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Design and Fabrication of Multi-Sieve Sand Sieving Machine

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Abstract: This paper presents the design and fabrication of a sand sieving machine with multiple sieves that can be changed according to the usage of the work. As we see at every construction site, sand is sieved by old hand-operated (mesh sieving) techniques. Where the siever of a particular size is kept at support from the ground and then sand is poured onto the siever and then manually the sand is sieved by the hand making the sand travel onto the siever and the leftover sediments will be left at one face and the sieved sand will be on another. This technique is time-consuming and for fine sand filtration, it will adequately take a much longer time to sieve. To overcome this problem there are many machines which were designed but only a few of them can be handled at work site. In our design, we use two siever plates which are kept one aside from the other which are hung by the chain of which on end is fixed with the main body. The sievers to which an offset shaft from the motor is attached are to be driven. This offset will create the torsional vibrations with the to and fro motion. This will create the charge particles to get sieved and the leftover charge will move forward and then it will be sieved onto the other siever and the leftover particles will discharge out of the machine. This will reduce the time of sand sieving compared to the hand-operated technique and hence the efficiency and profitability will increase.

Keywords: Sand, Sand Sieving Machine, Multi-Sieve, Motor Operated, Two Sieve, Mesh Plate, Screening, Vibrations.

I. INTRODUCTION

Sand is very commonly used in construction. It also helps in providing bulk, strength, and stability to other materials such as concrete, mortar, render, cement, etc. Sand is also used as a base layer which is known as 'blinding'. It is laid above a layer of hardcore to provide a level, and dry surface for construction works. Sand is an essential element in the field of construction and hence sand has broad usage in various fields. Different size of sand is required for different type of work. At a particular worksite, more than one size of sand is used to complete the work. Similarly, at the construction sites, it is required to use different sizes of sand for different types of work. For plastering the wall, fine sand of range 0.075mm to 0.25mm is used, for finishing, fine graded sand is used. And similarly, the size of sand ranging from 0.25 to 5mm is used for wall reinforcement, grounding, or flooring. And hence it is required to sieve the sand accordingly. To date, majorly, the sand is sieved manually. Hand-operated sieving of sand takes a longer time to sieve the fine grade of sand. And for sieving different sizes of sand , different types of sieves are used, which is a bit tedious work to handle the two-three type of hand-operated sievers at a construction site. If the fine graded sand is required for the job, then it becomes a time-consuming work to sieve the sand because of manual operation are performed for several time to get the fine grade of sand from the coarse sand. To inculcate this problem, we designed and fabricate a multi-sieve sand sieving machine which can be used in any industry where sieving is required, just by changing the sieve plate or mesh plate. Where the multiple sieves can be used to sieve the desire size of sand. Just by changing the sieves, different types of items can also be sieved. This machine can be used in various industries such as marble powder industry, resin industry, etc for sieving the material just by changing the sieve plate accordingly.

II. OBJECTIVES

1) To make a machine that can sieve multiple sizes of sand grains depending on the usage at the site
2) To reduce the time that is consumed by a manual sand sieving technique
3) To increase the efficiency at the work site
4) To design and fabricate a machine that can be operated by unskilled labour too
5) To develop a machine that can be easily portable from one site to another

