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COMPUTATIONAL MODELLING AND EXPERIMENTAL INVESTIGATION OF FLOW RATE OF RECIPROCATING VIBRO SEPARATOR

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Abstract- *The vibro separator is separating the final product by removing impurities and its principal based on vibration motion. The capacity of reciprocating vibro separator is 4 tons per hour. In this research work, try to increase the capacity of reciprocating vibro separator. In the Research work, two parameters like foundation of rubber properties and unbalance mass magnitude & position are kept constant. Two parameters like Motor speed and Motor Angel are considered as variable parameters. Reciprocating vibro separator of Gajanan Industry at Unjha District Mahesana Gujarat is used as an Experimental setup. Find out Amplitude and Dynamic motion behaviour of experimental set up Reciprocating Vibro separator, with help of vibro analyser Instrument. Computational model based on of experimental setup is modelled out in solid works 2017 software and analysed ANSYS 16.2 software. Also Find out Amplitude and dynamic motion behaviour is observed with the help of FFT, Time Domain Data and Poincare. In this research work, flow rate of wheat has been calculated at various motor angle and motor speed.*

Keyword- *Vibro Motor, Vibrating Screen, Unbalance Mass, Vibration Motion Characteristic, Screening Efficiency*

I. INTRODUCTION

Generally, any product is not available in pure form. There are always some impurities are there in required product. To get the final product we have to separate the final product from raw material so to remove that impurities we use vibro separator as separating machine. The vibro separator is separating the final product & impurities by using vibration motion.

The motivation is through an unbalanced motor with a double extended shaft, fitted at both ends with eccentric weights. The top weight on the motor shaft rotates in a plane close to the centre of the mass of assembly. Rotation of the top eccentric weights creates vibration in the horizontal plane, which causes material to move across the screen cloth to periphery increasing the horizontal throw, causing oversize material to discharge at a faster rate. The bottom eccentric weight rotates below the centre of mass creating tilt on the screen giving vibration in vertical and tangential plane. Increasing the vertical component of motion, this promotes turnover of material on the screen surface helping maximum quantity of undersize material to pass through the screen. Rugged Springs placed over the circular motor base amplifies the vibration.

The top weight on the motor shaft rotates in a plane close to the centre of the mass of assembly. Rotation of the top eccentric weight creates vibration in the horizontal plane which causes material to move across the screen cloth to periphery. Increasing the top eccentric mass, increases the horizontal throw, causing oversize material to discharge at a faster rate. The bottom eccentric weight rotates below the centre of mass, creating tilt on the screen, giving vibration in vertical & tangential planes. Increasing the vertical component of motion, this promotes turnover of material on the screen surface helping maximum quantity of undersize material to pass through the screen. The vertical motion also minimizes blinding of screen by "near size" particles. The tangential component of motion is controlled by the angle of lead given to bottom weights with relation to top weight. Variation in lead angle controlled the spiral pattern of material travel over the screen cloth. Speed & flow pattern of material travel over the screen cloth can be set by the operator for maximum throughout & screening efficiency for any screen able product, wet or dry, coarse or fine, heavy or light, hot or cold. Typical material passes rapidly through the screen during its travel to the periphery. The oversize materials get continuously discharged through a tangential outlet.

In that type of vibro- separator having some basic component-

1. Vibrating Feeder
2. Vibro Motor
3. Vibro Screen
4. Hopper
5. Supports
6. Beam

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Vibrating Feeder: A vibrating feeder provide the most effective and pecuniary method of conveying mass of materials and most importantly it is the simplest and easiest means of controlling rate of flow or feed.

Vibrating Screen: Vibrating screen is a kind of sieving equipment used to discrete material into multiple grades by grain size as product and for further processing.

Vibro motor: The vibration is often product by electric motor with an unbalance mass on its driveshaft.

Hopper: A storage container used in industries and is provided with additional width and depth for temporary storage of raw materials, for dust collection etc.

