Mechanisms of Different Vibratory Exciters Used – A Review.

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***Abstract* - Vibratory exciter is a mechanical device which generates shaking motion to the test specimen. In this device the frequency and amplitude on the device may be adjusted. In this paper various mechanisms which are used for the mechanical vibratory exciters are reviewed. The vibratory motion can be generated by using different methods or mechanisms. By using different mechanisms the cost, effectiveness and weight of the exciter varies. Mainly three types of vibration exciters are commonly used in industrial applications as: Electro-dynamic exciter, Hydraulic exciter and Mechanical exciter. Mechanical Exciters and its various types are reviewed in detail. These devices are mainly used for vibratory stress relief, vibratory feeder or hopper mechanics and conveyers.**

Keywords – Vibration Exciter, Electro-dynamic exciter, Hydraulic exciter, Mechanical exciter, vibratory stress relief.

I. INTRODUCTION

A vibration exciter is a machine which produces mechanical vibratory motion to test object. A body is said to be in vibration when it has to & fro motion. Vibration is of mainly three types which are free vibration, Damped vibration and Forced vibration. The Mechanical Vibration Exciter works on forced vibratory motion to test the object. The exciters are designed to produce a given range of harmonic or time dependent excitation force and displacement through a given range of frequencies. Vibration exciters are used to produce cyclic excitation force at a required frequency.

Sinusoidal or Sine Vibration has the shape of a sine wave as seen in Fig 1. The parameters used to define sinusoidal vibration testing are amplitude (usually acceleration or displacement), frequency, sweep rate and number of sweeps.

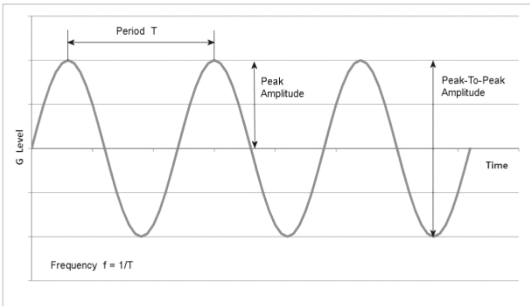


Fig.1 sinusoidal vibration test profile

A typical sinusoidal vibration test profile is shown in Figure 1. The amplitude is defined over a range of frequencies. The amplitude can be constant or variable. During a sine vibration test, the vibration wave forms are swept through a range of frequencies; however they are of discrete amplitude, frequency and phase at any instant in time. An important note is that the displacement increases as the frequency decreases for a given acceleration. At low frequencies, the displacement could exceed the limits of the test equipment. That is why some specifications use displacement for amplitude in the low frequency range. Sine vibration is not usually found in the real world unless your product is attached to equipment such as a motor or reciprocating compressor running at a fixed frequency. Why is it done? It is good to find resonances (amplitude magnification in the device under test), it is a simple motion and it also produces a constant acceleration vs. frequency. Also, it is probably carried over from old test methods prior to digital computer controllers. However sine vibration does not correlate to a field life unless the product is exposed only to fixed frequencies over its life

Certain machines and structures that develop excessive vibrations during their life and it may be required to make a diagnostic vibration analysis to prevent an impending failure of some of components. Such components can be tested using vibration exciters. Different types of vibration exciters are used for development, simulation, production, studying the effects of vibration and for evaluating physical properties of materials or structures. This paper also provides a brief description about different types of vibration exciters, its advantages and disadvantages over mechanical vibration exciter. It includes theory on forced vibration exciters. The three types of vibration exciters are commonly used in several applications as: Electro-dynamic exciter, Hydraulic exciter and Mechanical exciter. Further mechanical vibration exciters are having following types:

a. Eccentric and connecting link
b. Scotch yoke
c. Cam and follower
d. Rotating unbalance mass

II. LITERATURE SURVEY

A. MECHANICAL EXCITER

Jawaz Alam [1], designed Mechanical Vibration Exciter which produce mechanical vibratory motion to provide forced vibration to a specimen on which modal analysis and testing is to be performed. In the design & analysis of a mechanical vibration exciter, it contains cam and follower mechanism used to generate uniaxial vibrations. The exciter is designed to produce displacement by the given range of frequency which is to be provided. The analysis and construction of working device, its important parts and the results obtained from Fast Fourier Transform analyser are described here.

Nitinkumar Anekar [2], et al has designed mechanical vibrations exciter, which have unbalanced mass to generate uniaxial vibrations. The exciter is designed to produce a given range of harmonic or time dependent excitation force and displacement through a given range of frequencies. The mechanical vibration exciter produces vibrations due to centrifugal force of rotating eccentric mass. The vibrations produced lie in the low frequency range. The construction of working device and its important parts are described. The most important part of exciter is unbalanced mass attached with rotating disc of motor. Exciter has unbalanced mass at one end of disc, base frame, top plate as platform, springs and motor. This exciter is used for testing of welded parts, consolidation of concrete, concrete filling in mould.