III. DESIGN

Figure 1 Design of Multi-Sieve Sand Sieving Machine

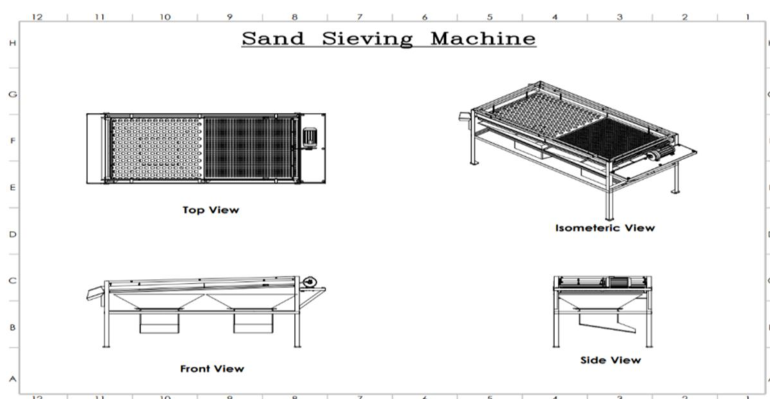

Figure 2 Drawing of Multi-Sieve Sand Sieving Machine

IV. CALCULATIONS

1) $To\ find\ the\ mass\ of\ sand\ in\ one\ tasla\ (kg)$

$Volume\ of\ tasla\ having\ dimensional\ specification$

$Inner\ diameter = 547mm \approx 0.547m$

$Outer\ diameter = 525mm \approx 0.525m$

$Height = 200mm \approx 0.2$

$\therefore Volume\ of\ tasla = 0.03m^3$

CONDITION OF SAND & DENSITY (Density of Building Materials As Per IS 875 Part-1)		
SR NO	CONDITION OF SAND	DENSITY (kg/m^3)
1.	Dry	1540-1600
2.	Wet	1760-2000

Table 1 Condition of Sand & Their Respective Density

$$Density\ (\rho) = \frac{Mass\ (m)}{Volume\ \ (V)}\ \ (kg/m^3)$$
$$Case\ 1 : Condition\ of\ sand\ = Dry$$
$$\therefore Mass\ of\ sand\ = 1600 \times 0.03$$
$$= 48\ kg \sim 50kg$$

$$Case\ 2 : Condition\ of\ sand\ = Wet$$
$$\therefore Mass\ of\ sand\ = 2000 \times 0.03$$
$$= 60\ kg$$

2) *Calculation of lift on sling*

$$Tension\ in\ each\ sling\ \ = \frac{Weight}{Number\ of\ legs} \times L.A.F$$

$$Considering\ weight\ of\ sand\ poured\ at\ a\ time = 50kg$$
$$\text{L. A. F for 90° sling angle} = 1$$
$$\therefore \text{Tension in each sling} = \frac{50}{2} \times 1$$
$$Tension\ in\ each\ sling\ = 25\ kg$$

3) *Torque calculation*

$$Taking\ motor\ of\ specification\ 960\ rpm\ , 1\ HP$$
$$1\ HP = \ 750W$$
$$Torque\ (T) = \frac{Power}{\omega}$$
$$T = \frac{60 \times P}{2\pi N}$$
$$T = \frac{60 \times 750}{2\pi \times 960}$$
$$T = 7.46\ N.m$$

4) *Machine efficiency* $(\eta_{Machine})$

$$Power\ of\ motor = \ \ 750Watt = 0.75KW$$
$$Power\ for\ 1\ hr\ = 0.75 \times 1 = 0.75\ KWhr$$
$$Unit\ Consumption\ = 0.75\ units$$
$$Working\ for\ 6\ hours\ a\ day\ = 0.75 \times 6 = units\ per\ day$$
$$One\ month\ consumption\ = 4.5 \times 30 = 135\ units$$
$$Approx\ bill\ for\ a\ month = 135 \times 10 = ₹1350$$

5) Manpower efficiency $(\eta_{Manpower})$

$$(Considering\ same\ amount\ of\ work\ done\ by\ the\ man\ power\ as\ compared\ to\ the\ machine)$$
$$Daily\ wages = \ ₹200$$
$$Monthly\ wages = \ ₹\ 200 \times 30 = ₹6000$$

(*Note : Even the sand will be sieved by machine but the labour will be required to pour the sand into the machine , but at the same time labour can do another work at the site. This is how the efficiency at the work site will be increased at the same wages.)

6) Power Calculation (P)

$$Power\ =\ Force\ \times Velocity$$
$$Considering\ velocity\ =\ 0.5\ m\ per\ sec$$
$$\therefore Power\ =\ mass\ \times\ accleration\ due\ to\ gravity\ \times\ veloctiy$$
$$\therefore P\ =\ 50\times 9.81\times 0.5 \qquad \cdots(When\ mass\ =\ 50\ kg)$$
$$\therefore P\ =\ 245.25\ watt$$

$$Taking\ factor\ of\ safety\ =\ 3$$
$$*\ (\ As\ the\ conditation\ sand\ will\ change\ as\ per\ the\ atmosphere)$$

$$P\ =\ 150\ \times 9.81\times 0.5 \qquad \cdots(When\ mass\ =\ 150\ kg)$$
$$\therefore P\ =\ 735\ watt$$

