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An Overview of Design and Development of Multipurpose Mechanical Vibration Exciter with Nonlinear Parameters

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***Abstract*-Vibration exciter is a machine which produces mechanical vibratory motion to 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. These machines can be mechanical, electro-hydraulic or electro-dynamic in nature. This can be used for experimentation purpose and testing product at different frequencies and also as the vibrating source for applications like vibrating screen separator, vibrating feeder and vibrating table. 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.**

Keywords: Vibration Excitation, Slider Crank Mechanism, Rammer, Feeder, Separator.

I. INTRODUCTION

Vibration exciters are used to produce cyclic excitation force at a required frequency. The cyclic excitation force produced by the exciter can be applied to the machine or structure to study its dynamic characteristics and also for producing machines like feeder, separator and rammer. The excitation force is usually a sinusoidal or random type signal applied with a number of discrete frequencies over a specific frequency range of interest. Present vibration exciters gives us a specific range of harmonic or time dependent excitation force and displacement through a given range of frequencies as per specific design, our approach is to design a vibration exciter which can give us various ranges of harmonic or time dependent excitation force and displacement and which can be useful for various applications like feeder, separator and rammer which is possible by using a gear box and slider crank mechanism with varying crank lengths.

Our objective of this work is to design and test a new type of vibration exciter which is equipped with a gear box and a slider crank mechanism to serve the purpose of having various ranges of excitation force and displacement.

Types of Exciters: The three types of vibration exciters are commonly used in several applications are:
1. Mechanical Exciter

2. Electro-dynamic Exciter

3. Hydraulic Exciter.

Their features are as given in Table-1.

Table- 1: Features of Exciters

Exciter Type → / Parameters ↓	Mechanical	Electro-dynamic	Electro-Hydraulic
Frequency	2-50 Hz	2-10,000 Hz	0.1-500 Hz
Maximum Displacement	2.5 cm	2.5 cm	50cm
Maximum Acceleration	20g	100g	20g
Maximum Force	4500 N	2000 N	450,000 N
Excitation Waveform	Sinusoidal only	High flexibility and accuracy	Average flexibility

Mechanical vibration exciters are of following types:

a. Eccentric and Connecting Link
b. Scotch Yoke
c. Cam and Follower
d. Rotating Unbalance Mass

II. REVIEW OF AVAILABLE TECHNOLOGIES

There has been lot of work carried out related to design and testing of vibration exciter. The research started from developing theories related to vibration exciters and is now moving towards designing various vibration exciters according to applications. Below there are some of the important literature reviews giving us the idea about possible future of vibration exciters

1. Design and Testing of Unbalanced Mass Mechanical Vibrational Exciter

Nitinkumar Anekar et al. [1] ,published paper on "Design and Testing of Unbalanced Mass Mechanical Vibrational Exciter".In this work they attempted to present

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design, construction, and performance and testing of 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 were 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, and top plate as platform, springs and motor.

2. Design, Modeling, and Simulation of a Geared Infinitely Variable Transmission

X. F. Wang et al. [2] ,invented GIVT and published paper on "Design, Modeling, and Simulation of a Geared Infinitely Variable Transmission". In this work an Infinitely Variable Transmission (IVT) to provide a continuous output-to-input speed ratio from zero to a certain value is designed, and its working principle is illustrated. Crank-slider systems are used in the GIVT; the output-to-input speed ratio is changed with the crank length. Since the crank-slider systems can introduce variations of the instantaneous speed ratio, this can become useful for producing multi-frequency operating vibration exciters.

3. Selection of Vibratory Motors for Vibrating Feeder by Analytical Approach for Material Handling Plants

A.V.Ramana Rao et al. [3] ,published paper on "Selection of Vibratory Motors for Vibrating Feeder by Analytical Approach for Material Handling Plants". 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. This report aims at explaining the vibrating motor power calculation, selection and working principle of vibrating feeder. It briefs about the different concepts used in constructing vibrating feeder and then details into the major components.

