS |          |                 |                            |
|------------|----------|-----------------|----------------------------|
| Item No    | Quantity | Part Name       | Description                |
| 1          | 1        | Feed Table      | Mild Steel (503mm x 405mm) |
| 2          | 2        | Roller Support  | Mild Steel                 |
| 3          | 2        | Flange Bearing  |                            |
| 4          | 1        | Body Frame      | Angle Iron (30 x 30)       |
| 5          | 2        | Pulley          |                            |
| 6          | 2        | Belt            | Leather                    |
| 7          | 1        | Electric Motor  |                            |
| 8          | 4        | Pillow Bearing  |                            |
| 9          | 26       | Bolt & Nut      | Mild Steel (M12)           |
| 10         | 1        | Platform        | Mild Steel (610mm x 320mm) |
| 11         | 2        | Conveyor Roller | Galvanized Steel (Φ 60mm)  |
| 12         | 1        | Conveyor Frame  | Angle Iron (30 x 30)       |
| 13         | 1        | Conveyor        | Awning Fabric ( 1160mm)    |
| 14         | 2        | Gear            |                            |
| 15         | 2        | Ball Bearing    |                            |
| 16         | 2        | Roller          | Galvanized Steel (Φ 113mm) |
| 17         | 4        | shaft           | Mild Steel (Φ 30mm)        |