II. LITERATURE SURVEY

The new design does not significantly affect the geometry of the traditional screens, keeping the same global dimensions and almost the same mass value. In fact, the aim of this study was to design a new vibrating screen having almost the same dimensions but that could give a much higher dynamic structural resistance at frequencies and load amplitudes much higher that the starting mass. Numerical finite element models were generated to investigate the structural and dynamic behaviour of a standard vibrating screen. These analyses allowed the modification of the geometrical parameters of the traditional screen and to design the new one. Accurate three-dimension FE models were so generated in order to evaluate the best design solution, in terms of dynamic structural resistance, able to reduce the stress values at the most stressed area. Strains at the most stressed area of the screen were measured in dynamic working conditions, at different frequencies and load amplitudes these stress value were compared with the numerical ones in order to validate the numerical results. DEM results and experimental data from a specially designed circularly vibrating screening model are compared quantitatively under a range of operating conditions. The validate DEM model can be applied to perform extensive numerical studies to achieve optimal performance and better operation of such complicated and important processes in mineral processing. vibrating feeders are used for a wide variety of applications such as metering and transferring of material from bins hoppers, silos and storage piles to crusher, screens and belt conveyors and protecting other equipment from impact loads and for feeding and scalping of ROQ (Run of Quarry) and ROM (Run of Mine) material prior to crushing and conveying. The feeder is used to control the rate of mixture entering the crusher. Thus, majorly used to control the feed rate. The vibrating feeder help in the flow of bulk material into the crusher machine for crushing purpose and bypass small rocks, stones and other particles into the crusher machine and all other small particles, pebbles and sand, etc. A mechanical model of the new motion was established and the characteristics of the new vibrating screen were analysed to establish its equation of motion by using the vibration theory, to include as technological parameters, amplitude, movement velocity, the throwing index through theoretical calculation. The efficiency of particle screening was studied at different values of frequency and the screening with the swing trace. The functional relationship between screening efficiency and the parameters was fitted with the least square method. The results show that high frequency and large swing angle are suitable for small particles, while small values are suitable for particles close to aperture size. Compare to linear vibration trace, both screening efficiency and processing capacity were efficiency improved.

Analysing the screening process of three different vibration screens, it proves that the variable linear vibration screen has better power distribution and screen surface movement. The flexible screen surface can increase the amplitude of the screen surface and reduce the material blocking phenomenon. The screen experiment results of the two-style screen surface vibration screens show the huge advantage of flexible screen surface than fixed screen surface in screen efficiency and avoiding material crush and it also provides a powerful proof to verify the correctness of simulation work. the nonlinear vibration system which supported by the soft nonlinear characteristics spring, the amplitude value of nonlinear system can be automatically compensated when the vibrating mass of the vibrating system fluctuating in small-scope, which make the amplitude approximate remaining constant.

III. EXPERIMENTAL SETUP

The experimental work is performed at **GAJANAND INDUSTARY**. The setup was prepared as per the computational work. Here the two vibro motor are running at 1000 rpm. The variation in motor speed is ± 20 rpm. Motor is having 0.5 Hp power of each vibro motor. The experimental setup is running in between 980 to 1020 rpm motor speed with 30-degree motor angle. Here the separator box has two motors connected at two side walls at the middle point of separator box height. Four unbalanced masses are connected to each motor, which of 3.34 kg each. The experimental result is taken 3 points. One of the point is shown in figure (3.2) and remaining two points are at each part of separator box. The piezoelectric accelerometers sensor (uni-axial) is used for picking up the vibration signals from the point on separator box. These special piezoelectric pickup type sensor is used with a frequency of range from 1-10kHz. The sensitivity of sensor 1.02 mv/(m/s^2) with integral electronics piezoelectric accelerometer input mode of sensor. The analyser used to measure the acceleration data is made by **Crystal corporation**. The model of analyser is **CoCo-80.**