4. Modelling and Analysis of 2-Stage Reduction Gear Box

Puttapaka Nagaraju et al. [4] ,published paper on "Modelling and Analysis of 2-Stage Reduction Gear Box". A reduction gear box is a part of a mechanical system of gears and shafts used to reduce the rotational speed of the input shaft to a slower rotational speed of the output shaft. This reduction in output speed helps to increase the torque of a system. Reduction gears are widely used in power transmission devices to reduce the high rotational speeds.This can be usefull for producing vibrational exciters with multi-range force amplitude.

5. Modeling, Simulation and Experimental Investigation of a Rammer Compactor Machine

Anders Jonsson et al. [5] ,attempted to work and published thesis on "Modeling, Simulation and Experimental Investigation of a Rammer Compactor Machine". The experience gained through this work is also intended to be useful for studying other types of dynamic compactor machines. Rammer compactor machines perform impact soil compaction. This is more efficient than static compaction. The machines are often used in places where a high degree of compaction is needed, and where the space for operation is limited. The complexity of this type of machine makes design optimization through traditional prototype testing impractical. This has pointed to the need for a theoretical model and simulation procedure for predicting the dynamic behavior of the machine. To be useful for optimization the theoretical model and simulation procedure must be verified. By concurrently working with theoretical modeling, simulations, experimental verifications, and optimization an efficient analysis support for product development is achieved.experimental investigations are used to verify theoretical models and simulations; and theoretical models and simulations are used to design good experiments. In this thesis, the complete approach concept is applied to a rammer soil compactor machine. An introductory iteration is described.

6. Slider Crank Mechanism Design with Time Ratio and Minimum Transmission Angle

Han Jiguang et al. [6] ,published paper on "Slider Crank Mechanism Design with Time Ratio and Minimum Transmission Angle". The size parameters of slider crank mechanism are directly treated as design variables. The analytical synthesis method of the mechanism with time ratio and the selecting range of design variable are presented. The mechanism synthesis method which simultaneously satisfies the conditions of time ratio and minimum transmission angle is presented. The synthesis problem of the slider crank mechanism, which makes it have minimum transmission angle when time ratio is given, is completely solved. This method can not only judge the feasibility of mechanism synthesis, but also determine the parameters of mechanism one time. The iteration and checking are avoided, so it makes the synthesis of mechanism fast and accurately.

7. Shaker Table Design for Electronic Device Vibration Test System

Waluyo Adi Siswanto et al. [8] ,attempted to work and published paper on "Shaker Table Design for Electronic Device Vibration Test System". A general purpose vibration test system has been developed to provide a testing platform for electronic devices. This paper presents the design of the shaker table for the platform-testing base where an electronic device will be placed and excited by the vibration exciter. Three design models are first analyzed their natural frequencies and the corresponding mode shapes. The model with the lightest weight and the highest first natural frequency is then selected to be manufactured. This selected shaker table can be used in a frequency range of service up to 2500 Hz and behaves as a rigid body when it vibrates. This paper also provides the general frequency range limitation when the vibration test is used at constant displacement or constant acceleration test.

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8. Vibration Analysis Techniques for Gearbox Diagnostic: A Review

Amit Aherwar et al. [9] ,attempted to publish paper on "Vibration Analysis Techniques for Gearbox Diagnostic: A Review". Vibration signal analysis has been widely used in the fault detection of rotation machinery. The vibration signal of a gearbox carries the signature of the fault in the gears, and early fault detection of the gearbox is possible by analyzing the vibration signal using different signal processing techniques. In this paper, a review is made of some current vibration analysis techniques used for condition monitoring in gear fault.

III. CONCLUSION

From the literature survey it can be seen that vibration exciter has been a hot research topic for many researchers, due to its important role in various industrial applications and use in dynamic testing of mechanical components and utilizing it as drive unit for different applications. The researchers started from developing theories related to general vibrational excitation and further moving to implementing it to the various parameters according to their application. As per the many researchers in mechanical type of vibration exciter they have only unbalanced mass mechanical exciter which is mostly used so it is quite desirable to apply some new techniques which are equipped with more advantages and test proposed vibration exciter for its output and validate for multiple applications.

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