Fig. 3: Exploded view of the motorized dough kneading machine

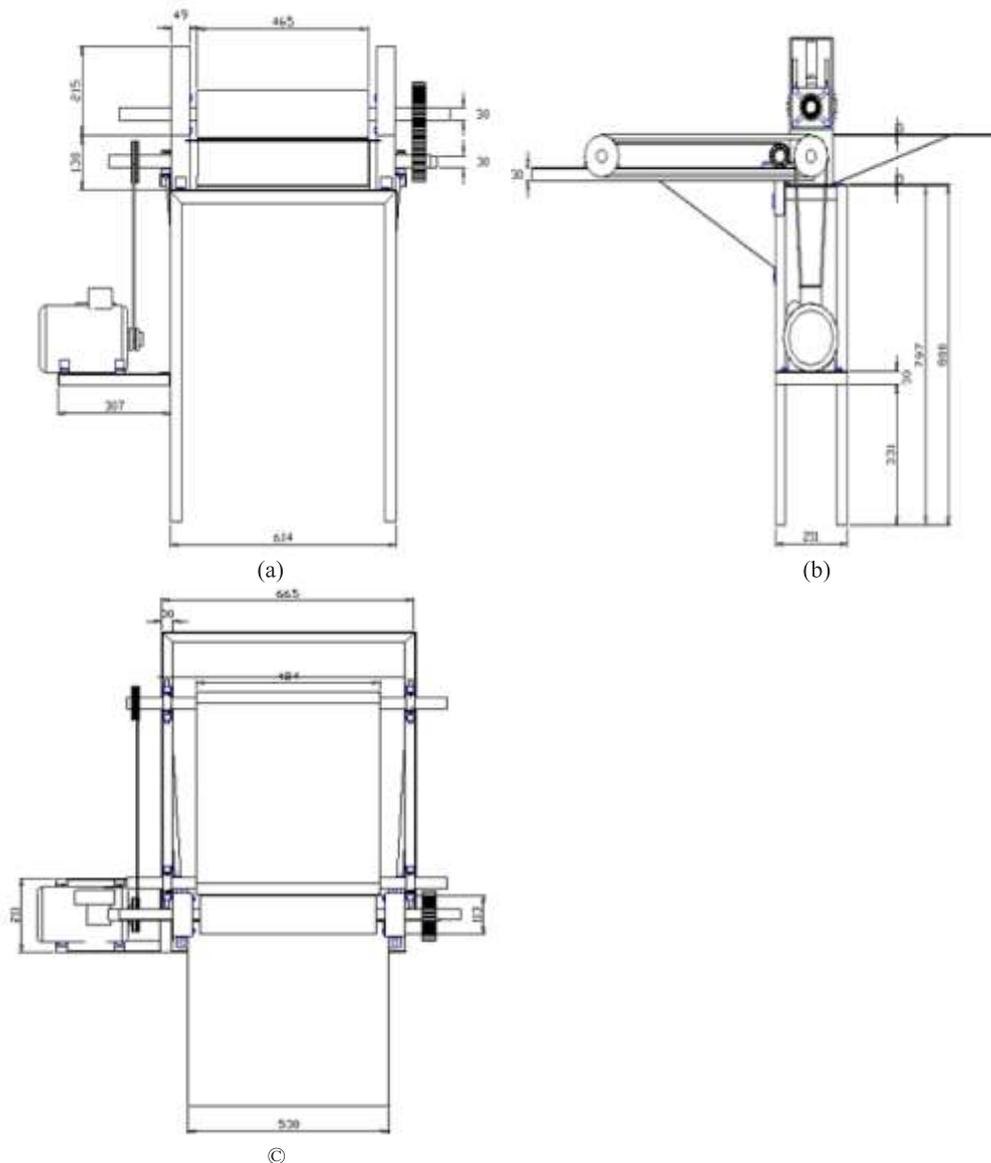


Fig. 4: Orthographic views of the machine (a-front view, b-side view, c- plan)

#### (c) Pulleys

The pulleys used are made of cast iron based on its low cost, good friction and wear characteristics as compared to pulleys made of mild steel which are lighter than the cast pulleys, but in many cases, its surface roughness generates high friction that may produce excessive wear of v-belt. To keep the driving part at its smallest distance, minimum-diameter pulleys are used. A single-groove pulley is attached to roller shaft and a double-groove pulley attached to the lower roller shaft.

#### 2.3 Fabrication Process

The operations involved in the fabrication of the machine starting from marking out procedure are; cutting operation, grinding operation, drilling operation, welding and painting. The cutting operations involve the use of oxy-acetylene

flame, hand grinder using cutting disc and chisel and hammering. Drilling operations were done using hand drilling machine, to drill holes into the frames for bolts and nuts to be used for assemblage. All other parts apart from those detachable were welded together using arc welding machine. Finally, for smooth surfaces and removal of all sharp edges, grinding operation was carried out using grinding disc, and thereafter was the painting of the job.

#### 2.4 Machine working principle

The machine operation is initiated by a motor drive, the motion which in-turn is transmitted to the bottom roller via the pulley attached to the shaft of the roller. This motion is simultaneously transmitted to the upper roller through the spur gear. The dough is fed through the rollers turning it into sheets until the desired thickness and texture is reached. The dough is flattened

by passing through the gap of the rollers. The design of the dough kneading machine is such that, with the aid of a motor drive attached to the lower roller at one end, the two rollers rotate in opposite direction with the aid of spur gears attached to the other end of the rollers. As the dough passes through the gaps of the rollers, it is received at the other end by the moving conveyor.

The conveyor is also driven by the same motor that drives the rollers. The isometric view of the dough kneading machine is shown in Figure 5.

$$\text{Kneading Capacity} = \frac{\text{Mass of Dough}}{\text{Time}} \quad (7)$$

(b) Kneading Efficiency

Kneading efficiency is determined by using the relation;

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100 \quad (8)$$

where,

Output: mass of successful needed dough ( $m_s$ )

Input: mass of dough fed in between rollers ( $m_i$ )

### 3.0 Results and Discussion

#### 3.1 Performance Evaluation Results

Performance test was carried out to determine functionality characteristics of the machine. This is necessary to ascertain functionality of the developed machine. This gives a better understanding of the machine handling. The two different tests carried out on the machine are: free rotating test and full load test. These two tests are necessary in order to determine the performance characteristics of the machine: free rotating and full rotating tests. For the free rotating test, the machine was set to run without load to ensure that there are no abnormalities or noise/vibration which may be as a result of improper alignment during fabrication and assembling of the machine working components. Figures 6 (a) and (b) show the photographic view of the machine operation during free rotating and full load tests respectively.

Initially, during the full load test, 0.25 kg of dough was fed between the rollers which rotated in opposite direction. The dough was picked and compressed adequately at 2 mm – 4 mm roll gap set. This was done repeatedly until satisfactory dough texture was achieved. The time taken for the effective kneading operation was recorded. This process was repeated for different dough masses: 0.3 kg, 0.5 kg, 1.0 kg and 1.5 kg and the performance test results were recorded as shown in Table 1. This full load testing were performed using dough samples of different masses aforementioned at rolling speeds of 65, 80, and 100 rpm. However, the roll gap was varied from 2.0 mm to 4.0 mm accommodated within gear teeth depth. Hence time taken for each mass of dough during kneading operation at different speeds and roll gaps were .

recorded against time. Then the average kneading efficiency for each gap on different dough masses were shown in Table 1. The optimum kneading efficiency and capacity were found to be 87% and 38.57 kg/h which occurred at 3.0 mm gap and machine speed of 100 rpm. The actual design capacity is 74kg/h

