Design and Fabrication of Vibration Tester

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Abstract:-In manufacturing industries, vibration plays an important role in design any component. As vibration causes following two major effects on a component. Due to vibration fatigue stresses increases and hence it reduces the life of component considerably. It produces a very high noise level in atmosphere which in turn the efficiency of an operator or it is irritating factor for human being. If seen from other side, the same vibration can be used to test the component. We can check the components on the vibration tester and we can justify the assumption regarding vibration made at design level.

In this project we have used slider crank mechanism with eccentric shaft to vibrate the platform at amplitude of 5mm.This vibration tester is best suited for industrial workshop condition in respect to ruggedness. The machine is manufactured using standard machining processes like turning, milling, drilling and uses dial gauge to check the flatness. This report includes the details of component drawing, process planning sheet for various parts and details instructions on assembly. The project is organized to demonstrate the development and manufacturing of vibration tester along with details of machining processes used.

Keywords:- Vibration, amplitude, frequency, eccentricity.

I. INTRODUCTION

Testing of the component in the manufacturing industry plays an important role. Without component testing no manufacturing industry can survive as quality and quantity both matters. As testing processes further adds the cost of component so the appropriate testing process for the particular component has to be carried out. So, based upon the component manufactured testing procedure also varies.

These tests are commonly conducted under an 'artificial' vibrating environment in which the source of the applied force is controlled by an external device that is often defined as a vibration exciter Testing of the component brings into the picture number of errors that are incorporated during design and manufacturing process. In the project that of vibration tester we have used the slider crank mechanism. The object of weight up to 250N can be placed on platform. The eccentric shaft is connected to motor through belt and pulley arrangement. The motor used is single phase induction motor having power of 1 (HP) and running at 1440 (RPM). In this project the amplitude of vibration is fixed, but as per requirement we can vary the frequency of vibration using variable pulley. This machine effectively replicates the road journey and its effects on the package and its contents.

A. What is Vibration tester?

Vibration tester is the simple workshop components testing facility, design to check the strength of components. The component is vibrated at required amplitude and frequency for the specific period of time.

Generally speaking, vibration testers can be categorized based upon the type of mechanism being used to vibrate the platform such as:-

1) Electro Hydraulic mechanism

2) Cam and Follower mechanism

3) Electromagnetic vibrating mechanism

1. Electro Hydraulic Mechanism:

A typical closed loop vibration exciter block diagram is shown in Fig.1.The major components are the system controller, which can be either analog or digitally based, the valve driver, the servo valve, hydraulic pump, the hydraulic actuator, the moving and instrumentation. The error signal is used to drive the valve driver, which is an electro hydraulic device that actuates the larger servo valve, which in turn controls the amount of oil that is forced into the hydraulic actuator. The hydraulic actuator drives the table which in turn excites the test item. The input force and motion is used as a feedback to establish that the designed motion is taking place. The hydraulic power supply usually consists of high performance hydraulic pumps with appropriate pressure relief valve, oil coolers. The flow rate performance of such pump system in a conjunction with an appropriate servo valve is function of frequency

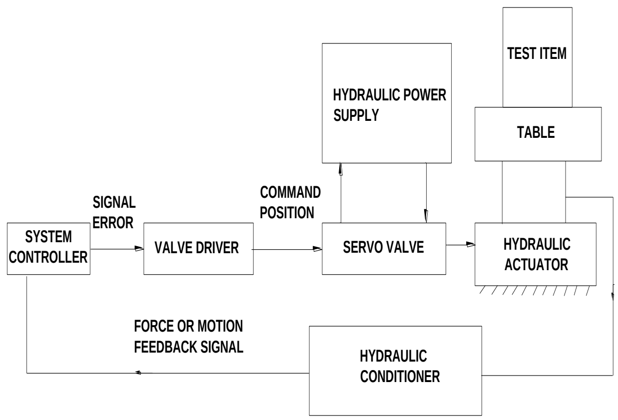

Fig.1 Block Diagram of Electro Hydraulic Mechanism

2 Mechanical Vibrating Mechanisms:

In the mechanical vibration exciter, the cam and follower is used to vibrate the table. The cam is connected to electrical motor through either belt pulley arrangement or gear mechanism. Based upon the cam profile the amplitude of vibration is obtained. For mechanical exciters both frequency bandwidth and output frequency range are narrow. Also the noise level of mechanical exciter is high. With increase in capacity size of machine also increases considerably.

