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DEVELOPMENT OF FOUNDRY SAND MIXING MACHINE

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ABSTRACT

Despite the evolution in various engineering practices towards a more mechanized means, this has set this work insight into the predominantly practice of mixing sand by hand (manual) during mould preparation in the foundry works. Due to sand mixing by hand, at times it is noted not to be properly done and this in turn may result in poor production of moulding and casting. This work intends to design, develop and evaluate a local sand mixer for moulding or casting. The major component of the mixer includes; motor control switch, pulley, belt, and shaft.

Keyword: sand, foundry, mixer, machine, casting, mould

1.0 INTRODUCTION

Foundry remains the major source for structural components since the inception of industrial civilization, although there are other various methods in which other engineering products can be made (Kaburu et al., 2016). According to Ukachi (2006), the deciding factor which favours foundry method are service requirement, feasibility and economic requirements, fabrication requirements etc. Salisu et al., (2018) sees the development of a nation solely on its development and advancement in technologies. Technologies has made work easier and increase quality and at the same time quantities of engineering products while cutting down the production cost. Foundry is the process of producing metallic components by melting, pouring molten metals into a prepared mould having cavity inside it and allowed to solidify, after this the molten metal takes up the shape of the cavity hence the desired component.

In order to achieve the stated processes in obtaining the desired product, foundry practices includes preparing of patterns and a mould in which the exact shape of the cast is technically imprint on the mould. The other important material in casting or mould preparation is foundry sand, foundry sand suitable for foundry practices most be uniformly sized, high quality silica sand, and clean. The most common sand used is the green sand; it is foundry sand having some additives such as bentonite clay, binder, additives. But in general the application of all these additives to the sand means there is need for a proper mixture in order to achieve the aim, the mixture of the sand with these minor additives can be carried out manually with the use of shovel on a flat ground but can be tedious, time wasting and less efficient thus improperly done which will defeat the aim of having a quality cast. To properly mix up silica sand with the minor additives, a motor powered machine is best implored, the sand mixer uniformly mixes the silica sand, binder, additive, water etc. to ensure a proper mixing and give out a quality cast. Therefore this work intends to address the above needs to improvise a suitable sand mixer locally fabricated capable of abolishing the local practice of using hand in mixing sand in foundry workshops. The mixer is expected to be power operated which less tedious, time saving and production effective.

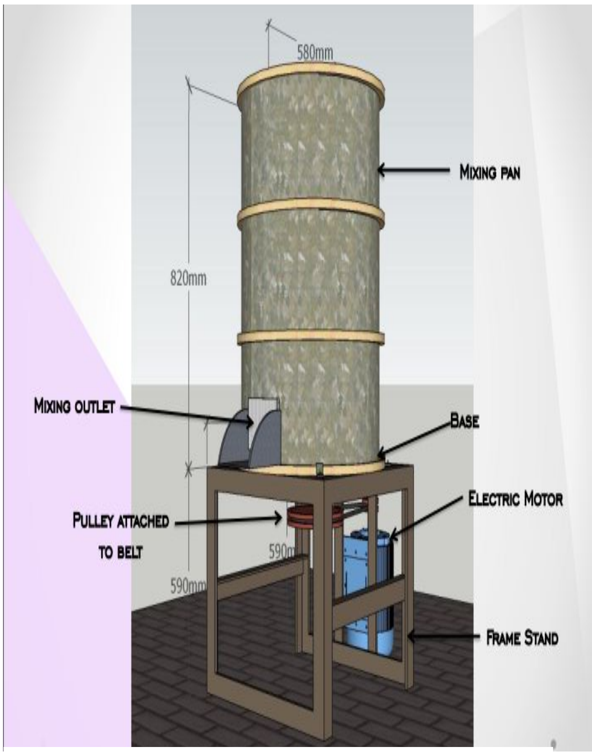
2. LITERATURE REVIEW

Foundry sands are wanted to be primarily free of dirt, good particle size why possessing quality silica content. The application of sand in foundry practices requires high quality sand for all its types of casting and after the first use, they are still implored or useable for another casting operation. Thus the addition of other sand quality materials might look difficult going by the manual method; therefore the use of a motorized mixer to substitute the manual effort of the craft-men or foundry users to mix sand is well important.

