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Vibration loosening of bolted fasteners

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Abstract— **Vibration is a repetitive motion of objects in alternately opposite directions from the equilibrium position when that equilibrium has been disturbed. It occurs in most machines, structures, and dynamic systems leading to many undesirable consequences. Vibration often becomes a problem due to unpleasant motions, noise and dynamic stresses that could lead to fatigue and failure of the structure or machine, energy losses, decreased reliability, degraded performance and loosening of bolts in treaded fasteners. Control of such vibrations is being widely studied in the engineering field. In vibratory conditions loosening of bolts is a common problem in engineering application. Total loss of the fastener or subsequent fatigue failure due to loss of bolt pre-tension are the predominant failure modes of vibration loosening. The aim of this study is to find a constructive way to protect a bolted connection from self-loosening. Junkers machine is discussed which is used to investigate the effect of transverse movement on preloaded threaded joint.**

Index Terms— **Preload, self-loosening, threaded joints, Transverse vibration.**

I. INTRODUCTION

Practically very engineering product with every degree of complexity uses threaded fasteners a key advantage of threaded fasteners over the majority of other joining methods is that they can be disassembled and re used. This feature is often the reason why threaded fasteners are used in preference to other joining methods and they often pay a vital role in maintaining the products structural integrity. However, they are also a significant source of problems in machinery and other assembly's .The reasons for such problems are due in part to them unintentionally self -loosening.

The pre load is the initial clamp forces imparted into a join by tighten a fastener. The vast majority of joints rely upon this pre load for their structural integrity .The pre load acts on the fastener threads creates a torque in the circumferential direction which is registered by friction. Self loosening of fasteners leads to a reduction and sometimes the elevation of this pre load which is frequently leads to joint failure [1]. Most bolted joints especially the ones associated with machinery, are subjected to significant vibration labels during their life span. Rotating or reciprocating machines such as gas, steam turbine, electric motors and IC engines are subjected to vibration of relatively high frequencies; gyratory crushers, jack hammers and so forth are subjected to medium frequencies vibration.

Forging/Stamping machine are subjected to relatively low frequency high amplitude vibrations. Certain dynamics structures are under go dynamic load fluctuations. It is common experience is that vibrations loosing of joints may occur when a bolted join undergo dynamic loads fluctuations. here are large numbers of thread locking devices available in the market in order to alleviate joint loosing problem.

In this paper reason of vibration loosing is studied and Junker vibration testing machine is discussed. Also one condition of conventional leaf spring vibrations loosing of fastener is discussed with different bolt size and different end conditions.

II. LITERATURE REVIEW

Bolted joint trouble still occurs due to it is always used at high stress. It is subjected to vibrations repeated external force. [2] Effect of pre load is further asencuated with increasing thread friction. Preload is the main economical way of preventing vibration loosing. A minimum pre load of 65% of the proof load of the fasteners should prevent vibration loosing under most common vibration environment. [1] Many industrial visits past recorded data shows that steel leaf springs are manufacture by EN45,EN45A,60Si7,EN47,EN48D,SS304 etc.This materials are wildly used for production of the parabolic leaf springs and conventional multi leaf springs. Leaf spring absorbs the vehicle vibrations, shock and bump loads by means of spring deflections, so that the potential energy is stored in the leaf spring and then relieved slowly. Ability to store and absorb more amount of strain energy ensures the comfortable suspension system.

Many suspension systems work on the same principle including conventional leaf springs. However, for the same load and shock absorbing performance, conventional leaf springs uses excess of material making them considerably heavy. This can be improved by introducing composite materials in place of steel in the conventional springs [4]. Modeling and analysis of composite leaf spring under the static load conditions is studied [4]. Transverse vibration loosening characteristic of bolted joints using multiple Jack bolt nut [3]. The finite element model is capable of predicting the four different processes observed experimentally. The FE results capture the essential features displayed by the experimental data. The FE model includes the primary factor that cause loosening and provides a powerful tool for evaluation of the details of fastener loosening [7].

