

Design, Fabrication and Testing of A 10kg Pedestal Foundry Sand Mixer for Mechanical Engineering Foundry Workshop, Nigerian Defence Academy Kaduna

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Abstract- *The Design and Construction of a 10kg pedestal Foundry Sand Mixer using readily available materials was carried out. The work provide efficient and cost-effective sand mixing equipment for the Mechanical Engineering Department NDA foundry workshop to drive the development of machines and equipment. The construction focuses on material selection and development of major componets of the sand mixer which include, the machine frame fabricated from robust steel section that provide a stable and durable structure base, the cylindrical mixing drum made of stainless steel material to withstand corrossion and scratching during mixing process. The mixing blade made from structural steel desingned to effectively agitate the sand during mixing process and the prime mover which consists of an electric motor and gear box. Selected to meet the requirement for the selected speed and torque to achieve desired mixing. The mixer test results show that the average mixing time of the sand mixer to mix 7.7 kg of sand was 7.7 minutes. The time of mixing was short, thus the machine performance is satisfactory. Performance and Evaluation tests carried out to evaluate the mixing efficiency at different load of 5kg, 8kg, 10kg was conducted and proper sand mix was archived at 5 min, 8 min, 10 min respectively. The mixing efficiency, based on the homogeneity of the mixed sand, was determined to be 52.45%. Which compared good with the imported existing foundry sand mixer, fulang model 18-20TH which has an efficiency of 59%. The cost of the production of the sand mixer was 629,000 Naira. Which is cheaper than the imported sand mixer of the same capacity at the cost of 2,800.000 naira. This work provides a valuable resource for small-scall foundry shops seeking an alternative approach to sand mixing, promoting efficient production while potentially reducing costs and reliance on foreign imports.*

Keywords: *Local fabrication, cost-effective, Small-Scale Foundry, Mixing efficiency, Stainless steel Drum.*

I. INTRODUCTION

The Foundry workshop of the Mechanical Engineering Department, Nigeria Defense Academy

Kaduna, is equipped with required foundry equipment except a Sand Mixer, which is a necessary equipment in the foundry, the sand mixer is a mechanical attrition machines which stir the sand to mix uniformity to achieve good texture before been used as moulding sand [Olunlade et al., 2019]. The mixing of material or combination of materials is accomplished by moving the materials together against themselves [Cam, & Kocak, 1998]. To achieve uniform mix, foundry sand mixer regardless of design or materials to be blended, is used to accomplish a uniform mix of the material, Whether mixing concrete, polymers, liquids, powders, or silica sand with differing chemical system, the purpose of the sand mixer is to move the materials against themselves to achieve a desired mixture [Chakrabarti, 2022].

In Foundry industry Sand mixing is done with very small amounts of different binding agents, all having different and variable properties [Khanduri, et al., 2010]. The first sand that exits the chamber is obviously not the same as the sand a few seconds behind it, as there is really nothing for the first sand to move against [McNulty, et al., 1965]. Even with today's technologies (timers, flow meters, valving), we cannot get away from this basic goal of making the first sand usable, and exactly the same as the sand right that follows it A properly trained and motivated mixer operator will waste very little sand, as he can catch the first 1 to 2 second of sand in the mixer and then get it properly mixed through continuous mixing [Shira, 2022]. The objective of a continuous mixing is to produce sand for quality cores or Molds using just enough binder to obtain the desired casting results at the lowest possible cost [Anwar, et al., 2021].

This paper details the design, fabrication, and testing of a 10kg pedestal sand mixer.

1.1 Statement of Problem

The Mechanical Engineering Department. Foundry does not have a Sand Mixer, therefore relies on manual Mixing of Sand, which is cumbersome, dirty and time consuming. Studies carried out on about 100 small/micro scale Foundry shops in the Panteka Industrial Market, Kakuri and other parts of Kaduna Nigeria reveals that over 95% of the shops use the manual sand mixing process, due to lack of a sand mixer. The manual Sand mixing process apart from being laborious, inefficient, and time consuming, produces very low-quality sand that lacks uniformity. The combination of these drawbacks stagnated the development of the micro/small scale Foundry shop at the Panteka in general, high cost of the imported Sand Mixer is cited by the Foundry shop operators as their main problem. Market research shows that, the least cost of an imported Sand mixer, FURLANG Model 18-20T H Cost 2.8 million Naira as at August 2025, the importation of industrial equipment such as Sand mixer constitutes a drain to the nation's reserve. Hence the need to design and develop a Foundry Sand Mixer for laboratory, small and medium scale foundries use that is efficient, reliable and cost effective.