3 Electromagnetic Vibrating Mechanisms:

Electromagnetic vibrator comprises of armature suspended from a starter and having the coil carried by armature located in an air gap in the starter. A dc magnetic field is produced across the air gap and when an alternating current is feed through the armature coil, the armature vibrates along its longitudinal direction. According to the invention armature is suspended by plurality of suspension members which are arranged in pair members and allow free movement of armature along its axis of vibration. For electromagnetic exciter frequency bandwidth and output frequency range are narrow. Because of the limitation caused by the magnetic saturation, electrical exciter is not able to produce a large force without sacrificing the bandwidth.

II. LITERATURE SURVEY

A. Review of Papers:-

1) "Dynamic analysis of the mechanical systems vibrating transversally in transportation" by authors "A.Buchacz and S. Zolkiewski".

The contemporary technical problems are lashed with high work demands such as high speeds of mechanisms, using lower density materials, high precision of work, etc. The main objective of this thesis was the dynamical analysis with taking into consideration the interaction between main motion and local vibrations during the model is loaded by transverse forces. Results of this thesis can be put to use into all machines and mechanisms running in transportation such as wind power plants, high speed turbines, rotors, manipulators and in aerodynamics issues, etc. Some results ought to be modified and adopted to appropriate models. High requirements applying to parameters of work of machines and mechanisms are caused the new research and new ways of modeling and analyzing those systems. One of these ways are presented in this thesis. There was defined the transportation effect for models vibrating transversally.

2) "Compact Vibration Measuring System for in vehicle Applications" by author "G. J. Stein, R. Chmurny1 & V. Rosík".

Low frequency vibrations occurring in ground transportation are of interest in research of the driver's and the passenger's comfort and in seating dynamics research. Piezoelectric accelerometers commonly used for vibration measurement are not well suited for the analyzed frequency range. Hence, other sensors capable of measuring accelerations down to the sub-Hertz region have to be used. Micro-Electro-Mechanical Systems (MEMS) acceleration sensors are particularly suitable for such purposes. A compact measuring system employing two three-axial MEMS accelerometers interfaced via a USB data acquisition unit to a laptop was designed and constructed. The digitized data were then processed by scripts in Matlab with the aim of analyzing both the effect of vibration on a seated person and the dynamic properties of the seat. Preliminary results of a test run with a passenger automobile are presented. One of the areas in which low frequency vibrations occur is ground transportation. The Frequency content may vary from well below 1 (Hz) Up to 80 (Hz).

3) "Determining the Effects of Vibration Parameters and Packaging Method on Mechanical Damage in Golden Delicious Apples" by author "Kubilay Vursavu, Faruk .Zg.Ven".

Research was conducted to evaluate the effects of vibration frequency, vibration acceleration, packaging method, and vibration duration on the mechanical damage during apple transportation. The research was performed in 3 stages. Firstly, vibration frequency and vibration acceleration were measured on the truck-bed for determining the vibration frequency and acceleration distribution. Secondly, packaging transmissibility and vibration frequency sensitivity for all the packaging methods used in this research were measured. Thirdly, a laboratory vibrator, which simulates the road transportation under laboratory conditions, was used to obtain some factors influencing the mechanical damage during apple transportation. According to the results measured on the truck-bed, vibration frequency values were 8.19 Hz and

12.59 (Hz) for 5-10(Hz) and 10-15(Hz) frequency intervals, respectively. Furthermore, vibration acceleration values were 0.33(g) and 0.63(g) for 0.25-0.50(g) and 0.50-0.75(g) intervals, respectively. The highest packaging transmissibility was obtained for the volume packaging method, and packaging transmissibility was at similar high levels at the vibration frequency interval of 8-9(Hz) for all packaging methods. Vibration frequency, vibration acceleration, packaging method, and vibration duration, which were taken into consideration as controlled variable parameters, significantly affected the equivalent severe bruise index at the 1% level of significance. Apples in the pattern packaging method had by far the lowest bruising, and the most suitable method for transit was pattern packaging.

