RESEARCH ARTICLE OPEN ACCESS

Design and Fabrication of a Portable Concrete Mixer

ADEDEJI Bukola Peter, Abiola Aderinto, Akano Isaac, Akinrinola Temitayo, Olafimihan Emmanuel.
(Department of Mechanical Engineering, Ladoke Akintola University of Technology,Nigeria

ABSTRACT
In major construction works such as building, roads and bridges, it is highly important to make use of concrete for rigidity of the structure. Hence, the design and fabrication of portable concrete mixer is essential at a low cost in which an average man can afford. The portable concrete mixer consists of an electric motor which transmits power via the belt pulley system to the mixing drum. The drum does the major parts with the shaft, and paddles. The efficiency of the designed Portable Concrete Mixer is approximately 95%. It has a capacity of 233.05Kg/m3.Materials used in the fabrication were carefully selected, considering suitability factors and economic consideration.

Keywords - Concrete, Concrete Mixer, design

Date of Submission: 01-05-2021 Date of Acceptance: 15-05-2021

I. INTRODUCTION

The Romans are general credited as being the first Concrete Engineers, but archaeological evidence says otherwise. Archaeologists have found a type of concrete dating to 6500BC, when Stone Age Syrians used permanent fire pit for heating and cooking. The newly discovered technology was widely used in Syrian as centered lime burning kills were constructed, concrete floors and water proofing cisterns.

The Egyptians used cement as far back as 2500BC. Some scholars believed that a cementing material produced from either lime concrete or burnt gypsums was used in forming the great pyramid at Giza. The earliest known illustration (dating to about 1950 B.C.) of concrete being used on Egypt is shown in a mural on a wall Thebes. Archeologists have long thought that the Egyptians were masters of the stone as stone artifacts (hard stone vessels, statues) made of metamorphic schist, diorite basalt were produced. These smooth and glossy stone artifacts bear no trace of tool marks. Some archeologists believe that the ancient Egyptian artists knew how to convert ores and minerals into a mineral binder for producing stone artifacts. They believed that many of the Egyptian status were not carved from rock, but rather were cast in moulds, and are synthetic stone status. Some years this age, the mixing of concrete components for construction works are often done using hand tools such as shovels and spade. This has proved tedious, slow and less efficient. Thereafter, a Kenmore washing machine tube, was also made.

The new development has led to the invention of better performance concrete mixer, Nabataean concrete mixer, Mortal concrete mixer, Mobile concrete mixer and Cement mixer. The above-mentioned machines are complex and expensive. Therefore, there is a need for a portable, simple and less expensive mixer that can perform the same operation but at minimal cost with an appropriate output. To overrule the afore-mentioned problem, a portable concrete mixer is designed and fabricated.

1.1 Development of portable concrete Mixer

These concrete mixers are designed to meet the needs of small batch requirements or where large ready mixed truck delivery is impossible.
They have several job applications, transport concrete from ready-mix plant to job, can be operated as a concrete batch plant at the site or they can be added to rental equipment market.

1.2 Components of Portable Concrete Mixer.

The portable mixer consists of the following essential parts:

i. Electric motor (prime mover)
ii. The mixing drum
iii. The belt and pulley
iv. Conical head
v. Rotation shaft
vi. Miscellaneous items such as bolts, nuts and washers
vii. Bearings
viii. Paddles

ix. Angle iron tripod stand
x. prime mover seat

1.2.2 Uses of Portable Concrete Mixers

The portable concrete mixer can be use or found applicable in the following are:

i. Commercial and residential fence installation
ii. Street, sidewalk curb and gutter repair
iii. Concrete footings
iv. Special mixers (latex, mortax, etc)
v. Sea wall, swimming pool construction and repair
vi. Farm and ranch use

Advantages of Portable Concrete Mixer

The major advantages of the machine are highlighted below:

i. It is less expensive in terms of cost of production
ii. It is easy to maintain
iii. It can be easily dismantled and assembled for troubleshooting
iv. It has less vibration and noise during the operation when compare with the complex type
v. It can easily be operated without stress

1.3. Principal of Operation of a Portable Concrete Mixer

The portable mixer operates with the conversion of electrical energy from the electric motor to the kinetic energy of the belt and the pulley transmitted to the driven shaft.