1.2 Justification

The design and construction of the sand mixing machine for Mechanical Engineering Department foundry will enhance laboratory experimentation in the area of foundry technology and production of machine components. It will also provide a viable tool for small scale foundries and local foundries at the panteka market kaduna.

1.3 Aim and objectives

This research was carried out to develop a foundry sand mixer for the Mechanical Engineering

Department Foundry and by extension small and medium scale foundry shops.

II. MATERIALS AND METHORDS

2.1 Materials

The following material were used in constructing the foundry sand mixer.

1. Stainless Steel sheet of 2mm gauge
2. Angle mild steel bar of 3mm
3. 24V/250W/13A/120RPM DC Gear Motor
4. 2.5-inch swivel wheels source from Panteka Kaduna Nigeria
5. Battery 12V/40Ah
6. E6013 Electrode
7. Cables
8. Ball bearings
9. 20mm hollo pipe
10. 10mm steel rod

2.2 Methods of construction

The methodology for this is design, selection of appropriate materials, fabrication and assembly using locally sourced and off-the shelf materials. The foundry sand mixer is designed to be potable, of reasonable capacity, mobile, and light weight, to permits its easy movement from one place to another for swift operation.

2.3 Description of the fabrication processes

(a) Mixing Drum

The steel sheet was measured cut out to length of 200mm and folded to diameter 200mm then welded. The base was afterward measured cut and welded to the shell. E6013 Electrode using 240V and 30A current is used using (Weld mate 1500 w-arc MSZ 2100) arc welding machine for the welding processes. Followed by cutting out the location of the exit door, which was measured and then cut open.

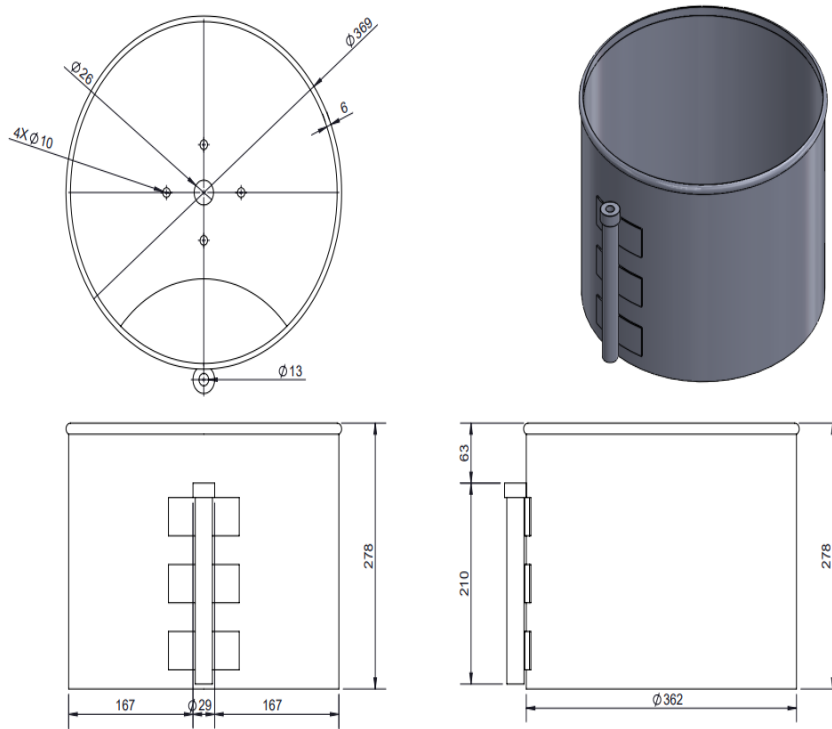


Figure 1: shows mixing drum solid work of the mixer.

(b) The machine frame

The machine frame was fabricated from low carbon steel. The angle bar was cut in to required size and a frame was constructed by welding, for the mixing pan to be at the top of it, the key prerequisite in the design

of the frame of the machine is that it maintains the proper relative position of the units and parts mounted on it over a long period of service condition. The choice of low carbon steel was mainly on strength and workability.