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Figure 3.1 Vibro Analyser

Table 3.1 specification of reciprocating vibro separator

Part Name	Weight(Kg)	Material
Separator box	505.63	Structural steel
Plate	6.37	Structural steel
Foundation rubber	0.335	Rubber
Each Motor Without Unbalanced Mass	26.96	Grey cast iron

IV. COMPUTATIONAL MODEL

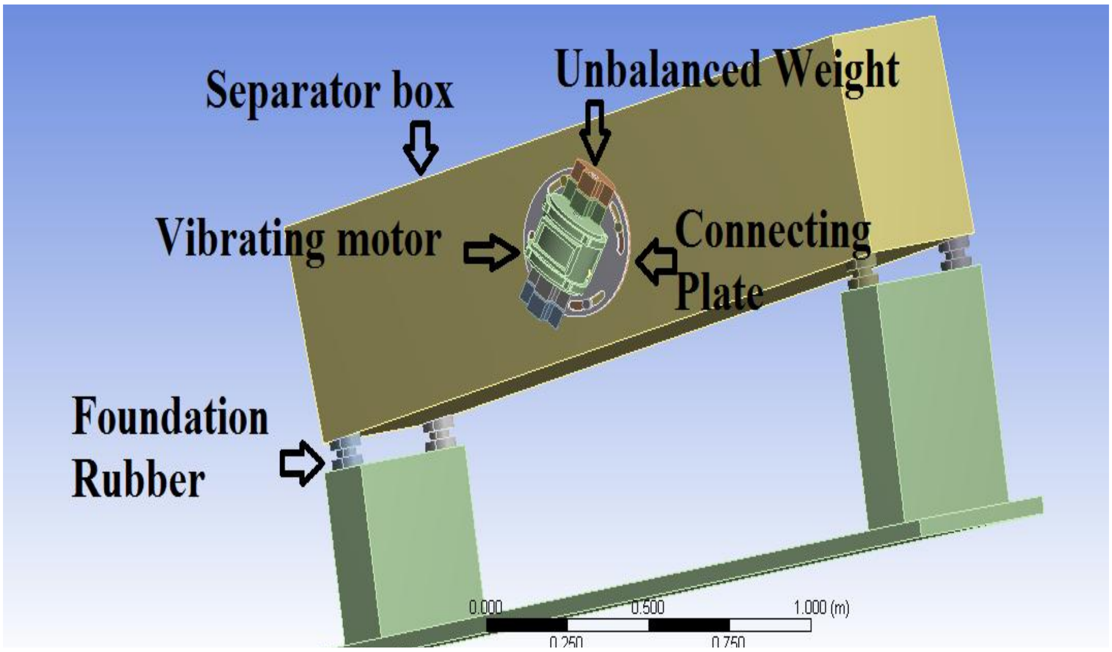

Figure. Reciprocating Vibro Separator Assembly

V. FLOW RATE CALCULATION OF RECIPROCATING VIBRO SEPARATOR

Flow rate of grain

$Q=\rho*A*v$ …………………………… (1)

Q= Flow rate of grain

ρ = Density of grain

= 12.19 Grain per cubic centimetres for wheat

=6.48 * 10^-5 kg per cubic centimetres

Table 5.2 Density of Different Product

No.	Product	Density (grain per cubic centimetre)
1	Wheat	12.19
2	Chickpeas	15.65
3	Grain millet	12.04
4	Sorghum grain	12.52
5	Kidney beans	15.65
6	Lima beans	10.18
7	Mung beans	6.78
8	black beans	16.76
9	Red lentils	12.52
10	Split beans	15.65
11	Sesame	15.65
12	Barley	9.65
13	Cardamom	6.05
14	Cumin	6.26

A= Area of separator box
Hear, **l =** 184 cm
b= 100 cm
h= 50 cm
Hear, we can be using length and Hight for calculating area of grain.
So, area of separator box = Length * Hight
= 184*50
= 9200 cm^2
= 0.92 m^2
v= velocity of the grain
We having all data based on Ansys work and that computational data gives the value of displacement, velocity, acceleration. All data mounted below table.

