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Research Article

Study of Vibration Fixtures

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Abstract

Vibrations are major problem in working of machine. Unwanted vibrations can cause resonance effect which can damage the delicate machine component, so while designing the machine, vibrations are also taken into account. After manufacturing of machine/machine component it undergoes various vibration test, Fixture transmit energy to test sample. Fixture design must be rigid simple lightweight and most important economic. Use of modern analysis tools and also Computer Aided Design software have made design of fixtures effortless.

Keywords: *Finite element methods, Vibrations, Vibration fixture.*

1. Introduction

Historically only damping was used to restrict the unwanted vibrations during the working of a machine. But due to the research and development in the recent years it has become possible to control the vibration characteristics from the design stage. Thus it lead to the vibration testing of products and made vibration fixtures indispensable.

Virtually there is no feasible analytical method for designing fixtures with complicated shapes, hence fixture design engineers had to stick close to mathematical models of beam and plate vibration theories to design fixtures since the last century. Slow development of dynamics of structure lead to bulky and overdesigned fixtures.

2. Need of vibration fixture

Almost all advanced machineries and dynamic mechanical systems employ electronics for controlling and monitoring its performance. The dynamic nature of the machine elements leads to the generation of vibrations within the system. These vibrations fatigue the mechanical components in the long run as well as disturb the sound working of the electronic components in the long run.

If the frequencies generated matches with the natural frequencies of any of the components resonance occurs and it might permanently damage the system. So, vibration testing of the electronic components employed in a mechanical system is important for its proper working.

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3. Method

Vibration testing is carried out by mounting the test article in a manner similar to its in-service mounting method onto a light and rigid vibration fixture which itself is mounted onto a horizontal slip table which is excited by a dynamic shaker. Traditionally, the design principle followed for vibration fixture was concurrent with the usual 3-2-1 fixture principle, which sought to constraint 6 degrees of freedom of the workpiece to be machined. This design procedure would satisfy the need of rigid fixing for machining at a given cutting speed (same frequency).

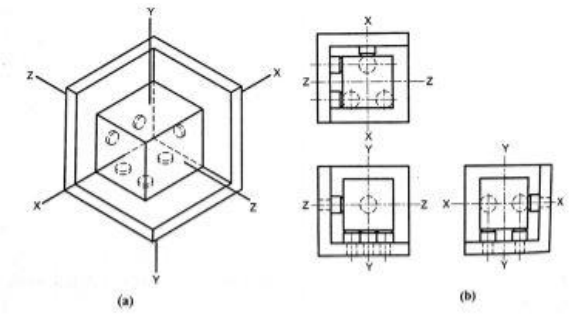

Fig. 1 3-2-1 Method

Even if the fixture design fails to restrict vibrations, the cutting speed is changed suitably or additional stiffeners incorporated in the fixture. But when it is employed for vibration testing for an entire range of frequencies any particular frequency cannot be skipped. Also, additional stiffeners will alter the resonance frequency of the assembly, which will also be in the working range. The net effect of the stiffeners make the fixture bulkier exhibiting low natural frequency.

Developments in finite element methods especially modal analysis and the use of computers lead to the concept of Computer Aided Design (CAD) which made design of fixtures efficient and easy. Presently, sophisticated FEA tools design and virtually test their vibration characteristics. Advanced simulation techniques extract natural frequencies, node shapes, deformation etc. for given boundary conditions. Modern analysis tools in the design of vibration fixtures is most reliable

4. Types of vibration fixtures

1) Head plates and expanders

These are the simplest of all fixtures. In these fixtures to increase shaker's available surface area, horizontal mounting is provided. This allows testing of large test articles or multiple items.

Fig. 2 Head plates and expanders

2) 'I' Type Fixtures

Test can be performed in X,Y and Z axes concurrently on single vibration fixture when 'I' fixture is used. Fixture is attached in vertical direction to shaker. The 'I' fixture provides high rigidity and strength of a solid one-piece weldment.

3) 'Cube' Type Fixture

Cube type fixtures provide up to 5 mutually perpendicular mounting surfaces that enable three simultaneous axes of vibration or six axes of shock while attached to the vibration exciter, horizontal slip table or shock machine.

Fig.3 Cube' Type Fixture

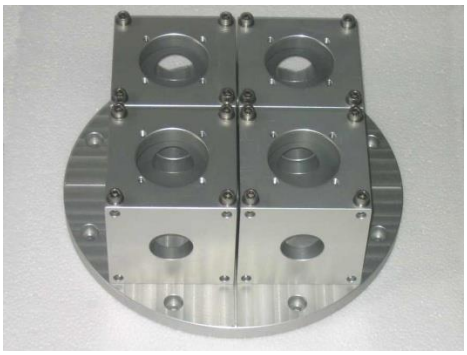

Fig. 4 Cube' Type Fixture

4) Custom made fixtures

In every fixture some custom changes are made as per requirement. But in some special cases entire fixture has to be designed as per the test specimen. These are called Custom made fixtures.

Fig. 5 Custom made fixtures.

5) 'L' and 'T' Type Fixtures

Single vertical mounting surface is provided 'L' and 'T' fixture for most test applications. 'T' fixtures are manufactured with two vertical mounting surfaces to a cylindrical test article can be tested in tri-axis using this fixture. The vertical mounting surface can be considered as a short beam or plate making the design using analytical and FEM for plate vibrations easier. 'T' fixtures are relatively simple in design and design and require less material. The 'L' type fixture is selected for the further design and evaluation.

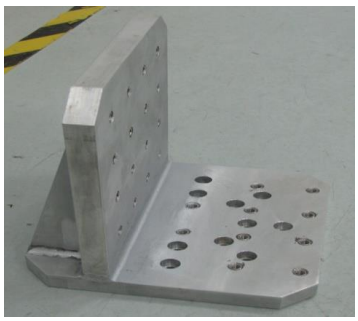

Fig. 6 'L'' Type Fixtures

Fig. 7 'T' Type Fixtures

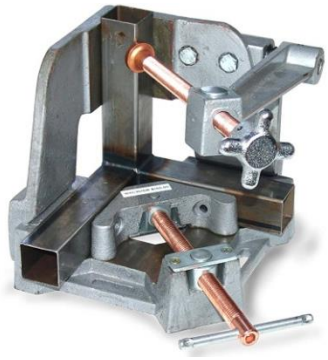

Fig. 8 Tri-Axis fixture

5. Study of test specimen orientation configurations

A fixture should be designed so that, once it is bolted to the design table, the specimen should experience vibrations in all three orthogonal directions simultaneously or only the reorientation of the specimen on the fixture to experience all three orthogonal vibrations, one by one, without the need to reorient the fixture table.

Uni-axis fixture

In vibration testing, the dynamically excited slip table can produce vibrations along a single axis. But, the main aim is to test the specimen under vibrations in all the three orthogonal directions. In uni-axis fixture test specimen is mounted on the fixture and this assembly is oriented with respect to the slip table, one test axis after another so as to test the specimen along its three orthogonal axes.

Tri-Axis fixture

In this type the test specimen is oriented with respect to the fixture and hence the slip table, so as to perform testing along three orthogonal axes one after another. The tri-axis fixture considerably reduces the required time for bolting, unbolting and orientation of the assembly.

Multi-Axes fixtures

A multi-axes fixture allows testing along three orthogonal axes simultaneously. The fixture is designed is such a way that the test specimen is mounted and the fixture at different angles, preferably 45^0, with respect to the vertical and horizontal plane of the fixture.

Fig. 9 Multi-Axes fixtures

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