Aditya Pawar[3] et al have designed & constructed a mechanical vibration exciter which has a cam and follower mechanism used to generate uni-axial vibrations. The exciter is designed to produce displacement through a given range of frequencies. The construction of working device and its important parts and the results obtained from FFT analyser are described.

A cam is a rotating machine element which gives reciprocating or oscillating motion to another element known as follower. The cam and follower have a line contact and constitute a higher pair. The cams are usually rotated at uniform speed by shaft, but the follower motion is predetermined and will be according to the shape of the cam. The Mechanical vibration exciters can prosecute only a single type of output like Simple Harmonic Motion i.e S.H.M. These usual cam profiles cannot provide shocks and sudden jerks. Cam and follower can be used for providing sudden jerk motions.Fig.2 below shows cam and follower vibratory exciter.

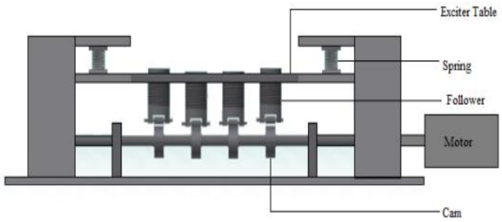
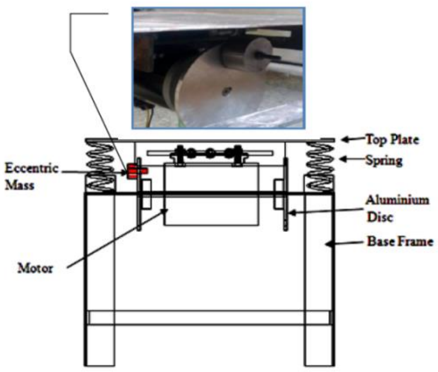


Fig.2. Mechanical Vibration Exciter using Cam and Follower Mechanism

In rotating unbalance mass type mechanical exciter, an eccentric mass is mounted on a rotating shaft to generate vibration. The product of the mass and the distance of its centre from the axis of rotation is referred to as the mass unbalance or the rotating unbalance or simply the unbalance. The force resulting from this unbalance is referred to as the unbalanced force. This type exciter consists of at least one rotating unbalance mass directly attached to the vibrating table. The unbalance force is transmitted through bearings directly to the table mass, causing a vibratory motion without reaction of the force against the base. Fig 3. Shows the set of rotating unbalance mass type mechanical exciter.

The scotch yoke is a reciprocating motion mechanism, converting the linear motion of slider into rotational motion, or vice versa. The piston or other reciprocating part is directly coupled to sliding yoke with a slot that engages a pin on the rotating part. It is a simple mechanism, the rotary motion of pin convert into linear motion.

Eccentric-and-rod mechanism, arrangement of mechanical parts used to obtain a reciprocating straight-line motion from a rotating shaft; it serves the same purpose as a slider-crank mechanism and is particularly useful when the required stroke of the reciprocating motion is small in comparison with the dimensions of the driving shaft Fig 4. Shows the mechanism of Eccentric-and-rod mechanism.



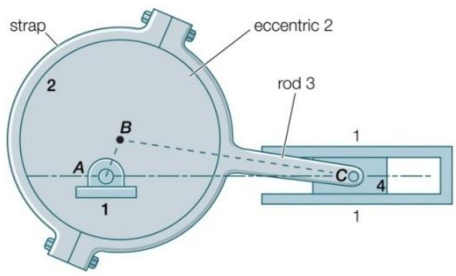


Fig.3. Schematic of Unbalanced Mass Mechanical Exciter. Fig.4.Eccentric and connecting link mechanism

B. ELECTRO HYDRAULIC EXCITER

Željko Despotović [4], et al used an electronically controlled two-axis hydraulic vibratory exciter used for studying the behaviour of the human body under the influence of vibrations. It deals particularly with the influence of vibrations that occur in motor vehicles. Regarding vehicle oscillatory comfort, understanding the transmission mechanism of vibrations through the human body and their influence on psycho-physiological abilities are very important for automotive design.

C.ELECTRO DYNAMIC EXCITER

Paulo S. Varoto[5], et al This article aims to study one of these sources of error, namely, the interaction between the electrodynamics exciter and the structure under test (SUT). The effects caused by the shaker armature mass on the dynamics of the SUT are assessed in different testing conditions by using theoretical models and experimental analyses that include the exciter dynamic characteristics.

M. A. Peres[6], et al reviewed the basic design of exciter as beneficial to modal testing, and the common problems associated with setup issues and resulting measurement errors.

D.HYDRAULIC EXCITER

Jianzhuo Zhang[7], et al have studied a kind of hydraulic exciter based on rotary valve control, the composition of the exciter and its working principle were introduced, and the mathematical model of the system was established. The characters of the system were simulated using MATLAB. From the results of the simulation, we get the relationship of the amplitude of Vibration oil cylinder between the system's pressure and the exciting frequency.

