Nigerian Journal of Technology (NIJOTECH)
Vol. 33 No. 4, October 2014, pp. 604 – 609

University of Nigeria, Nsukka, ISSN: 1115-8443
www.nijotech.com
http://dx.doi.org/10.4314/njt.v33i4.22

DESIGN AND FABRICATION OF A FOUNDRY SAND MIXER USING LOCALLY AVALIABLE MATERIALS

J. O Osarenmwinda[1,*] and K. O Iguodala[2]
[1,2] DEPARTMENT OF PRODUCTION ENGINEERING, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA
E-mail address: [1] *joosarenmwinda@yahoo.com*, [2] *kiguodala@yahoo.com*

ABSTRACT
Most small foundry shops mix their sand manually which is not efficient since homogenous mix cannot be guaranteed and even when foundry mixer are available most of them are imported costing the nation huge foriegn exchange. A foundry sand mixer capable of mixing foundry sand has been designed and fabricated using locally available material. The sand mixer components machine frame, mixing pan, motor support, gear box speed reducer, Shaft, discharge door and Mixing blades were designed ,produced and assembled together to produce the mixer. A step-turned shaft of diameters 23mm and 33mm attached to a 2hp, 3 phase electric motor to transmit the torque required to effectively turn and mix the sand in the pan. The mixer test results show that the average mixing time of the sand mixer to mix 20kg of sand was 14minutes and the mixer efficiency was 52%.The fabricated mixer compare favourably with the the imported existing one which has an efficiency of 59%.The application of this sand mixer by foundry shops will eliminate the use manual effort which is cumbersome, time wasting and inefficient.It will also save the the country of huge foreign exchange used in the importation of foundry sand mixers

Keywords:*foundry,sand mixer,fabrication,design,blades,shaft,efficiency*

Nomenclatures

D_p = Diameter of the mixing pan, m
F_s = Force acting on the shaft, N
H_p = Height of the mixing pan, m
M_s = Mass of moulding sand, kg
N_1 = Rotational speed of the electric motor, rpm
N_2 = Rotational speed of the shaft, rpm
P = Power required, W
S_s = Allowable sheer stress of shaft material, N/m^2
T_s = Torque on shaft, Nm
V_p = Volume of the mixing pan, m^3
d_b = Distance from one blade to another through the centre of the shaft
d_s = Diameter of shaft, m
g = Acceleration due to gravity, m/s
r_b = Radius of one blade to the centre of the shaft
ε = Efficiency of the machine, %
ρ_s = Density of moulding sand, kg/m^3

1. INTRODUCTION

The increasing demand for castings in the growing car and machine building industry during and after World War I and World War II, stimulated new inventions in mechanization and later automation of the sand casting process technology. Foundry sand is high-quality uniform silica sand that is used to make moulds and cores for ferrous and nonferrous metal castings [1]. The metal casting industry annually uses an estimated 100 million tons of foundry sand for production [2]. The proper blending of these materials enhances desirable properties for moulding. Therefore, Sand mixing is a process of kneading and working sand for the purpose of distributing the ingredients (additives) into a homogenous mixture [3].The properties of moulding materials are very vital to the production of sound dimensionally accurate castings.Inwelegbu and Nwodoh produced a dough mixing machine [4], while Sothea et al [5], developed a crush and mix machine for composite brick fabrication [5]. Sekar, et al [6] designed and constructed multiple casting machine which is a foundry equipment.

There is an ever-present trend to increase the tonnage of prepared sand from sand preparation units. This has caused the time for mixing to be shortened to such an extent that the quality of the sands have suffered materially. The bond is not being uniformly blended

*** Corresponding author, Tel: +234-802-371-8684**

into the sand, nor is mixing being sufficient to make use of the bond. This certainly does not reflect favourably on the foundry industry where better castings are so important.

Though sand mixture can sometimes be done manually especially in small foundry shops, most foundry sands can prove very difficult to mix and could lead to fatigue of the foundry man . Even when mixed by hand the mix is nowhere as good when compared to when mixed with a Mixer .The objective of sand mixing using a mixer is to achieve a uniform distribution of sand grains, since this affects permeability and surface fineness [7, 8]. Uniformly mixed sand gives high flowability. The grain size distribution also influences strength properties of bonded mixtures. An inverse relation exists between compression strength and grains size with a uniform bond coating [9]. Due to the fact that most of the foundry sand mixer in Nigeria are imported this study therefore focus on the design and fabrication of foundry sand mixer using locally available materials.