Table 5.1 Computational data of vibro separator

Angle (degree)	Speed (rpm)	Displacement (mm)	Velocity (mm/s)	Acceleration (mm/s^2)
28’	1000	3.0229	424.19	1.3624
	1050	3.5072	630.08	3.6534
	1100	3.0274	465.65	1.2347
30’	1000	2.9990	405.27	1.3495
	1050	0.6031	190.77	1.97582
	1100	0.7856	189.45	1.3163
32’	1000	3.0310	426.67	1.3906
	1050	3.4852	395.27	1.2088
	1100	3.0274	630.08	3.6534

Hear, density and area are constant in our calculation because density of grain is no change in any process. Also, area of the separator is no change in any process it’s all time same so area also constant.
Density ρ = constant
Area A = constant
So, the equation we get,
Q α ρ

<u>Calculation 1: Angle 28 And Speed 1000 rpm</u>

Experimentally we having flow rate 4 tons per hour.

$$\frac{Q1}{Q2} = \frac{v1}{v2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(2)}$$

Hear **Q1=** flow rate of experimental = 4 tons per hour
Q2= flow rate of computational=?
v1= velocity of grain at 30’ angle 1000 rpm = 405.27 mm/s
v2= velocity of grain at 28’ angle 1000 rpm = 424.19 mm/s
put all value in equation (2)

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$$\frac{4}{Q2} = 405.27/424.19$$

So, Q2= 4.186 tons per hour.

Calculation 2: Angle 28 And Speed 1050 rpm

Q1= Flow rate of experimental = 4.186 tons per hour

Q2= Flow rate of computational=?

v1= velocity of grain at 28’ angle 1000 rpm = 424.19 mm/s

v2= velocity of grain at 28’ angle 1050 rpm = 630.08 mm/s

$$\frac{Q1}{Q2} = \frac{v1}{v2} \qquad (3)$$

$$\frac{4.186}{Q2} = 424.19/630.08$$

So, Q2= 6.217 tons per hour.

Calculation 3: Angle 28 And Speed 1100 rpm

Q1= Flow rate of experimental = 4.186 tons per hour

Q2= Flow rate of computational=?

v1= velocity of grain at 28’ angle 1000 rpm = 424.19 mm/s

v2= velocity of grain at 28’ angle 1100 rpm = 465.65 mm/s

$$\frac{Q1}{Q2} = \frac{v1}{v2} \qquad (3)$$

$$\frac{4.186}{Q2} = 424.19/465.65$$

So, Q2= 4.590 tons per hour.

V. RESULT AND DISCUSSION

Table 6.1 Comparison of Experimental and Computational Data

Experimental data of reciprocating vibro separator		
Angle (degree)	**Speed (rpm)**	**Flow Rate**
30	1000±20	4 tons per hour
Computational data of reciprocating vibro separator		
Angle	**Speed (rpm)**	**Flow Rate**
28	1000	4.186 tons per hour
28	1050	**6.217 tons per hour**
28	1100	4.590 tons per hour

VI. CONCLUSION

1. Flow rate calculation of reciprocating vibro separator for motor angle 30’ and motor speed 1000 rpm is 4 tons per hour. While flow rate of reciprocating vibro separator at motor angle 28’ and speed 1000 rpm is 4.186 tons per hour. We can say that where getting higher flow rate motor angle 28’ and motor speed 1000 rpm.
2. At an angle of 28’ speeds are varied from 1000 rpm to 1100 rpm at an increment of 50 rpm. In these three speeds we get maximum flow rate of 6.21 tons per hour at 1050 rpm which is more than the reference i.e. 30’ and 1000 rpm.

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