The rotation of the output shaft of the electric motor is transmitted through the pulley and belt to the driven shaft. The rotation shaft of the concrete mixer equally rotates the paddles since they are welded together. The rotation action of the paddles due to the rotation shaft causes the mixing of the concrete components by sweeping at about an angle of 30^0 to the shaft. Sand, stones, cement and quantified amount of water ready to be mixed are fed through the conical head into the mixing drum. The paddles' rotation leads to the mixing of the concrete components for a period of about 15 seconds depending on the amount of the input components. The outlet is then opened to allow for the passage of concrete.

1.3 Designed of Power Transmission System.

1.4.1 Belt and Pulley

The choice of best for this design is totally based on efficiency of power transmission, capacity, speed of rotation and durability. The v- belt is chosen to transmit the power from the prime mover to the rotation shaft because of the following reasons.

i. It can easily be installed and removed
ii. The belt has the ability to reduce the shock when the machine is started.
iii. The drive is positive, because the slip between the belt and the pulley groove is negligible.

1.4.2 Pulley Analysis

Assuming a factor of safety of 1.2 and availability of a 2hp electric motor, the power available for driving the shaft is approximately 1.53kw. Using standard belt type and the corresponding size, we have

Top width (b) – 17mm
Thickness (t) – 11mm
Groove angle of pulley – 38^0 (KURMI and GUPTA 2003)
Speed of the electric motor, Se = 600rpm
Calculated speed of the shaft, S= 247rpm
Diameter of pulley on the electric motor, De=70mm
Diameter of pulley on the shaft, Ds = 170mm

1.4.3 Determination of angle of contact, angle of wrap and length of the belt.

For the belt: the angle of contact 'β' is given as

$$\beta = \sin^{-1}\frac{D-d}{2c} \text{ or } \sin^{-1}\frac{R-r}{2c}$$

Where: β = angle of contact
D = diameter of the large pulley
d = diameter of the small pulley
R = radius of the large pulley
r = radius of the small pulley
The angle of wrap is given as:

$$\alpha_1 = Л\ 2\ \beta = 180^0 - 2\sin^{-1}\frac{D-d}{2c} \quad \text{OR}$$

$$180^0 - 2\sin^{-1}\frac{R-r}{C}$$

Where α_1 = angle of wrap of the large pulley
α_s= angle of wrap of the small pulley

From figure 3.1, the total length of the belt can be calculated as follows:

L = Arc GJE + EF +Arc FKH + HG
= 2 (Arc JE + EF+ Arc FK)

The power transmitted through the belt from the electric motor to the driven shaft is

$P = (T_1 - T_2)\ V$ watts

Where: P =Power transmitted (watts)
T_1 = Tension on the tight side (N)
T_2 = Tension on the slack side (N)
V = Velocity of the pulley on the motor (m/s)

But $V = \frac{ЛdN}{60}$

Where, d = diameter of the pulley on the electric motor (m)
N = evolutional speed of the pulley (rpm)

1.7 Volumetric Capacity of The Portable Concrete Mixer

3.7.1 Determination Of The Volume Of The Mixing Space

The total volume of the mixing space comprises the volume of the cylindrical mixing drum and that of the conical head.

i.e. $V = V_1 + V_2$

Where V = total volume of the mixing space (m^3)

V_1 = total volume of the mixing drum (m^3)

V_2 = volume of the conical head (m^3)

$V_1 = \pi r^2 h$

$V_1 = 3.142\,(0.295)^2\,(0.64)$

$V_1 = 0.175m^3$

This can be shown in figure 3.6.

The volume of the conical head is determined by assuming that is a frustum since a bigger cone is beheaded.