$$\therefore 750\ watt\ motor\ is\ suitable\ for\ the\ power\ transmission$$

7) Torsional Force in Shaft

(Material of shaft → Mild steel)

$$Maximum\ tensile\ stress\ of\ mild\ steel\ (\sigma_{Tensile})\ =\ 525MPa$$
$$Maximum\ shear\ stress\ of\ mild\ steel\ (\sigma_{shear})\ =\ \frac{525}{1.75}\ =\ 300MPa$$
$$Diameter\ of\ shaft\ (D)\ =\ 30mm\ =\ 0.0.3m$$
$$Maximum\ Torque\ transmitted\ by\ circular\ shaft\ (T_{max})\ =\ \frac{60\times P\times K_l}{2\pi N}$$
$$(Taking\ K_l\ =\ 1.5)$$
$$\therefore T_{max}\ =\ \frac{60\times 750\times 1.5}{2\pi N}$$
$$\therefore T_{max}\ =\ 11.2\ N.m$$

8) Torsional Vibration

$$E\ =\ 200\ GN/m^2 = 200\times 10^9\ N/m^2$$
$$D\ =\ 30mm\ =\ 0.03m\ ,\ L\ =\ 1.5m$$
$$Moment\ of\ Inertia\ (I)\ =\ \frac{\pi}{64}D^4$$
$$I\ =\ \frac{\pi}{64}\times 0.03^4\ =\ 3.97\times 10^{-8}\ m^4$$

$$Static\ deflection\ (\delta)$$
$$\delta\ =\ \frac{Wa^2b^2}{3EIL}$$
$$\delta\ =\ \frac{50\times 9.81\times 0.2^2\times 1.3^2}{3\times 200\times 10^9\times 3.97\times 10^{-8}\times 1.5}$$
$$\therefore \delta\ =\ 9.256\times 10^{-4}\ m^4$$

$$Natural\ frequency\ of\ torsional\ \ vibrations\ (f_n)$$
$$f_n\ =\ \frac{0.4985}{\sqrt{\delta}}$$
$$f_n\ =\ \frac{0.4985}{\sqrt{9.256\times 10^{-4}}}$$
$$f_n\ =\ 16.385\ Hz$$

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9) $Critical\ speed\ of\ shaft\ (N_c)$

$$N_c = f_n \times 60$$
$$N_c = 16.385 \times 60$$
$$\therefore N_c = 983.07\ rpm$$

10) *Range of speed (N)*

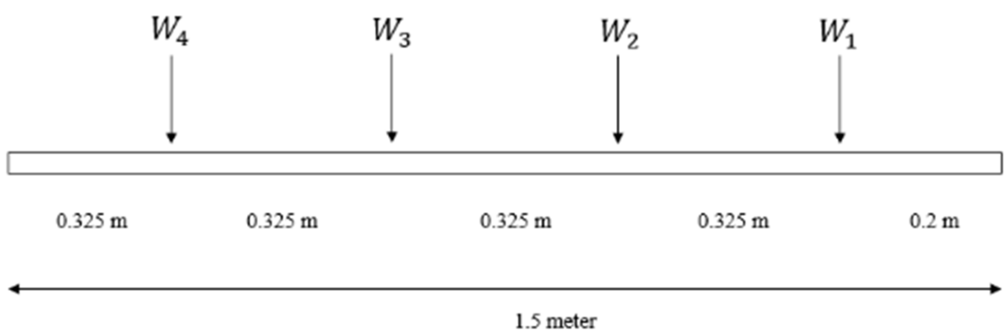
$$N = \frac{N_c}{\sqrt{1.16}} \quad or \quad \frac{N_c}{\sqrt{0.84}}$$

$$N = \frac{983.07}{\sqrt{1.16}} \quad or \quad \frac{983.07}{\sqrt{0.84}}$$

$$\therefore N = 912.76 rpm \ \& \ N = 1072.617 rpm$$

$$\therefore Range\ of\ speed\ is\ from\ 912.76\ rpm\ to\ 1072.617\ rpm$$
$$\therefore The\ selected\ speed\ of\ motor\ is\ sufficient\ to\ drive\ the\ load.$$

