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# A REVIEW PAPER ON DESIGN DEVELOPMENT AND ANALYSIS OF FORM SPRINGS OF EN48 (D) AND SS304 FOR APPLICATION IN JUNKER'S VIBRATION TEST RIG

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## ABSTRACT

The main spotlight of this study is to design and develop test rig for vibration loosening of bolts. Design and development of system components for interchangeability of different bolts. Test & Trial on test rig to develop the loosening characteristics of bolts and derive the decay graphs versus cycles. . It is widely believed that vibration causes bolt loosening. By far the most frequent cause of loosening is side sliding of the nut or bolt head relative to the joint, resulting in relative motion occurring in the threads. If this does not occur, then the bolts will not loosen, even if the joint is subjected to severe vibration. By a detailed analysis of the joint it is possible to determine the clamp force required to be provided by the bolts to prevent joint slip. Junker's vibration test rig is the most popular method to measure the vibration loosening of bolts or commonly referred to as bolt decay phenomenon. The Junkers vibration test rig uses a special form spring to connect the eccentric arrangement for providing vibration to the test specimen . Commonly used material for the material of this form spring is spring steel in the tempered form. The same experiment was carried out with Comparative analysis of decay characteristics of individual bots with various end condition and to predict vibration loosening using this study.

**KEYWORDS**: transverse vibration loosening, torque, bolts, nut, washers,

## INTRODUCTION

A significant advantage of a bolted joint over other joint types, such as welded and riveted joints, is that they are capable of being dismantled. This feature however, can cause problems if it unintentionally occurs as a result of operational conditions. Such unintentional loosening, frequently called vibration loosening in much of the published literature. It is widely believed that vibration causes bolt loosening. By far the most frequent cause of loosening is side sliding of the nut or bolt head relative to the joint, resulting in relative motion occurring in the threads. If this does not occur, then the bolts will not loosen, even if the joint is subjected to severe vibration. By a detailed analysis of the joint it is possible to determine the clamp force required to be provided by the bolts to prevent joint slip. Junker's vibration test rig is the most popular method to measure the vibration loosening of bolts or commonly referred to as bolt decay phenomenon. The Junkers vibration test rig uses a special form spring to connect the eccentric arrangement for providing vibration to the test specimen. Commonly used material for the material of this form spring is spring steel in the tempered form.

Due to shape of spring and nature of loading the springs made from spring steel do not last for the expected number of work cycles, thus resulting into premature failure of spring thereby leading to unsuccessful test and loss of time and money. Object of project is to develop a mathematical model to develop the shape of the spring to impart 0.5 to 1.5 mm amplitude of vibrations and frequency in the range of 800 to 1400 cycles per minute. The spring models will be developed using Unigraphix and critical modal and strength analysis will be done for EN48(D) and SS304 as materials using ANSYS. The analysis will be carried out as single load step and multi-load step approach and to validate the theoretical stresses. The force transmitted and net displacement of springs thus determined will be further validated experimentally by application of these springs in a Junker's vibration test rig to determine the bolt decay in M6 & M8 size bolts. The force transmitted by the springs will be experimentally evaluated using load cell where as the strain gage bridge will be used to determine the amplitude of vibration or displacement offered by the spring.

The other parameter of design will be the experimental determination of change in dimension of the springs and change in form of the mounting holes of the springs after a predetermined number of cycles and the data thus obtained will be used

to predict the failure of springs at the specified locations for given values of amplitude and frequency by use of iterative techniques. Data thus generated will be used to recommend specific material of spring for a given application of Junker's vibration for determination of bolt decay.

## LITERATURE REVIEW

Following are some of the important reviews of different researchers and scientists in the Vibration field.

**Transverse vibration loosening characteristics of bolted joints using multiple jack bolt.**
**Umesh Da et. al. (1)** In this paper, The objective of this study was to apply the correct engineering principles to establish the relationship between tightening torque and bolt preload and to verify the loosening characteristics of bolted joint under transverse vibration condition by experimental setup under the application of wrenching torque. A simplified bolted joint including a holed plate with assembly of single bolt and Multiple Jack Bolt Nut was considered to carry out the experiments. The same experiment was carried out with the standard nut with spring washer assembly for comparison. Experiment was carried out on a test setup called as Junker's Transverse Vibration Machine. The relation between the clamping force and number of cycles have been displayed in graphs.

**Bending forces and spring back in v-die bending of perforated sheet metal components.**
**Mohammad A. F. et al (2)** Sheet metal bending is one of the most widely applied sheet metal operations. The bending operations present several technical problems in production, such as prediction of spring-back and the punch load. In this paper, the value of the spring-back and bending forces are investigated for a low carbon steel material. Two thicknesses of material (0.95 and 0.75 mm) are applied. Sheet metal components, which are used in the experiments, have oblong holes on their bending surfaces. The influence of the area of the holes, die angles, die widths and punch radius on the value of the spring-back and the bending forces in V-die bending is studied. It is found that all these parameters affect the spring-back and the bending forces, but not in the same way. A new equation is suggested in this paper to predict the bending forces in V-shaped dies for parts with holes on the bending surfaces.

**A proposal for the absolute estimation method on self-loosening of bolted joints during off-road vehicle operation.**
**Soichi H.et al (3)** This paper presents a method for estimating the absolute lock effect in bolted joints during off-road vehicle operation. There is a good linear relation between axial tension decrease tendency (Loosening phenomenon) and the operation time (or mileage or number of operations) after the tightening on logarithmic coordinates. Based on this relation, this report leads to two estimating methods described below. 1) Decrease of axial tension (self-loosening) is estimated accurately after long hours since tightening by measuring the initial axial tension behavior using the bolt loosening evaluation diagram. 2) Method of Estimating the locking device availability (usefulness) on actual machine operation is obtained from laboratory loosening test results.