2. SAND MIXERS WORKING PRINCIPLES AND DESIGN

The Sand Mixer was designed to quickly, uniformly and mechanically manipulate a heterogeneous mass of sand materials, of varying aggregate sizes, into uniformly blended and bonded homogenous product. It consists of cylindrical pan, four heavy blades, which rotate in a circular path about a vertical shaft. A discharge door is provided at the bottom of the pan. The four blades are divided into two sets of two blades each (one set on top the other) and they are slightly off the true radius to allow for free rotation as well as eliminate any wear due to friction which may arise from contact between the blades and the pan. The design theory of the sand Mixer considers the geometrical parameters of the Mixer, which includes the frame mixing pan, blades, shaft and driving mechanisms.

2.1 Support Frame

The main requirement 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 under all the working conditions. The second consideration or requirement is strength. The frame is designed to withstand the various weight mounted on it. The shape invariability is also very vital.

2.2 Mixing Pan

The mixing pan is cylindrical in shape, it is made from mild steel material of 6mm thickness .The volume V_p was determined using [10]:

$$V_p = \frac{\pi D_p{}^2 H_p}{4} \tag{1}$$

With $D_p = 394mm$ and $H_p = 280mm$, the calculated V_p is shown in Table 1. Since, the pan is to contain moulding sand, the mass of the moulding sand is given by:

$$M_{s=} \ \rho_s \times V_p \tag{2}$$

The variable ρ_s of aerated silica sand is 1500kg/m^3[3].

2.3 Trap Door for Discharge

The trap door for discharge is made of galvanized steel since galvanized steel has a smoother finish than regular steel to allow for free movement of the door. The groove for the door stands at 80mm from the base of the mixing pan. This height is just sufficient enough to effectively discharge the components of the pan.

2.4 The Blades and Blade Support

The sand mixer has four blades, which are responsible for the mixing action. The blades are slightly curved to overcome the force of moulding sand acting against the blades and also to allow for effective mixing of the sand while the blades cuts through the mixture. The straight length from the end of one blade to another through the centre of the shaft is 379mm.

2.5 Electric Motor

A 2hp, 3 phase electric motor running at a speed of 1560rpm was used. The motor converts electric energy into mechanical energy (rotation of the shaft)

2.6 Reduction Gear Box

Reduction gear box with gear reduction ratio of 20:1 was procured to reduced speed (in rpm) of the electric motor.

2.7 Shaft

For the sand mixer, the shaft was used to support the rotating mixing blades and it is subject to torsion and to transverse or axial loads, acting singly or in combination. The shaft carries the blade support and the blades, and it is powered by an electric motor through a ball bearing and gear system. The forces acting on the shaft are those acting on the blades which are transmitted to the shaft, these include the reaction due to weight of blades; reactions due to green compression strength of moulding sand and centrifugal effect on both blades and shaft.

The electric motor provided supplies a power of 2hp and it rotates at a speed of 1560rpm and it is attached to a gear reduction system of ratio 20:1. The rotating shaft is attached to the gear reduction system.

Using gear speed ratio, the speed of the shaft in rpm was determined using:

$$\frac{N_1}{N_2} = \frac{20}{1} \quad (3)$$

With $N_1 = 1560$, N_2 is evaluated.

Recall from design considerations that the angular velocity, ω_s of the shaft is determined using [10, 12]:

$$\omega_s = \frac{2\pi N_2}{60} \quad (4)$$

Also, the torque on the shaft is given by [10, 11] as $T_s = r_b \times F_s$, where, $r_b = \frac{d_b}{2}$. The force F_s acting on the shaft wais determined using:

$$F_s = M_s \times g \quad (5)$$

This is the maximum force that can act on the blades connected to the rotating shaft.