11) *Natural frequency of transverse vibrations for a shaft subjected to number of point load (f_n)*



$$Considering,$$
$$W_1 = 50kg = 50 \times 9.81 = 490.5\ N$$
$$W_2 = 35kg = 35 \times 9.81 = 343.4\ N$$
$$W_3 = 20kg = 20 \times 9.81 = 196.2\ N$$
$$W_4 = 10kg = 50 \times 9.81 = 98.1\ N$$

By Dunkerley's Method,

$$\frac{1}{f_n^2} = \frac{1}{f_1^2} + \frac{1}{f_2^2} + \frac{1}{f_3^2} + \frac{1}{f_4^2} + \cdots + \frac{1}{f_s^2}$$

$$f_n = \frac{0.4985}{\sqrt{\delta_1 + \delta_2 + \delta_3 + \delta_4 + \cdots + \delta_s}}$$

$$\delta_s = Static\ point\ deflection$$

$$\delta = \frac{Wa^2b^2}{3EIL}$$

$$\delta_1 = \frac{490.5 \times 0.2^2 \times 1.3^2}{3 \times 200 \times 10^9 \times 3.97 \times 10^{-8} \times 1.5}$$

$$\delta_1 = 9.2801 \times 10^{-4}\, m$$

$Similarly,$

$$\delta_2 = 2.5178 \times 10^{-3}\, m$$

$$\delta_3 = 1.676 \times 10^{-3}\, m$$

$$\delta_4 = 4 \times 10^{-4}\, m$$

$Transverse\ vibration\ at\ each\ point$,

$$f_n = \frac{0.4985}{\sqrt{\delta}}$$

$$f_1 = \frac{0.4985}{\sqrt{9.2801 \times 10^{-4}}}$$

$$f_1 = 16.364\, Hz$$

$$f_2 = 9.934\, Hz$$

$$f_3 = 12.18\, Hz$$

$$f_4 = 25\, Hz$$

$According\ to\ Dunkerley's empirical\ formula, natural\ frequency\ of\ whole\ system\ is\ given\ by;$

$$f_n = \frac{0.4985}{\sqrt{\delta_1 + \delta_2 + \delta_3 + \delta_4 + \cdots + \delta_s}}$$

$$f_n = \frac{0.4985}{\sqrt{9.2801 \times 10^{-4} + 2.5178 \times 10^{-3} + 1.676 \times 10^{-3} + 4 \times 10^{-4}}}$$

$$f_n = 6.7085\, Hz$$

$\therefore Natural\ frequency\ of\ transverse\ vibration\ of\ whole\ system\ (f_n) = 6.7085\, Hz$

V. WORKING PRINCIPLE

A single phase 960rpm , 1HP motor is used to drive the shaft. The rotary motion provided by the motor to the main shaft is then connected to the another shaft having an offset which will drive the main sieve frame . The offset is given to the shaft connected with the sieves. This offset will create the torsional vibrations and transverse vibration as it will move back and forth / reciprocating . Due to this back and forth motion on the sieve, the sand will be sieved of the desired size from the mixture of sand.

VI. WORKING

1) Charge is poured on to the sieve
2) Electric supply is given to the motor.
3) Main shaft of the motor is attached further to another shaft which has an offset with main shaft which is connected to the sieves.
4) As the motor starts, the driving force will provide the back and forth motion on the sieve which will also experience the torsional vibrations.
5) Due to the torsional vibration , transverse vibrations and sliding motion, the charge will experience the motion which will result in meshing the charge from the sieves and the remaining charge will move further.
6) The desired sieved charges will then pass through H hopper into the collecting container.

VII. ADVANTAGES

1) Simple construction as it is not having any complicated mechanism.
2) Easily transported from one site to another as the weight of body is less.
3) Parts of the machine can be dismantle and transportation become easier.
4) Different types of material can be sieved just by replacing or changing the sieves.
5) Economical if produced at large scale.
6) No skilled labour is required.
7) Low maintenance is required as the machine is not having any complicated mechanism.

VIII. APPLICATION

This machine has a wide application in every filed where sorting of material is required.

1) At construction site, sorting of different size of sand for different type of work.
2) In agriculture, sorting of particular size of food grain , fruits, etc.
3) In metallurgy, sorting of different size of metal powder to refine the efficiency of mixing.
4) In food industry, sorting of various size of sugar, salt, food and fruit item.