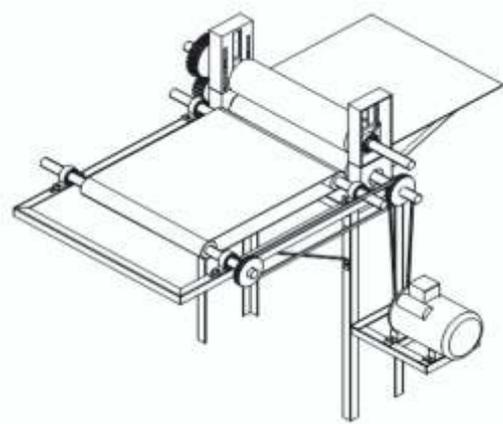


Fig.5: Isometric View of the Design Model



(a)



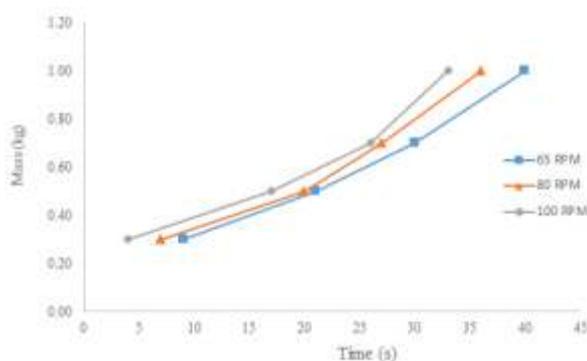
(b)

Fig. 6: Photographic view of the developed machine (a- Free rotating test, b- Full load test)

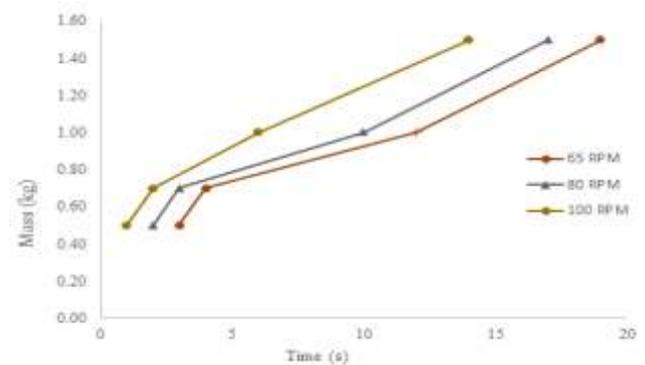
### 3.2 Discussion

The aim of this work has been achieved through the series of tests carried out on different masses of dough against time taken at different roll gaps. The main purpose of the kneading operations is to obtain a homogeneous mixture of the raw and auxiliary materials, and at the same time obtain dough with visco-elastic structure and properties better than dough of primitive method. Generally, at the dough mixing stage, the dough contains some quantity of air, which is very important for rheological properties of dough, and for the quality of the final product even at proofing stage. The formation of the dough and the rheological properties are influenced by some factors which are the quantity of water, flour quality, and most importantly the intensity of kneading and optimum time of kneading. Fig. 7(a), (b), and (c) show the plots of mass (kg) of dough against time (s) at each roll gap. The kneading capacity of the machine was observed to be increasing linearly with rolling speeds, but at maximum value on roll gap of 3.0 mm as shown in Fig. 7(a), (b), and (c). A linear relationship is obtained between the mass (kg) of dough kneaded and the time taken (s) required for kneading the dough. At 2.0 mm roll gap, the maximum kneading capacity occurred on the roller speed of 100 rpm, while the minimum kneading capacity occurs at roller speed of 65 rpm. The same trends were observed at roller gaps of 3.0 mm and 4.0 mm.

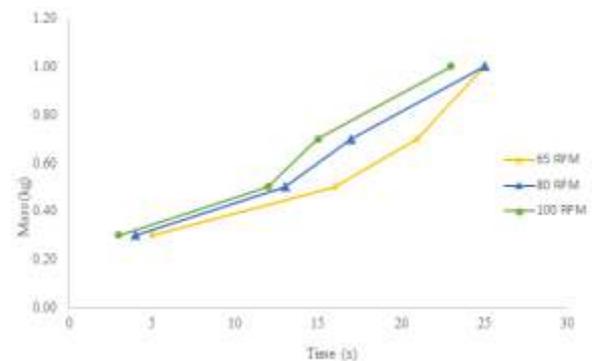
The maximum kneading capacity and efficiency occurred at 3.0 mm roller gaps (Table 1 and Fig. 7c), while the minimum kneading capacity and efficiency occurred at 2.0 mm roller gap. This observation shows that the optimum roller gap setting must remain at 3.0 mm during kneading operation, likewise on the speed of 100 rpm. Furthermore, it was also observed that viscous-elastic structure and good texture of homogeneous kneading was obtained at 3 mm roller gap than any other gap settings. The optimum kneading time associated with 3.0 mm roller gap is shown in Fig. 7b as 14.0 s, and the optimum feeding rate is 0.11 kg/s.