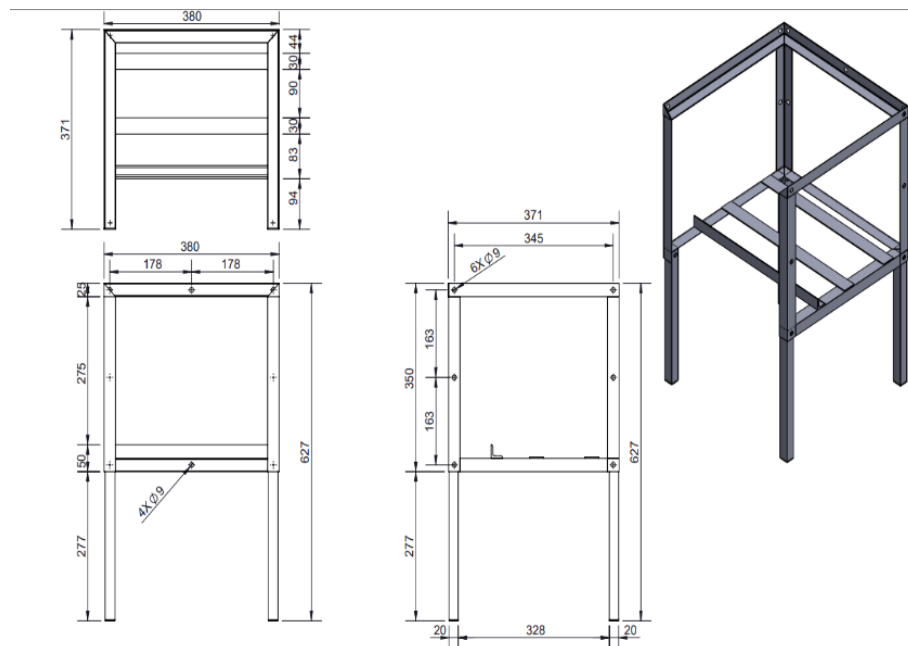


Figure 2: Fabricated machine frame constructed from 3mm angle iron

(c) Drive system connection

The drive system, typically a center shaft using key way, between the motor and the rotating blades. This will transmit power from the motor to the blades, enabling them to mix the sand.

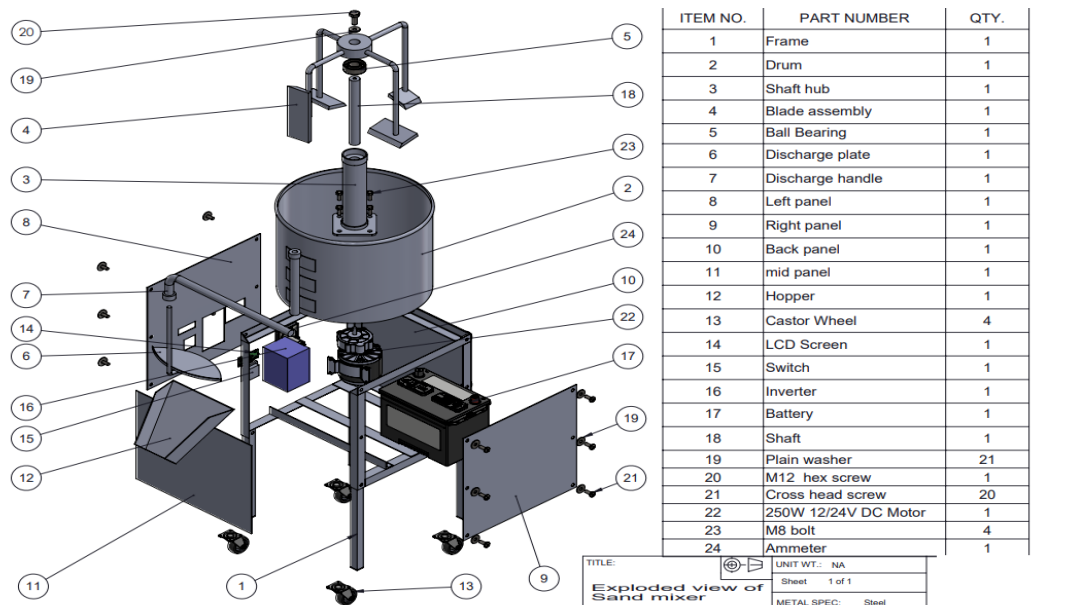


Figure 3: Exploded view of the fabricated sand mixer

III. DESIGN CALCULATIONS

(a) Determination of the mixer design parameters

(i) Design Calculations of the mixing bucket

The capacity of the mixing bucket is given by [72].

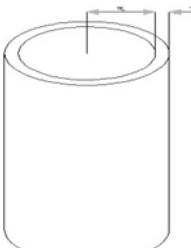
$$V_b = \pi \frac{D_b^2}{4} \times h \dots\dots\dots (3.1)$$

where,

D_p = Diameter of the mixing bucket 200(mm)

V_p = Volume of the mixing bucket (m^3)

H= Height of the mixing bucket 200(mm)

Design Calculations of the mixing bucket		
Data	Calculations	Results
$H_b = 200mm$ $D_b = 200mm$ $\pi = 3.14$ $V_b = ?$	From equation (3.1) $V_b = \pi \frac{D_b^2}{4} \times h$ $V_b = 3.14 \left(\frac{200^2 \times 200}{4} \right)$ $V_b = 6280000mm$ $V_b = 0.00625m^3$ 	The volume of the mixing bucket is: $V_b = 0.00625m^3$

(b) Calculations for the Required Torque
the torque required is given by [72].