Kaburu et al. (2016), developed a foundry sand mixer but their type was manually operated, their choice of the manual operation was considered due to the economical factor of their work. But they opined that the operation of the mixer was an upgrade of the human effort with the use of shovel on the ground. Bala (2004) worked on a foundry sand mixer; their mixer design utilized a piston attached to the lower end of the machine and dips into the specimen tube. But their work was manually operated with the aid of two cams. Lastly their worked recorded tremendous success with the application of the mixer in mixing foundry sands with additives. Osarenmwinda and Iguodala (2014) developed and fabricated a foundry sand mixer, the mixer components consisted of; cylindrical pan, four heavy blades, discharge door. The mixer was operated manually and the mixer design theory considered the geometrical parameters such as; mixing pan, blades, and shaft and driving mechanisms. Also Inwelegbu and Nwodoh, (2011) produced a dough mixing machine, while Sothea *et al*, (2010) in their work developed a crush and mix machine which was capable of fabricating a composite brick. Sekar, *et al*, (2013) also designed and fabricated a multiple casting machines which are foundry equipment.

3.0 METHODS

The design of the mixer was thoroughly considered base on economic factor as well as the nature of work intended. Another problem is rusting/corrosion due to the daily contact with sand and water so in selecting materials, for construction, adequate care must be taken not to use a degrade able material due to the contact with sand and water. Figure 1 below represents the 3D design of the developed foundry sand mixer.



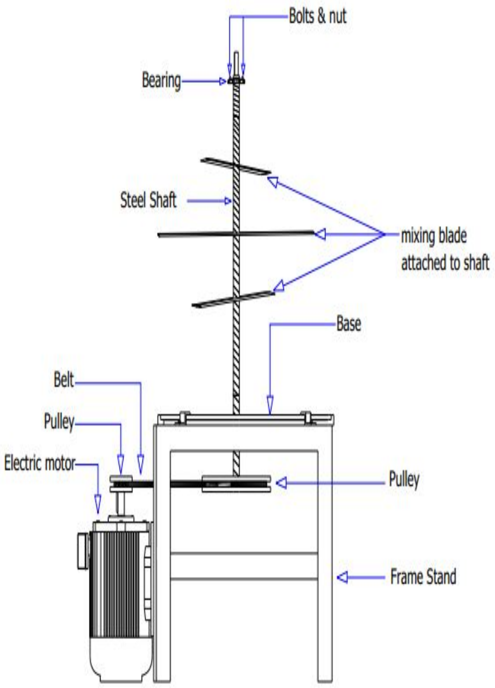


Figure 3.0: Assembled moulding sand mixer

3.1 DESIGN ANALYSIS

The –mixer major analysis was centred on the capacity of foundry silica sand it can mix at a single batch of operation, after that the linking system and the power components required to provide motion to the system.

3.1.1 Mixer Drum Capacity

The mixer drum was considered to have a cylindrical shape using mild steel material of 6 mm thickness to resist effect of corrosion and the load of the sand and other components in total. Equation 3.1 was considered to evaluate the mixer drum capacity when fully loaded as given by Kaburu et al. (2016).

$$V = \frac{\pi D^2 h}{4} \qquad 3.1$$

Where:

V = Volume of mixing drum

D = Diameter of mixing drum = 0.57m

h = Height of mixing drum = 0.81m

$$V = 0.207\ m^3$$

3.1.2 Volume of Moulding Sand in the Mixer

The volume of moulding sand the mixer can mix or hold in a batch of production is aimed at the volume of two full head pan and is given in the Equation 3.2 below. Which is calculated to be one-six (1/3) of the total volume of the mixing pan, then:

$$V_s = \frac{V}{3} \qquad 3.2$$

Where:

V_s = Volume of moulding sand in the mixing pan

V_p = Volume of mixing pan = 0.207m^3

$$V_s = \frac{0.207}{3}$$

$$V_s = 0.069\ m^3$$

3.1.3 Speed of the Shaft

Speed of the shaft can be determined using Equation 3.3 as given by Khurmi and Gupta. (2005a)

$$\frac{N_1}{N_2} = \frac{D}{d} \qquad 3.3$$

Speed of electric motor, N_1 = 1430rpm

Diameter of electric motor pulley, d = 50mm

Diameter of mixer pulley, D = 165mm

Speed of machine pulley (i.e. shaft) = N_2

$$N_2 = 433.3rpm$$

Hence, the speed of the shaft, N_2 = 433.3rpm, this implies that a speed reduction ratio of 3:1

3.1.4 Angular Velocity of the Shaft

The angular velocity of the shaft was determined using Equation 3.4 below as given by Iguodala, (2013).

$$\omega_s = \frac{2\pi N_2}{60}$$

3.4

ω_s = Angular velocity of the Shaft

N_2 = Speed of the Shaft = 433.3rpm

$$\omega_s = 45 rad/\sec$$

3.1.5 Force acting on the Shaft

The force acting on the shaft was determined using Equation 3.4 below as given by Salisu, *et al*, (2018).

$$F_S = M_S \times g$$

3.5

Where:

F_s = Force acting on the shaft

g = Acceleration due to gravity = 9.81m/s^2

M_s = Mass of moulding sand = 103kg (given by using density volume relationship)

$$F_S = 103 \times 9.81$$

$$F_S = 1010.43\ N$$

3.1.6 **Power Design**

Considering all other factors, such as:

Tensions on the belt T_1 = 338.4 N, T_2 = 24.92 N

Belt length = 1047 mm

Torque = 83 Nm

The required power to mix the sand is given by Equation 3.6 below as given by Khurmi and Gupta (2005)

$$P_t = (T_1' - T_2')V_b$$

P_t = Power transmitted by the Shaft

T_1' = Total tension on the tight side = 338.4N

T_2' = Total tension on the slack side = 24.92N

V_b = Peripheral velocity = 3.76m/s

$$P_t = (338.4 - 24.92) \times 3.76$$

$$P_t = 1178.69\ W$$

4.0 Results and Discussions

4.1 The mixer

After the full fabrication of the foundry sand mixer, operational evaluation of the mixer on mixing of sand was carried out. The mixer with a maximum full load of 0.069 m^3 of sand was test-run at a speed of about 433 rpm, the optimal results recorded were for varying testing load of 5kg, 10kg, 20kg and 30kg, which represents an average mass of sand mostly required in a foundry workshop for casting operations. Table 4.1 below shows the recorded time taken (sec) to mix the prepared sample of foundry sand using both manual methods and the motor powered method. The time taken for each mass batch using both methods was recorded and tabulate. Figure 4.1 represents the results of the mixing rate using both methods. The grain size analysis of the mixture was also considered presented in Table 4.2 and Figure 4.2 respectively.

Table 4.1: Time Taken to Mix Sand using both methods

S/N	Mass (Kg)	Time taken by mixer (min)	Time taken by hand (min)
1	0.5	1.6	3
2	1.0	2.4	4
3	5.0	9.0	15
4	10.0	15	27
5	20.0	20	32
6	30.0	25	68

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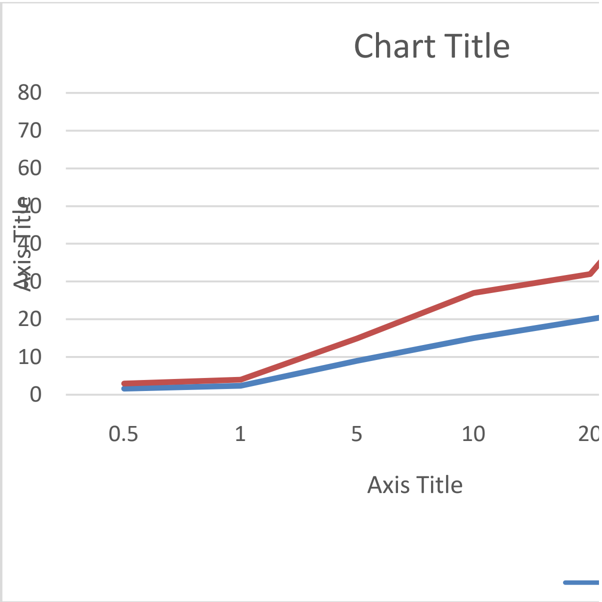

Figure 4.1: Graph Result for both Mixing Methods

The time taken graph to mix the silica sand with other additives shows that it requires more time to carry out the mixing in the workshop using the manual hand method. This will certainly be tedious, time consuming and might be unreliable. The machine mixer time showed linear increase in time taken which means that time to mix higher masses can be pre-determined.