(a)



(b)



Finally, at 4 mm roll gap, as mass of the dough is increased from 0.3 kg to 1.5 kg, dough become sticky to the rollers with less compressive force. This shortcoming increase kneading time taken, which eventually resulted to low kneading capacity and efficiency (Fig.7c). The same trend was previously reported by Dahiru et al. 2007 on manually operated dough kneading machine for domestic use, having kneading capacity and efficiency of 7 kg/h and 78%, respectively. The newly developed motorized prototype has higher capacity and efficiency that will enhance productivity of bread even in the rural area. Furthermore, Hwang and Gunasekaran (2001) reported on wheat dough convectional mixer. Various masses of wheat dough of 0.5, 1.0 and 1.5 kg of moisture contents 43, 45 and 47% were mixed at agitator speed settings of 63, 113 and 205 rpm for the performance evaluation of the machine. They concluded that the optimum agitator speed and mixing time are 113 rpm and 510-580 s. respectively. This observation follows the same trend with the motorized dough kneading machine of the study. Hence, they reported medium speed (113 rpm) to be the optimum speed instead of 205 rpm, which correlated with the optimum speed of 100 rpm of motorized dough kneading machine.

Fig. 7: Graph of mass of dough against time ( a- at roll gap 2 mm, b- at roll gap 3 mm, c- at roll gap 4 mm)

#### 4. Conclusions

From the results of the performance evaluation of this newly developed small-scale motorized dough kneading machine the following were achieved: the dough kneading machine is efficient in kneading the dough, the machine can knead dough of considerable thickness within limited time, and the dough kneading machine is found to be less stressful with a vertical height to enhance its operation ergonomically. The optimum roll speed and roll gap having been established for better handling. Finally, these results obtained showed a considerable decrease in kneading time with possibility of adjusting the speed if need be and it has reduced fatigue on the operator unlike manual type.

#### Acknowledgement

The authors acknowledge the facilities and support of T. Olasunkanmi and K. Akanji, at Department of Mechanical Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria.

#### References

- Dahiru, D. Y., Sumaila, M., and Hamman, Y. (2007). Design, construction and performance evaluation of a manually operated dough kneading machine for domestic use, *Continental J. Engineering Sciences*, 1, 20–26.
- Dixon J. R and Poli C. (1995): 'Engineering Design and Design for Manufacturing', A structural approach, field stone publishers, Conway, MA.
- Gisslen, W. (2004). *Professional baking*. Hoboken, New Jersey: Wiley. Red Star Yeast. (n.d.). Creative bread for educators. Retrieved on February 21, 2010, from [http://redstaryeast.com/lessons/classroom\\_baking\\_lessons/creative\\_breads\\_for\\_educators.php](http://redstaryeast.com/lessons/classroom_baking_lessons/creative_breads_for_educators.php)
- Hall A.S., Holowenko A.R., Laughlin H.G. (1983) *Schaum's outline series of theory and problems of machine design*, McGraw-Hill Publishers Incorporated, New York.
- Hwang, C. H. and Gunasekaran, S. (2001). Determining wheat dough mixing characteristics from power consumption profile of a conventional mixer. *Cereal Chemistry*, 78 (1): 88-92.
- Khurmi, R.S., and Gupta, J.K. (2003). *A Textbook of Mechanical Engineering Design*. Eurasia Publication house (PVT) Ltd. Ram Nagar New Delhi, India.
- Khurmi, R.S., and Gupta, J.K. (2005). *A Textbook of Machine Design*. S. Chand & Company Ltd. Ram Nagar New Delhi, India.
- Kordylas, J.M. (1990). *Processing and Preservation of Tropical Foods*. 1st ed. Macmillan Education Ltd, London, pp 65.
- Morakinyo, T. A., Ogunsina, B. S., and Adebayo, A. A. (2014). Adaptation of Impact Hammer Mill for Crushing Cocoa Pods Husk as a Livestock Feed Constituent. *Journal of Agricultural Engineering and Technology*, 22(3), pp 1-11.
- Pyler J. (1988) *Baking science and technology*, 3rd ed. SOS land publishing CO. Kansas city, Vol. pp. 174-175.
- Rumble, V. (2012). Dough kneader and mixers, <<http://thehistoricfoodie.wordpress.com/dough-kneaders-mixers-c/>> [Accessed April 20, 2015].
- Zounis, S., and Quail, K. J. (1997). Predicting test bakery requirements from laboratory mixing tests. *J. Cereal Sci.* 25:185-196.