Eq. for Required torque (3.2)

$$T = F \times r = (kmg)r$$

Were,

$T = \text{torque (Nm)}$

$F = kmg$

$r = \text{drum radius(m)}$

$m = \text{mass of sand (10kg)}$

$g = 9.81\text{m/sec}$

$k = \text{friction factor(0.5)}$

Calculation for the required torque		
$T = \text{torque (Nm)}$ $F = kmg$ $r = \text{drum radius(m)}$ $m = \text{mass of sand (10kg)}$ $g = 9.81\text{m/sec}$ $k = \text{friction factor(0.5)}$	From equation (3.6) $T = F \times r = (kmg)r$ $T = 49.05 \times 0.1$ $T = 4.905\text{Nm}$	The required torque $T = 4.905\text{Nm}$

(c) Calculations for the angular velocity of shaft

The angular velocity of the shaft is given by [72] (3.3)

$$\omega = \frac{2\pi N_1}{60}$$

Were,

$\omega = \text{Angular velocity}$

$N_1 = \text{Rotational speed of the electric motor (rpm)}$

Calculation for the angular velocity of shaft		
$N_1 = 75 \text{ RPM}$ $2\pi = \text{is aprxly } 6.2831$ (constant pi times 2) $\omega = ?$	From equation (3.3) $\omega = \frac{2\pi N_1}{60}$ $\omega = \frac{6.2834 \times 75}{60}$ $\omega = 7855 \text{ rad/sec}$	The angular velocity is $\omega = 7855 \text{ rad/sec}$

(d) Calculations for the rotational speed of shaft

is given by [72] (3.4)

$$N_2 = \frac{60\omega}{2\pi N_1}$$

Were.

$N_2 = \text{is the rotational speed of the shaft (RPM).}$

$\omega = \text{is the angular velocity (rad/s).}$

$2\pi = \text{is approximately } 6.28318 \text{ (the constant pi times 2).}$

$N_1 = \text{Rotational speed of the electric motor (rpm)}$

Calculation for the rotational speed of shaft		
$N_1 = 75 \text{ RPM}$	From equation (3.4)	The speed of shaft is $N_2 = 10 \text{ RPM}$

$2\pi = \text{is aprxly } 6.2831$ $(\text{constant pi times } 2)$ $\omega = 7855 \text{ rad/sec}$ $N_2 = ?$	$N_2 = \frac{60\omega}{2\pi N_1}$ $N_2 = \frac{60 \times 7855}{4713}$ $N_2 = 10 \text{ RPM}$	
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(vii) Calculations for the efficiency of the mixer

The efficiency ϵ , of a machine was determined using [72] (3.7)

$$\epsilon = \frac{\text{output power}}{\text{input power}} \times 100$$

(vi) Calculation for the efficiency of the mixer		
$P_{\text{output}} = T \cdot \omega$ $P_{\text{input}} = V \cdot I \cdot \text{pf}$ $\eta = \frac{P_{\text{output}}}{P_{\text{input}}} \times 100\%$	From equation (3.7) $T \cdot \omega = 4.905 \times 7.855$ $V \cdot I \cdot k = 12 \times 13 \times 0.47$ $\eta = \frac{38.529}{73.32} \times 100\%$	<i>the efficiency</i> $P_{\text{output}} = 38.529$ $P_{\text{input}} = 73.32$ $\eta = 52.549\%$



Figure 4: The finished foundry sand mixer

IV. RESULTS

Results the design calculation results obtained is show in Table 3.1. The results obtained from designed calculation show that the volume of the mixing drum, the torque required, the angular

velocity of shaft, speeds of shaft, force acting on the shaft and the efficiency of the mixer were 0.00625m³, 4.905Nm, 7855rad/s, 10RPM, 49.05N and 52.49% respectively. The force calculated for was minimal enough for easy operation of the machine.

(a) Result

Table 4.1 Results of design calculations:

Table 1: Table of design calculations.