III. JUNKER'S MACHINE – FASTENERS TRANSVERSE VIBRATION MACHINE

Work completed during the 1960's in Germany indicated that transversely applied alternating forces generate the most severe conditions for self loosening. The result of these studies led to the design of a testing machine which allowed quantitative information to be obtained on the locking performance of self locking fasteners. Such machines, often called Junkers machines. In the literature - after its inventor, have been used over the last twenty years by the

major automotive and aerospace manufacturers to assess the performance of proprietary self locking fasteners. As a result, a rationalization of the variety of locking devices used by such major companies has occurred. For example, conventional spring lock washers are no longer specified, because it has been shown that they actually aid self loosening rather than prevent it. There are a multitude of thread locking devices available. Through the efforts of the American National Standards Subcommittee B18:20 on locking fasteners, three basic locking fastener categories have been established. They are: free spinning, friction locking, and chemical locking. [4]

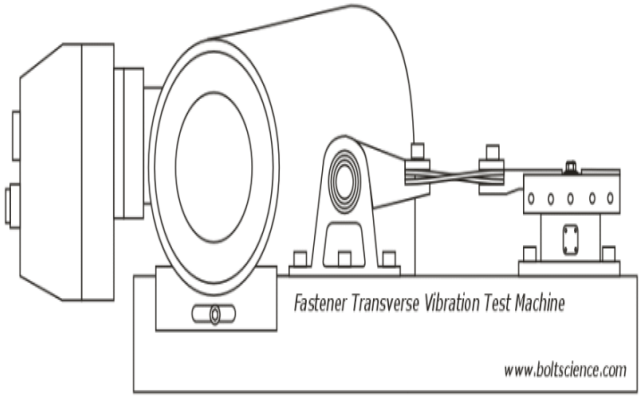

Figure no.1: Fastener transverse vibration test machine

Fasteners coming loose is a common problem across many industries. We can complete an assessment of a fastener's self loosening characteristics using a transverse vibration test machine (often referred to as a Junker machine and the test performed, a Junker Vibration Test). The fastener preload decay graphs produced can allow an assessment to be made of a fastener's resistance to self-loosening. The test can be performed on the locking mechanism forming part of a nut (such as with nylon insert nuts), on a bolt (such as bolts with a nylon coated patch on the bolt) or a washer (such as a helical spring lock washer).

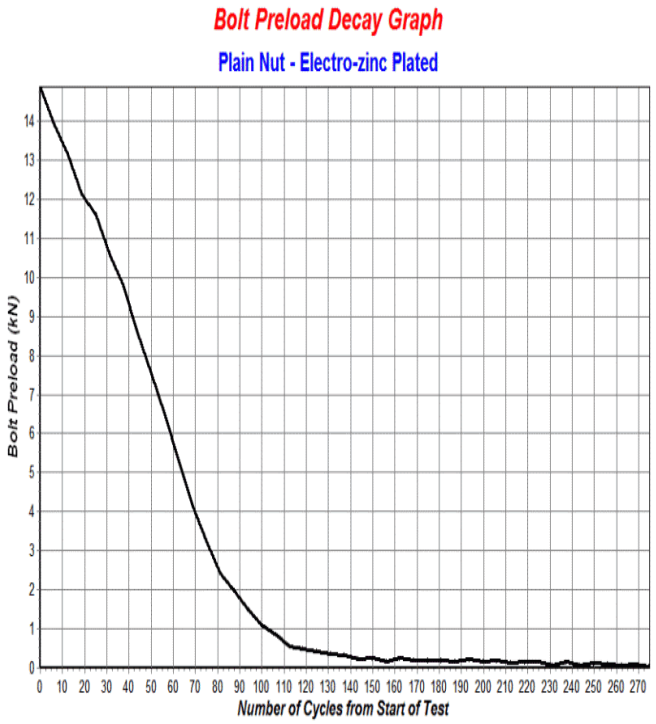

Figure no.2: Bolt preload decay graph

IV. PROBLEM STATEMENT

Junker's vibration test rig is used to find the bolt decay characteristics in which we are to test M4, M5 ,M6 bolts and nuts for vibration loosening sing different end conditions namely , without washer , with plain washer , with spring washer at various pretension in bolt i.e., various torques.