Also, the Power P, required was determined using Eqn 6:

$$P = T_s \times \omega_s \quad (6)$$

Again, the diameter of the shaft was determined using [10, 11]:

$$d_s = \sqrt[3]{\frac{16T_s}{\pi S_s}} \quad (7)$$

The shear stress of mild steel is about 0.04KN/mm^2

2.8 Efficiency of the Mixer

The efficiency ε, of a machine was determined using (8) and:

$$\varepsilon = \frac{Output\ Power}{Input\ Power} \times 100\% \quad (8)$$

For the sand mixer, the efficiency is determined by [10, 11]:

$$\varepsilon = \frac{Power\ Required}{Power\ Supplied} \times 100\% \quad (9)$$

Power required has been calculated as 774.408W

Power supplied is the power rating of the electric motor provided i.e 2hp

Recall, 1hp = 746W, therefore, 2hp = 746 × 2 = 1492W and the efficiency is evaluated using (9) as 52%.

Table 1 shows a summary of the results of the calculated parameters

Table 1: Results of the calculated parameters

Parameters	Symbol	Value	Unit
Volume of pan	V_p	0.034	m^3
Height of pan	H_p	0.28	m
Diameter of pan	D_p	0.394	m
Mass of moulding sand	M_s	51	kg
Radius of the blades	r_b	0.1895	m
Force on the shaft	F_s	500.31	N
Rotational speed of shaft	N_2	78	rpm
Angular velocity of the shaft	ω_s	8.168	rad/sec
Torque on shaft	T_s	94.81	Nm
Power required	P	774.408	W
Diameter of shaft	d_s	0.023	m
Efficiency	ε	52	%

3. MATERIAL SELECTION AND MACHINE FABRICATION

3.1 Material Selection

Mild steel material was used for the construction of the mixing pan and blades because its good physical and chemical properties by the material such as strength and its availability. In the fabrication of the foundry sand mixer, Galvanized Steel was used for the fabrication of all parts of the trap door for discharge because of its high corrossion resistance ability.

3.2 Fabrication of Sand Mixer

The sand mixer components machine frame, mixing pan, motor support, motor and gear box speed reducer, shaft and mixing blades wetre produced and assembled together. The material (mild steel plate) for the mixing pan of the sand mixer was cut to the required dimensions (406mmx280mmx6mm). Then U-channel mild steel bar of dimensions (3000mm x 100mm x 40mm) was procured and cut to the required dimensions. Angle bars of mild steel material was procured and cut down to size using hack saw. This carries the electric motor and gear reduction system. Mild steel was machined down and stepped turned using the centre lathe to form the shaft. Mild steel plate was cut using hack saw and bent on a vice to give the required shape of the mixing blades. Length of curve is 165mm while the width of the blades are 40mm. Galvanized steel plate was bought and cut to size with the aid of a guillotine. The thickness is 1.5mm. M10 bolts were used to fasten the electric motor to the stand. The mixing pan was welded to the support frame using arc welding. The blades were also attached to the blade support using arc welding. The shaft was attached to the reduction gear box. In between the shaft and the reduction gear box, a bearing is fixed to allow for free rotation of the shaft. The blade supports (now carrying the blades) are the fixed to the shaft using M10 bolts.The Exploded View of the Foundry Sand Mixer, Side View of the Foundry Sand Mixer and Pictorial View of the Sand Mixer is shown in Figures 1, 2 and 3 respectively.