From study of above papers we conclude that, the frequency during transportation varies ,but amplitude of vibration remains constant so we use this data to design vibration tester.

III. PROBLEM DEFINITION

To design and fabricate a vibration tester using slider crank mechanism with eccentric shaft to vibrate the platform at amplitude of 5mm and which can vibrate maximum load of 250N.

IV. DESIGN OF COMPONENTS

A. Selection Procedure for Motor:

1. Required Specifications:

First, determine the basic required specifications such as operating speed, load torque power supply voltage and frequency.

2. Calculate the Operating Speed:

Induction and reversible motor speeds cannot be adjusted. Motor speed must be reduced with gear heads to match the required machine speed. It is therefore necessary to determine the correct gear ratio or reduction ratio.

3. Calculate the Required Torque:

Calculate the required torque for motor by the load torque.

4. Select a Motor and Gear head:

Use the required torque and speed to select a motor and gear head.

5. Confirm the speed:

In a single-phase induction motor, starting torque is always lower than the rated torque. Therefore, to drive a frictional load, select the speed on the basis of starting torque. This will cause the actual speed to exceed the rated speed. Also, the motors close to the rated speed of rotation.

1) Reduction ratio: 2
2) Calculating the required load torque.

Force, F= μ x m x g

Load torque: T= F x D/2

Required Motor Torque = Load torque/Reduction ratio

Power, P=T` ϖ

From above calculation the motor is selected for required application.

B. Shaft Design:

Motor selected is 1 (HP).

Let, T1 and T2 are the tension in the tight and slack side (N).

For motor pulley diameter=d

Speed of Motor= N

Velocity of the belt(V) = (π x d x N)/60

Power(P) = (T1-T2) x V (1)

Let, d= motor pulley

D = Shaft pulley

C = Centre Distance between the pulleys

Lap Angle, ϕ = Tan^{-}1[(D - d)/C]

T1/T2 = $e^{\mu \vartheta}$ (2)

Solving (1) and (2) we get, values of T1 and T2

Permissible shear stress (τ) is given by,

$\tau = S_{yt}$ / (fos) (Where, S_{yt} is Yield strength)

= (0.5xSyt) / (fos)

Torque supplied to shaft is given by,

M_t = (T1-T2) x D

Then calculate maximum Bending moment (M_b).

Maximum Shear Stress is given by,

$\tau_{max} = (16/\pi d`^3)[(M_b)^2 + (M_t)^2]^{1/2}$

solving above equation we get diameter of shaft(d`).

C. Design of Connecting Rod:

Let, ρ = MS Density

l = Length (mm)

b = Breadth (mm)

t = thickness of material (mm)

Weight of top plate

= Volume X Density

= (l x b x t) x ρ x g

Weight of top support = [(t x b x l) + 2 x (l x t x b)] x ρ x g

Considering the maximum weight of component to be vibrated.

Vibrating Weight (W)

= Wt of top plate + Wt of top support + Wt of component.

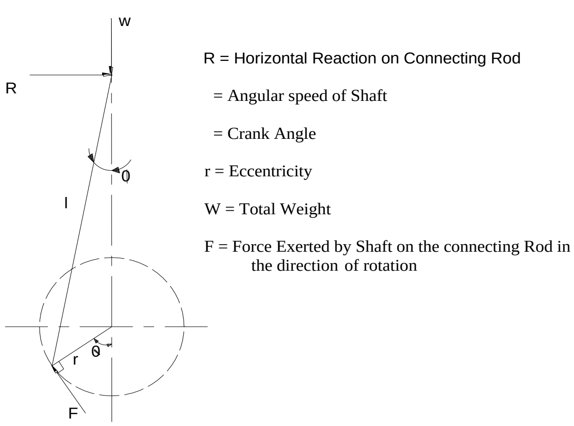

Fig.2 Forces on Connecting Rod

Force on the crank as shown in Fig. 2,

$$F = \text{Power}/(r \times \varpi)$$

$$\text{Sin } \phi = (\sin \vartheta) / n$$

$\sum F_h = 0$ (Summation of Horizontal Forces)