In earlier case the leaf spring used for transmission of vibrations from the input eccentric to moving plate via the jokey is of the following profile:

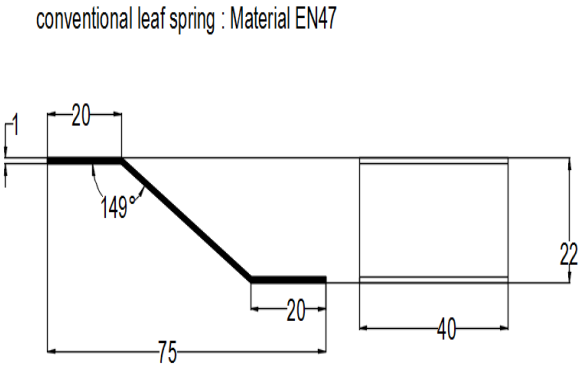

Figure no.3: Conventional leaf spring

The EN47 spring showed pre mature failure and could not withstand the number of vibrations cycles necessary with pretension above 0.6 N-m in bolts hence it was decided to replace the spring steel material by EN48D, which is recommended material with slight tempering for stress relieving.

A) Why composite material?

As mentioned earlier, the ability to absorb and store more amount of energy ensures of the comfortable operation of a suspension system. However, the problem of heavy weight of spring is still persistent. This can be remedied by introducing composite material, in place of steel in the conventional leaf spring.

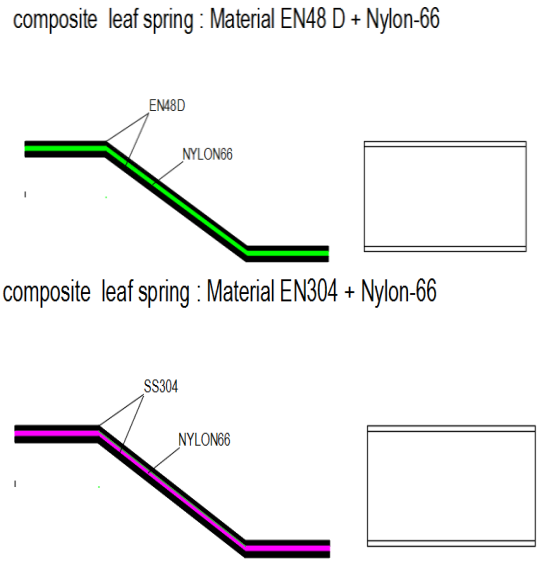

Figure no. 4: composite leaf spring

Composite with EN48D and SS304 with nylon -66 material sandwiched between the leaf springs will offer better service life owing to higher material strength and flexibility of the nylon 66 material.

B) Flow of problem solution

a) Design development and analysis of leaf springs with EN48D and SS304 as spring materials
b) Development of composite spring with nylon 66 (2mm) thickens sandwiched between two leaf springs of either en48D or SS 304.
c) Testing of the vibration loosening of the M5 , M6 bolt, with plain washer and spring washer to determine number of cycles before loosening as an indicator of bolt decay , and displacement of moving plate after given number of cycles .

V. CONCLUTION

Preloaded fasteners self-loosen when relative movement occurs between the matting treads and the fasteners bearing surface. Such relative movement will occur when the transverse force acting on the joint is larger than the frictional resisting force generated by the bolts preload. Under repeated transverse movements this mechanism can completely loosen fasteners.

Junker developed a test machine to investigate the effect of transverse movement on preload treaded fasteners. The test machine allows a cyclic transverse displacement to be imparted into a bolted joint. By using the same principle Bolt test rig can be design and we can take the different results for leaf spring as damping device with different bolt size. We can compare different leaf spring material and find best material for preventing vibration loosening of bolts.

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