**Causes and prevention of loosening in pre-stressed bolts.**
**Ravinder Kumar (4)**In Vibratory conditions loosening of bolts are a common problem in engineering applications. Total loss of the fastener or subsequent fatigue failure due to loss of bolt pretension are the predominant failure modes of vibration loosening This effect of self-loosening of high strength bolts has been assessed since the 1940's. Still a lot of questions are unsolved. This is especially the case in the field of bolts for steel structures with sizes from M6 to M36, where the number of results is low. At risk for self-loosening are steel structures under cyclic loads, such as cranes, mast constructions, smokestacks and bridges. To protect connections against the self-loosening several anti-loosening devices were on the market. Recent results showed that unfortunately almost all of them were malfunctioning. Due to that in 2003 all German regulations for these elements were withdrawn. The aim of this study is to find a constructive way to protect a bolted connection from self loosening. Therefore several tests to identify the important parameters were performed, especially the variation of the clamping length. Within the paper the results of the project so far were presented. Finally, the paper discusses the available locking devices and their correct usage and limitations.

**Advanced Monitoring System For Bolted Connection In Vehicle Construction.**
**Marco Buchmann (5)** Bolted connections where used from the beginning of vehicle construction for joining two or more parts. The reliability of bolted connections is still a major problem. The objective of this research thesis is focused on an advanced monitoring system for bolted connections in vehicle construction. A mechanical "vibrating test bench", which was developed by the aeronautical engineer Mr. Junkers, is being adapted, to suite the requirements of the automotive industry. It is designed according to DIN 65151 standards. The bolted connection is tightened to a specific torque to achieve the required preload forces and then exposed to an oscillating elastic shear force. The preload force and their loss

are measured in relation to the number of load cycles. The ideal locking mechanism would be, if no settling occurs. Realistic
in practice is the remaining of a sufficient preload force which doesn't decry with time. The aim of this thesis is, to gain knowledge that will assist in the future control of the bolt locking procedure. The test bench can be used to verify the clamping capability of a bolted connection. With the dynamic computer- aided test system it will also be possible to test critical bolted joints and their safety, which reduces the probability of costly product recalls, or even severe cases of failure.

**On the Anti-Loosening Property of Different Fasteners.**
**S. Saha1 et al. (6)** Threaded fasteners are widely used for joining different mechanical parts temporarily due to its distinct advantages. However, screw threads have the problem of loosening under hostile vibrating conditions, which leads to decreasing of clamping force and finally failure of the system. To study the anti-loosening phenomenon of the threaded fasteners, a testing rig has been designed and fabricated where the clamping force can be continuously recorded under the application of accelerated known frequency vibration between two plates of nuts and bolt. In the present paper, the results obtained on the anti-loosening property of a number of threaded fasteners are presented, discussed and the effective one is found out.

**Report on Junker Vibration Tests on the BAMAC Thread.**
**William Eccles (7)** A series of tests have been performed using a Junker vibration test machine on a modified M* thread designed to resist vibration loosening. In total, tests on five such threads were completed. The tests involved measuring the clamp force provided by the bolt as a transverse displacement is imposed on the plate supporting the screw head. The results of the tests are presented in a graphical format, the clamp force is plotted against the test cycles. Such preload decay curves are a standard way of assessing a fastener's (or fasteners' in this case) loosening resistance. The most influential paper1 on the subject to-date was published by Gerhard H. Junker in 1969 in which he reports on a theory he developed as to why fasteners
self-loosen under vibratory loading. Junker found that transverse dynamic loads generate a far more severe condition for self-loosening than dynamic axial loads. The reason for this is that radial movement under axial loads is significantly smaller than that which is sustained under transverse loading. Junker showed that preloaded fasteners self-loosen when relative movement occurs between the mating threads and the fastener 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 bolt's preload. For small transverse displacements, relative motion can occur between the thread flanks and bearing area contact surface. Once the thread clearances are overcome the bolt will be subject to bending forces, and if the transverse slippage continues slippage of the bolt head bearing surface will occur. Once this is initiated the thread and the bolt head will be momentarily free from friction. The internal off torque, present as a result of the preload acting on the thread helix angle, generates a relative rotation between the nut and the bolt. Under repeated transverse movements this mechanism can completely loosen fasteners. The machine used this series of tests was based upon Junkers work. It was initially difficult to unwind the nut from the bolt following the test. Following information provided by BAMAC, if, following the test the nut is tightened slightly more and a pin inserted in gap between the two threads, the nut could be removed. The conclusions that may be drawn from the tests are:

1. At the vibration levels tested, the BAMAC thread design resists self loosening. No nut rotation was noted during the tests.
2. A reasonably high settlement loss was observed on these tests. It is thought that the reason for this was that the socket head cap screw had a relatively small head size. The transverse movement rocked the head on the adapter in the machine resulting in a higher amount of settlement than would normally be anticipated.

## CONCLUSION

After bottomless study of various national, international papers, books we come to concluded that ,

1. Spring washer is more effective than Plain washer & No washer.
2. Nyloc washer + nut is more effective than spring washer.
3. At the vibration levels tested, the BAMAC thread design resists self loosening. No nut rotation was noted during the tests.

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