Volume of the frustum = Volume of the bigger cone (V_b) – Volume of the smaller cone (V_s)

Therefore $V_2 = V_b - V_s$

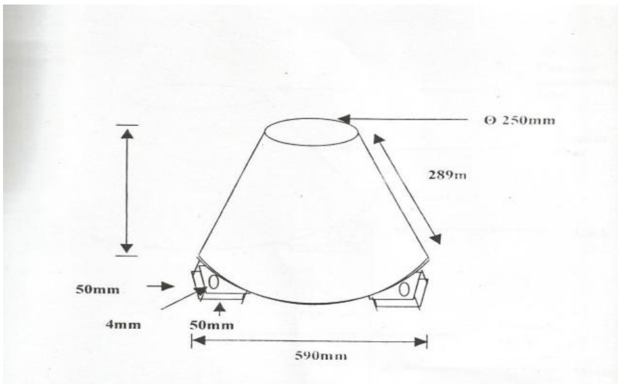

Fig 3.7 conical head

From fig 3.6: Conical Head

From fig. 3.6

$$\frac{X}{d_1} = \frac{(250+x)}{d_2}$$

Where x = height of the smaller cone.

250 + x = height of the bigger cone.

d_1 = diameter of the smaller cone.

d_2 = diameter of the bigger cone.

d_1 = 250mm; d_2 = 590mm.

$$\frac{x}{250} = \left(\frac{250+x}{590}\right)$$

$250(250 + x) = 590x$

$62500 + 250x = 590x$

$62500 = 590x - 250x$

$62500 = 340x$

$$x = \frac{62500}{340}$$

$x = 183.8mm$

$V_b = \frac{1}{3}\pi r_b^2 h_b$

$r_b = {}^{590}/_2 = 295mm = 0.295m;$

ha = x = 183.8mm = 0.184m.

$V_a = \frac{1}{3}\pi \times 0.125^2 \times 0.184 = 0.030m^3$

Volume of the conical head $V_2 = V_b - V_a$

$V_2 = 0.0395 - 0.0301$

$V_2 = 0.094m^3$

Total volume of the mixing space $V = V_1 + V_2$

$V = 0.175 + 0.094$

$V = 0.295m^3$

1.7.2 Capacity of the Mixing Drum

The capacity of the mixing drum is the mass of the concrete components that the mixing drum can contain at a particular time without any negative effect on the performance of the device.

The capacity of the mixing drum can be ascertained if the permissible weight of the concrete and volume of the mixing space are known.

Capacity of the mixing drum = permissible weight/ mass of the concrete

Volume of the mixing drum

$C = M/V$ (kg/m^3)

$C = 60kg/0.29 = 223.05kg/m^3$

1.7.3 Output Rating

The output rating is the ratio of the mass to the time taken to completely or satisfactorily mix specified masses of sand, cement, stones and water under specified working conditions.

Output rating = mass of the Concrete Components/Time taken

R = M/t (kg/s)

Where R = output rating (kg/s)

M = Mass of the concrete components (kg)

t = Time taken for complete mixture (s)

Given that the time taken to completely mix 60kg of concrete components is $1^1/_2$ minutes, then the output rating can be calculated as:

$$\textit{Efficiency} = \frac{\textit{power output}}{\textit{Power input}} \times 100\%$$

The output power is derived from the rotating shaft and can be written as:

$$P_1 = \frac{2\pi N_1 T}{60}$$

whereN_1 = shaft revolution per minute

T = Torque on the rotating shaft (Nm)

Power input is the power transmitted from the electric motor through the belt to the shaft.