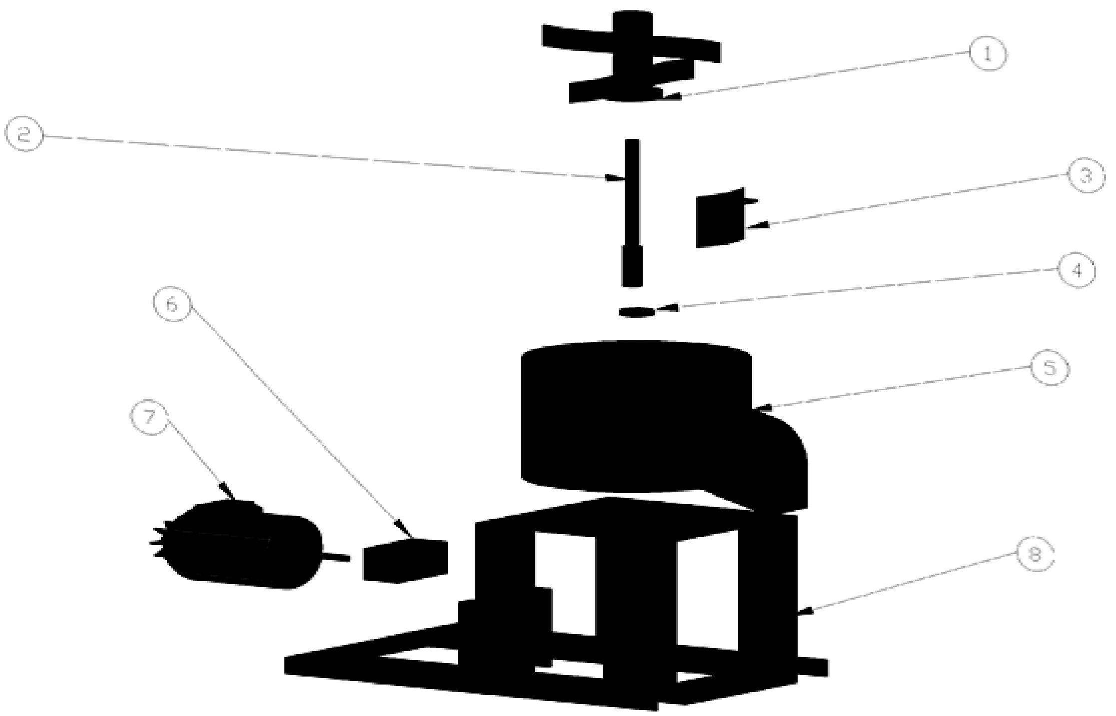

Figure 1: Exploded View of the Foundry Sand Mixer

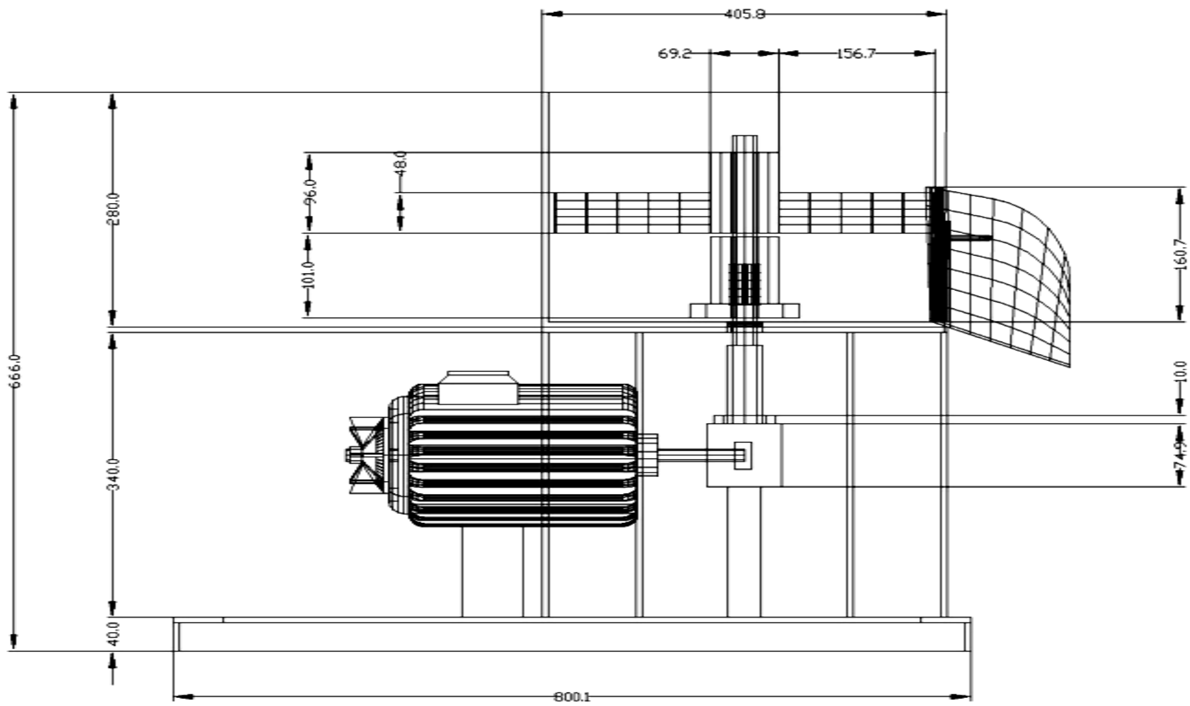

Figure 2: Side View of the Foundry Sand Mixer (All dimensions are in mm)