III.APPLICATIONS

The mechanical vibration exciter is tested for different applications. The actual testing of machine is done by varying speed of motor and the corresponding amplitude is noted. Vibration exciters are used to produce cyclic excitation force at a required frequency. Some of the major applications are discussed below.

A. VIBRATORY STRESS RELIEF.

Residual stress is a problem often seen during manufacturing. This problem is critical and if left unaddressed could have disastrous consequences, especially in aeronautic and aerospace industries. Typically, residual stress in materials and manufactured parts is due to the presence of thermal gradients or mechanical deformation. Each of these can have a considerable impact on fabrication processes and subsequent service of a work piece.

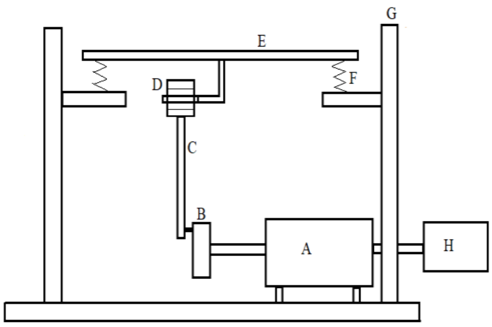


Fig.5. Schematic of Eccentric and connecting link mechanical exciter

Where, **A** = Motor, **B** = Circular Disc, **C** = Connecting Rod, **D** = Bearing, **E** = Exciter table, F = Spring, **G** = Support, **H** = Supply

Vibratory stress relief (VSR) technology is a green and efficient aging technology compared with the traditional natural stress relief (NSR) and thermal stress relief (TSR). Residual stress in welds is produced by localized metal tensions occurring immediately after welding, which are:

A. CONTRACTION STRESS. This is the main source of residual stress. It takes place during the cooling of the welded areas, which have undergone non uniform heating.

B. STRESS DUE TO HIGHER SURFACE COOLING. When a weld cools down the surface cools faster than the inside, even if this cooling occurs in still air. The greater the thickness, the more stress is generated.

C.STRESS DUE TO PHASE TRANSFORMATION. It occurs due to the transformation of austenite (face centered cube, (FCC) to ferrite (body centered cube, (BCC) that causes an increase in volume to which the base metal is opposed.

Advantages of VSR include short production cycles, ease of implementation in the manufacturing process, and low investment costs. VSR has been proposed repeatedly as an alternative to thermal stress relief and is widely used in various industrial fields. Residual stress relief occurs when the sum of the induced cyclic stress and the residual stress exceeds the local yield stress of the material, and it can improve the dimensional stability and fatigue life of the component.

B.VIBRATORY FEEDER

A vibratory feeder is an instrument that uses vibration to "feed" material to a process or machine. Vibratory feeders use both vibration and gravity to move material. Gravity is used to determine the direction, either down, or down and to a side, and then vibration is used to move the material. They are mainly used to transport a large number of smaller objects.

A belt weigher are used only to measure the material flow rate but weigh feeder can measure the flow material and also control or regulate the flow rate by varying the belt conveyor speed.

Versatile and rugged vibratory bowl feeders have been extremely used for automatic feeding of small to large and differently shaped industrial parts. They are the oldest but still commonly used automation machine available for aligning and feeding machine parts, electronic parts, plastic parts, chemicals, metallic parts, glass vials, pharmaceuticals, foods, miscellaneous goods etc. Available in standard and custom designs, vibratory bowl feeders have been largely purchased by varied industrial sectors for automating high-speed production lines and assembly systems.

C.TURBINE BLADE HIGH CYCLE FATIGUE TESTING

High cycle fatigue testing is a critical component of aircraft engine turbine blade qualification. It is becoming increasingly important with power generation turbine blades. Depending on the location of the blade, turbine blade failure in an aircraft engine can cause catastrophic damage as the blade causes secondary failures in other blades. In fact, turbine blade failure has been the cause of several crashes of jet aircraft and highlights the importance of turbine blade high cycle fatigue testing. For testing, the base of the turbine blade is attached to a fixture on an Electrodynamic shaker. For testing of smaller blades, with higher resonance frequencies, a piezoelectric shaker may be used. Usually, an accelerometer is placed on the fixture as a reference measurement and a non-contact sensor, typically a laser displacement sensor, is used to measure the response of the tip of the blade. To simulate the environment inside the engine, the turbine blade may be heated.

IV.SUMMARY

Parameters	Mechanical	Electrodynamic	Electrohydraulic
Frequency	2 – 50 Hz	2 – 30000 Hz	0 – 400 Hz
Max Displacement	2.5 cm	2.5 cm	50 cm
Max acceleration	20g	20g	20g
Max Force	4500N	2000N	450000N
Excitation Waveform	Sinusoidal only	Highly flexible and accurate	Average Flexibility

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