Power input, $P_2 = (T_1 - T_2)V$

But $V = \frac{\pi d N_2}{60}$

So that

$$P_2 = \frac{(T_1 - T_2)\pi d N_2}{60}$$

Where N1 = speed of the electric motor (rpm)

T_1 = Tension in the tight side (N)

T_2 = Tension in the slack side (N)

V = Velocity of the belt (m/s)

d = Diameter of the belt rotating shaft pulley (m)

Efficiency, $E = P_1/P_2 \times 100\%$

$$= \frac{2\pi N_1 T_1}{60} \Big/ \frac{(T_1 - T_2)\,\pi d N_2}{60}$$

$$E = \frac{2N_1T}{(T_1 - T_2)d} \times 100\% \qquad P_2 = N_2$$

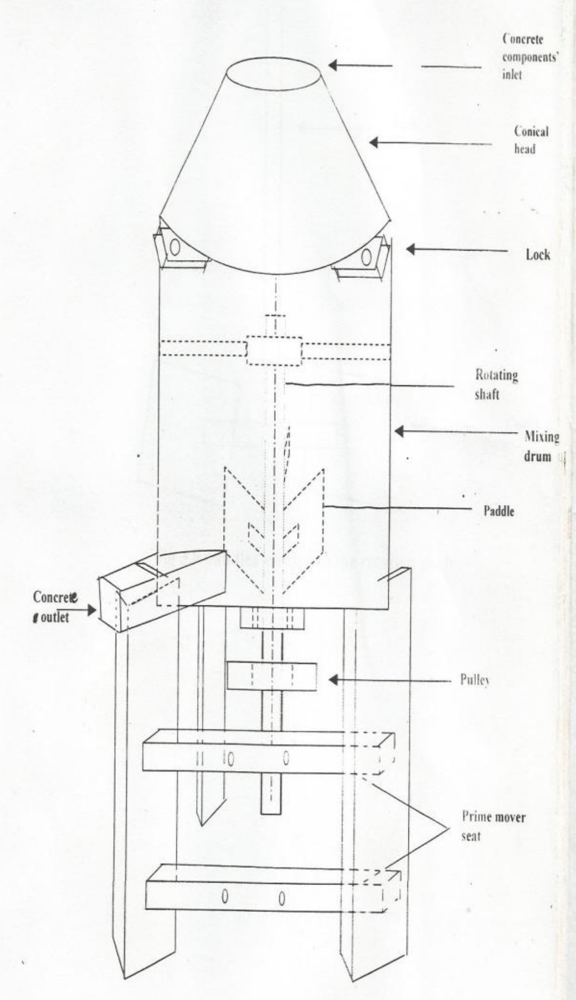

Fig 3.8 portable concrete mixer

Fig. 3.9 Photogragh of portable concrete mixer

4.2 Material Types, Dimensions, Quantities, Cost and Specifications

The selected material for design and fabrication are summarized in the table shown below:

II. CONCLUSION AND RECOMMENDATION

The designed and fabricated portable concrete mixer performed satisfactorily when tested. The limitation is that it can only be used where there is electric power supply. There are no wheels incorporated into the design. It can only be used for gravel of a maximum sieve number 13.2mm.

It is commended that a source of electrical supply should be made available in rural areas where electricity is not available. It is also recommended that a means of mobility should be made available to avoid unnecessary stresses.

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Table 1: Material Specification

S/N	Components	Materials	Qty	Dimensions (mm)
1	Rotating shaft	Low carbon steel	1	24
2	Bearings	Mild steel	2	6305 (standard) KG international FZCo
3	Mixing drum	Mild steel	1	295 × 640
4	Conical head	Mild steel	1	590×250
5	Pulley	Iron rods and plates	1	170
6	Belt	Rubber	1	12.5×1050L aA40
7	Bolts & nuts	Mild steel	8	13,17 sizes
8	Paddles	Mild steel plate	3	212 × 220
9	Tripod stand	Angle iron	3	46 × 46
10	Prime mover seat	Angle iron	2	46 × 46
11	Bearing support	Iron rod	3	10
12	Electric motor		1	

ADEDEJI Bukola Peter, et. al. "Design and Fabrication of a Portable Concrete Mixer." *International Journal of Engineering Research and Applications (IJERA)*, vol.11 (5), 2021, pp