Table 4.2: Sieve Analysis for both Mixing Methods

Sieve no.	%Mass Retained					
	0 min	2 min	5 min	10 min	20 min	30 min
40 m	23.0	22.0	21.8	22.0	22.2	22.5
40 s	20.0	23.0	24.0	22.0	22.0	20.0
60 m	17.0	17.3	17.8	16.7	16.4	16.1
60 s	16.5	19.8	18.7	16.9	20.0	15.4
200 m	9.0	7.4	7.1	7.0	7.0	7.0
200 s	7.0	9.2	7.5	7.3	5.7	4.9

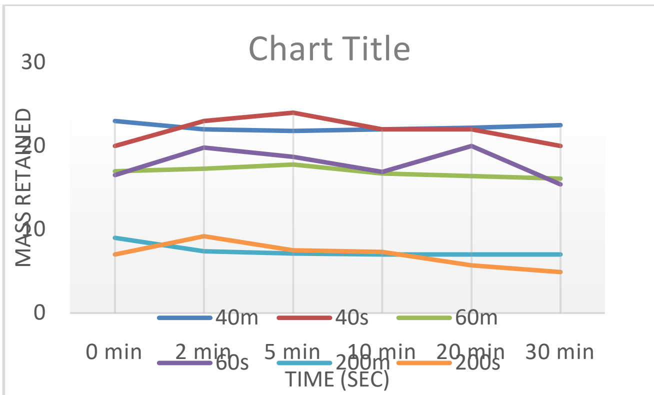

Figure 4.2: Sand Grain Analysis after Mixing by both Methods

The sieves number 40, 60 and 200 are compared in the above graph, the graph shows hand mixing method to be varying unlike the machine mixer having a constant mass retained. This signifies that the use of a machine powered mixer can be more reliable and gives finer particle grain size of mixed silica sand with other additives added to it to improve some targeted properties.

5.0 Conclusion

In foundry, sand mixing is a very important part in the casting process and is quiet a difficult and complex operation. The design and construction of the moulding sand mixer has made the operation easy and simple. The development and construction of a Moulding Sand Mixer imploring available local materials have been achieved. The foundry sand mixer components includes; the base and stand frame, mixing chamber, electric motor, pulleys, shaft, discharge door and mixing blades. Some of the mixer evaluating factors are; the volume of mixer pan, volume of the moulding sand in the mixing pan, speed of the shaft, force acting on the shaft, torque required on shaft, diameter of shaft, time rate of mixing the sand with other additives and the fineness of the sand grain after mixture. The sand mixer showed higher efficiency while recording a lower time to mix the foundry sand. The application of the developed foundry sand mixer will no doubt help in eliminating the use manual effort which is tedious, time consuming and less efficient. It will also help in promoting the idea and technology of imploring machines locally made in substituting human efforts in our society.

6.0 Recommendations

Having worked on the moulding sand mixer, it is expected to produce moulding sand with a homogenous mix in a short period of time and promote the production process by enhancing the casting process to produce a cast with good surface finish and adequate job production. Though its installation cost might be high for some small foundry workshop, this is duly preferable to the foreign sand mixer.

However, effort should be made to adapt this moulding sand mixer for large-scale foundry production in producing the required homogenous moulding sand mix. We also recommend that the moulding sand mixer is been work upon to increase the mass of moulding sand mixed in the mixing pan by increasing the torque of the mixer to promote mass production and increase the mechanical efficiency of the sand mixer to 59% which is the efficiency of the foreign sand mixer.

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