# Journal of Engineering and Engineering Technology

## Contents

### Volume 11 Issue 1, 2017

- |    |  |  |
|----|--|--|
| 1  | Ajibade, F. O. and Adewumi, J. R.  | Performance Evaluation of Aquatic Macrophytes in a Constructed Wetland for Municipal Wastewater Treatment            |
| 12 | Fadeyibi, A., Osunde, Z. D.,<br>Yisa, M.G. Okunola A. A.                     | Investigation into Properties of Starch-based nanocomposite materials for fruits and vegetables packaging - A review |
| 18 | Melodi, M.M. and Agboola, D.A.   | Labour Productivity Assessment of Dredging Operations in Some Selected Companies in Lagos State, Nigeria             |
| 23 | Olubanjo, O. O.  | Effects of Wastewaters From an Abattoir on Surface Water Quality in Akure, Ondo State, Nigeria.                      |
| 29 | Jabar, J. M., Lajide, L., Adetuyi, A. O.,<br>Owolabi, B. J. and Ayoade G. W. | Chemical modification of coir, empty fruit bunch and palm kernel fibres for polymer reinforcement                    |
| 37 | Awopetu O.O.   | Effect of Rake Face Reinforcement on Cutting Tool Life of Cemented Carbide Tools during Turning of a-Titanium Alloy  |
| 43 | Famurewa, J.A.V. and Faboya, E.T.  | The Effects of Drying Temperature on the Physicochemical Properties of Ogbono (Irvingia Gabonensis)                  |
| 48 | Olutomilola E. O. and Ogedengbe T. I.  | Evaluation of the Effect of Constituents on Insulation Quality of Selected Biomass Composites                        |
| 56 | Mogaji, P.B., Abioye, T.E.,<br>Ohuruogun, N.O.                               | Development of Epoxy Resin Composite Reinforced With Cow Horn and Cassava Particles for Car Dashboard                |
| 62 | Akingbade, K. F. and Apena, W. O.  | Modelling of Electric Power Subsystem for a Weather Balloon Microsatellite   |
| 68 | Daniyan I.A., Bello E.I., Ogedengbe T.I.,<br>Lajide L. and Mogaji P.B.       | Development of a Model For Predicting the Yield of Biodiesel During Biodiesel Production                             |

### Volume 11 Issue 2, 2017

- |     |  |  |
|-----|--|--|
| 73  | Ayodeji S. P., Adeyeri M. K. and<br>Oni O. O.                    | Conceptual Design of Battery Powered Vehicle for Children Amusement Park Using Nigerian Anthropometric Parameters. |
| 81  | Owolabi, H. A., Omidiji, B. V.,<br>Oke, A. O. Morakinyo, A. T.   | Development of a Small-Scale Motorized Dough Kneading Machine  |
| 89  | Akingbade K. F.  | Development of Chemical Proportion Formulation Model for Quality Control in Flexible Polyurethane Foam Production. |
| 96  | Isa J. and Aderotoye M. A.                                       | Effect of moisture content on the physical and aerodynamics properties of cashew nut                               |
| 103 | Abegunde, A. J., <sup>1</sup> Omidiji B. V.<br>and Ajewole P. O. | Characterization of Ado-Ekiti River Sand for foundry applications  |
| 112 | Yaru S. S. and Adegun I. K.                                      | Analyses of Biogas and Digestate from Cattle Dung Anaerobic Digestion  |
| 119 | Awopetu O. O., Farayibi P. K.,<br>Ismail K. A.                   | Optimization of Major Process Parameters for Surface Roughness of ASTM 25 Grey Cast Iron using Taguchi method      |
| 126 | Afu D. J., Ifelola E. O., Ayodele S. G.,<br>Ekun A. and Itunu A. | Survey of the Effects of Operational Noise on Quarry Workers in Akoko-Edo Local Government Area of Edo State       |
| 133 | Melodi, M. M. and Onipede, T. G.                                 | Economic Appraisal of Some Selected Quarries Operation in Ondo State, Nigeria                                      |
| 139 | Ojediran J.O., Fasinmirin J.T., Owa O.P.                         | Development and Performance Evaluation of an Indigenous Fish Feed Palletizing Machine                              |

Available online at  
[www.jeet.futa.edu.ng](http://www.jeet.futa.edu.ng)

Design & Print by



FUTAJEET