IX. CONCLUSION

The continuity of the study lies in old traditional method of sand sieving technique with modern methods with the help of machine and motor operated. With the help of this machine, two size / grades of same material can be sieved off and hence reduce the human effort and simultaneously increases the profitability. This machine can be used in various industries just by changing the sieve of the required grade size. As the machine does not have typically constructive mechanism, the maintenance cost of the machine will be low. This sand sieving is portable as the parts of it can be dismantle and can be reassemble at the site easily.

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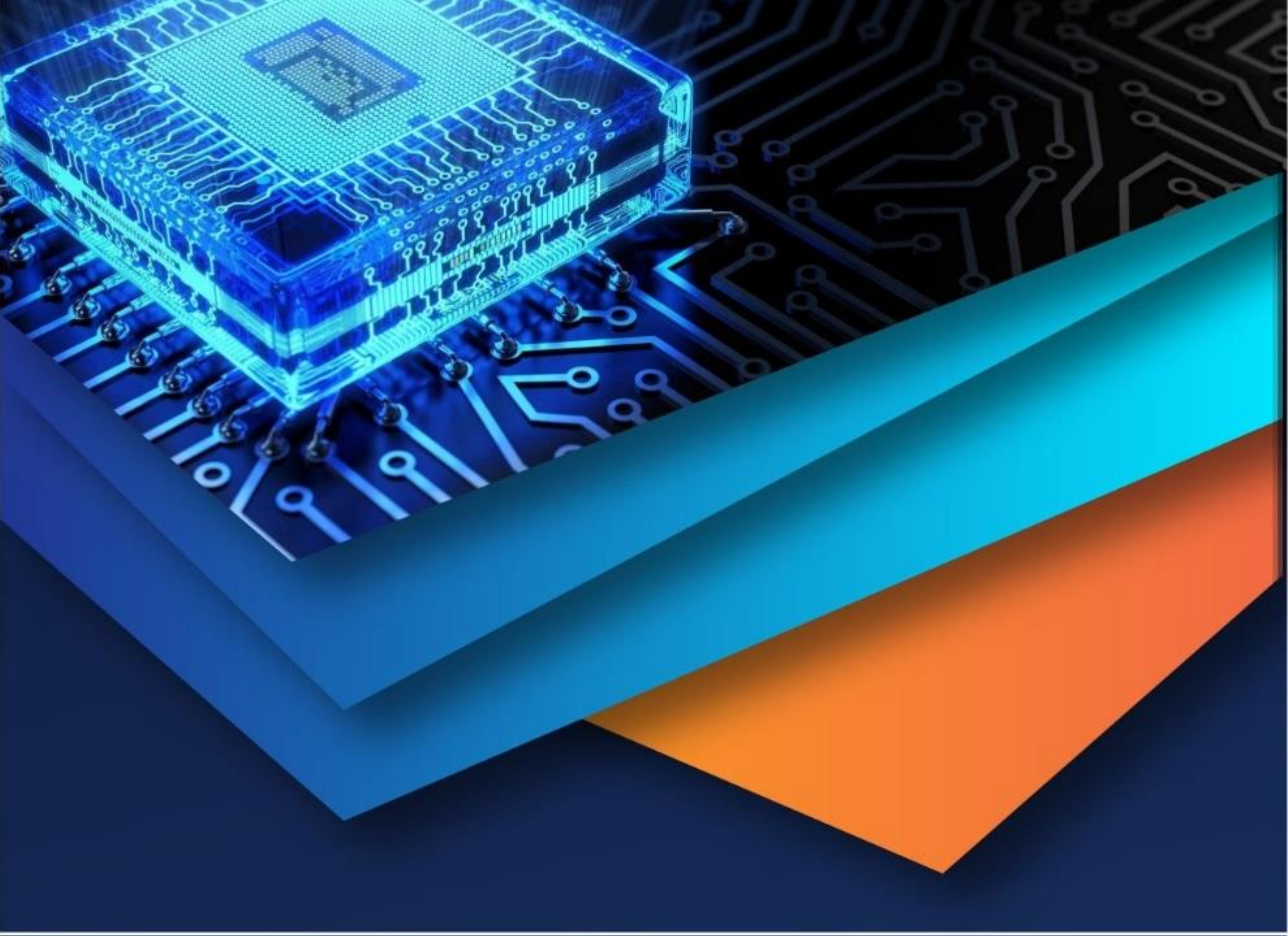

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