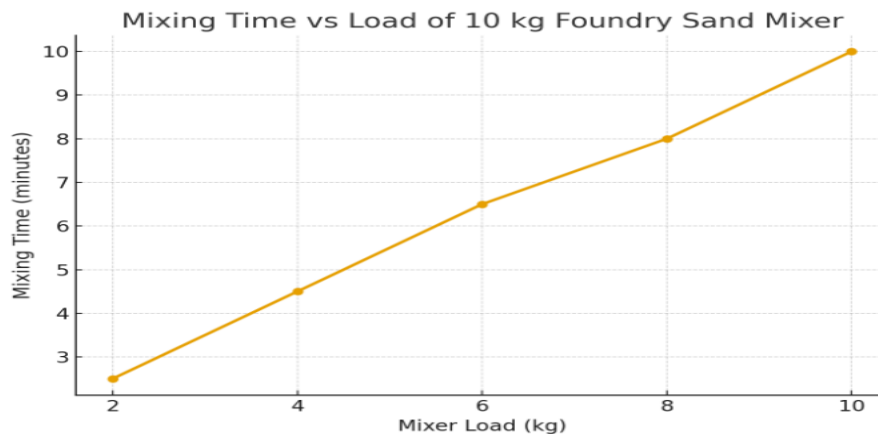
s/no	Description	Calculated value
1	The volume of the mixing Drum (V_b)	$V_b = 0.00625m^3$
2	The required torque (T)	$T = 4.905Nm$

3	The angular velocity (ω)	$\omega = 7855 \text{ rad/sec}$
4	The speed of shaft (N_2)	$N_2 = 10 \text{ RPM}$
5	The force acting on the shaft (F_s)	$F_s = 49.05 \text{ N}$
6	The efficiency of the mixer (η)	$\eta = 52.549\%$

Moreover, different masses of sand were used to evaluate the machine ranging 5kg, 8kg, and 10kg. The mixing drum was loaded with sand while the mixing blades is rotated clockwise so that proper mixing can be achieved. At the achievement of a homogeneous mixture, the trap door was opened while the machine is still being operated to allow the sand to be pushed out and collected. This was repeated for three times and the average mixing time recorded as show in

(b) Table:2 performance Test results

Serial no.	Mass of sand (kg)	Time taken (min)
1	5	5
2	8	8
3	10	10
Σ	23	23
Ave.	7.7	7.7



V. CONCLUSION

A functional 10 kg capacity pedestal foundry sand mixer powered by a 12 V, 250 W, 13 A DC gear motor have been successfully fabricated from locally sourced materials at a cost of ₦629,000, and performance evaluation also successfully carried out. The mixer was developed to provide an efficient, low-cost, and locally fabricated solution for small-and medium-scale foundry applications. The design analysis established the required torque, power, and mixing speed necessary to achieve homogeneous sand–binder mixtures. Fabrication was done primarily using mild steel materials due to their mechanical strength, ease of machining, and affordability. The use of a DC gear motor provided adequate torque at low rotational speed (75 rpm),

ensuring thorough blending without excessive energy consumption. Testing of the fabricated mixer with a 10 kg sand batch demonstrated effective and uniform mixing within average time 7.7 minutes of operation. The mixer exhibited stable performance, minimal vibration, and low noise levels, confirming its suitability for small scale foundry workshops, educational laboratories.

VI. RECOMMENDATIONS

It is recommended that:

- the equipment should be equipped with a digital timer.
- Further research to be carried out to automate the entire system

c. The product be mass produced for sell to small medium scale foundry operators.

REFERENCE

- [1] Olunlade, B. A., et al. (2019): "Design of Curved-type Impeller Foundry Sand Mixer." *Journal of Scientific Research and Reports*. 21(5), pp.1-8.
- [2] Çam, G., & Koçak, M. (1998). "Progress in joining of advanced materials". *International Materials Reviews*, 43(1), 1-44.
- [3] Chakrabarti, A. K. (2022). *Casting technology and cast alloys*. PHI Learning Pvt. Ltd.
- [4] Khanduri, A., & Siddique, R. G. (2010). *Properties of mortar incorporating waste foundry sand* (Doctoral dissertation).
- [5] McNulty, J. W. (1965). *An experimental study of arching in sand* (No. 1). University of Illinois.
- [6] Shira, S. (2022). Mixing and blending. In *Integration and Optimization of Unit Operations* (pp. 249-271). Elsevier.
- [7] Anwar, N., Sappinen, T., Jalava, K., & Orkas, J. (2021). Comparative experimental study of sand and binder for flowability and casting mold quality. *Advanced Powder Technology*, 32(6), 1902-1910.
- [8] Kurmi, R. S., and Gupta, J. K., (2003), "*Text Book of Machine Design*," Eurasia publishing PVT, New Delhi