Figure 3: Pictorial View of the Sand Mixer

Table 2: Foundry mixer components legend

S/N	Item	No. of components
1	Blades and Blade supports	2
2	Shaft	1
3	Trap door for discharge	1
4	Bearing	1
5	Mixing Pan	1
6	Reduction Gear Box	1
7	Electric Motor	1
8	Support Stand	1

3.3 Testing of Mixer

The machine was first turned on to ensure the blades are rotating freely. The mixing pan was then loaded with sand and while the motor is rotating enable it turn and mix the sand evenly, with little water added. When an homogenous mixure have been obtained, 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 (each time varying the mass of sand) and the average mixing time recorded in Table 3. From Table 3 the average time for the mixer to adequately mix 10kg, 20kg and 30kg was 11min.,14min and17min respectively.

The fabricated mixer efficiency was determined to be 52%. This was found to compare favourably with the the imported existing foundry sand mixer which have an efficiency of 59% [12].

Table 3: Mixing time Test results

Serial No.	Mass of sand (kg)	Time taken (min)
1	10	11
2	20	14
3	30	17

4. CONCLUSION

The design and fabrication of a Foundry Sand Mixer using locally available materials have been achieved. The sand mixer components Machine frame,Mixing pan, motor support, gear box speed reducer, shaft, discharge door and mixing blades were design ,produced and assembled together to fabricate the mixer. Some of the determined mixer parameters are volume of mixer pan, force of shaft, torque on shaft, diameter of shaft , mixer efficiency and maximum mass of sand the mixer can mix at a time are 0.034m, 500.31N, 94.81Nm, 23mm, 52% and 51kg respectively. The application of this sand mixer by foundry workhops will eliminate the use manual effort which is cumbersome, timewasting and inefficient.It also save the the country of foreign exchange used in the importation of sand mixers.

REFERENCES

REFERENCES

[1] Benson, C. H. and Bradshaw, S."*User Guideline For Foundry Sand In Green Infrastructure, Recycled Materials*" Resource Center, University of Wisconsin-Madison, Madison, 2011.

[2] American Foundry Society (AFS).*"Foundry Industry Bench marking Survey: Industry Practices Regarding the Disposal and Beneficial Reuse of Foundry Sand –Results and Analysis*", http://www.strategicgoals.org/benchmarking/foundry.html.Accessed on January, 2012.

[3] Beeley, P. R. "*Foundry technology",* Butterworth Scientific, London , 2001.

[4] Inwelegbu, J. O and Nwodoh, T. A. "FPGA controller design and simulation of a portable Dough mixing machine", *Nigerian Journal of Technology,* Vol.30, No.1, 2011, pp 47-63.

[5] Sothea, K., Fazli, N., Hamdi, M. and Aoyama, H. "Development of a crush and mix machine for composite brick fabrication", *Proceeding of International conference on advances in materials and processing Technologies*, Paris, .2010, pp 1437 -1442

[6] Sekar, K., Aliesu, K., Joseph, M.A "Design, construction and performance evaluation of multiple casting machine", *Nigerian Journal of Technology,* Vol.32, No. 3, 2013, pp 498-506

[7] Bala, K. C. "Design and Development of Sand Muller and Standard Sand Rammer." *M. Eng. Thesis, Mechanical Engineering Department, Federal University of Technology,* Minna. 1998.

[8] Bala, K. C. " Design analysis and Testing of sand Muller for foundry application", *AU Journal of Technology, Assumption University, Thialand,* Vol.8, No.3, 2005, pp 153 -157.

[9] Heine, R. W., Loper, C. R., Rosenthal, P. C." *Principles of Metal Casting",* Mc Graw-Hill, New York, 1967.

[10] Hall, S. A, Holowenko, A. S and Laughin, H. G." *Theory and Problems of Machine Design. Shaum's Outline Series",* Mc Graw-Hill, New York, 1988.

[11] Spolt, M. F. *"Design of Machines Element",* 6th Edition, Prentice Hall, New Delhi, 1988.

[12] Iguodala, K. O."Design and fabrication of foundry sand mixer".*B.ENG Thesis, Department of production Engineering, University of Benin,* Benin City, 2013.