$$F (\cos \vartheta) = R_h = (P \cos \vartheta) / (r \varpi)$$

$\sum F_v = 0$ (Summation of vertical Forces)

$$F (\sin \vartheta) - mg - ma = 0$$

$$\text{i.e., } ma = mg - (P \sin \vartheta) / (r \varpi)$$

$\sum M=0$ (Summation of moments)

$$(F \cos \vartheta) x (\ell \cos \phi) + (F \sin \vartheta) x (\ell \sin \phi) = M_c$$

…… (Mc is torque on connecting rod)

$$F x \ell (\cos \vartheta \text{ x } \cos \phi + \sin \vartheta \text{ x } \sin \phi) = M_c$$

$$\text{i.e., } M_c = F \text{ x } \ell \cos (\vartheta - \phi)$$

Value of eccentricity(r) and speed of larger pulley(n) is known.

$$\phi = \sin^{-1} [(\sin \vartheta)/n]$$

$$n = \ell / r$$

find ℓ.

Substituting above values find

$$R_h, ma, M_c = F \ell \cos (\vartheta - \phi)$$

If c/s area is A, then,

Find mean stress in terms of A,

$$\sigma_m = (F_{max} + F_{min})/(2A)$$

and Stress Amplitude in terms of A,

$$\sigma_a = (F_{max} - F_{min}) / (2A)$$

Then using Soderberg Criteria calculate area(A);

$$1/fos = \sigma_m/S_y + \sigma_a/S_e$$

Assuming suitable breadth (b) according to geometry,calculate thickness(t).
Therefore,
Weight of Connecting Rod = volume x density x g

V. APPLICATIONS

A. Shock Absorber

Shock absorbers are widely used in automobile and construction industries to absorb shocks that are being generated. Shock absorber has high damping coefficient. With the help of vibration tester we can test the absorber by introducing fluctuating loads on the absorber at the given amplitude for which it is design.

B. Packaging Industry

While transporting the finished products to the long distance we cannot justify the type of road surface. So, the proper packing system to the finished components is required to be carried out. Now, with the help of this vibration tester we can determine the strength of this packing system and the level up to which it can sustain the vibration.

C. To Check The Reliability of A Lot of Components In Bulk Manufacturing Industry.

In bulk manufacturing Industry, were components are produced in very large quantity, it becomes very irritating to carry testing for each and every components which further increases the time and cost of the final product. So, by accelerated life testing method, in which, the large number of components are tested in the given time by placing the number of component on the vibrating platform.

D. To Check The Strength Of Highly Sophisticated Components Like Electric Bulbs, Microprocessor.

Sometimes in manufacturing industry though manufacturing design carried accurately but due to variation in the product material there might be some defective components. So, to separate those defective components the series of vibration tester are arranged under the conveyor and hence while transporting the components to different places they are passed over this conveyor and defective components get separated easily. Such type of system can also be used to test the soldering connections in microprocessor.

E. To Check Engine Mountings, Engine Mounts, Pipe Welding And Filter Connections.

To dampen the effect of vibration and oscillations. While our vehicle constantly adapts to road irregularities, the part secures your engine in place and in position to prevent serious damages. As this parts are subjected to constant vibrations hence to check the check Engine Mountings, Engine Mounts, pipe welding and filter connections against such vibration an artificial vibrating environment is created.

CONCLUSION

The machine is easy to use and assemble and can be used for quality testing of highly sophisticated components.Machine is easy to handle and portable.Machine can be used as an accelerated life testing by increasing the number of components at a time in bulk manufacturing industryAs the overall cost of this machine is less hence it can be used for small scale industries.

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