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Investigation on the Self Loosening Behavior of Nylock Nut in Curvic Coupling under Transverse Load

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ABSTRACT:The Failure fastener usually fatigue or self-loosening by dynamic loads. Even partial loosening can reduce the preload of the fasteners, increase the dynamic loads by fasteners loading to increase of fatigue failure. The Nylock nut has property to preventing self-loosening under vibration under safety application. In this project self-loosening of bolts in curvic coupling is analyzed for standard hexagonal nut and nylock nut by applying cyclic transverse load on disc after the preload of bolt. ANSYS and PRO-E 3D Model are used for curvic coupling and thread is established to study details of self-loosening mechanism of bolt in standard hexagonal nut nylock nut.

KEYWORDS:3D Model,FEA, Nylock nut, static structural analysis.

I. INTRODUCTION

Fastening and joining are defined as an act of bringing together, connecting or uniting to becoming one or a unit. There are many types of fasteners such as bolts and nuts, adhesive bonds, welds, etc. Joints and fasteners are used to transfer loads from one structural element to another. In composite structures, there are two types of joints commonly used, namely, mechanically fastened joints and adhesive bonded joints. Fastened joints include bolts, rivets, and pins.

The design of adhesive joints depends on the size of the parts to be joined and the amount of overlap required to carry the load. Adhesive joints are often acceptable for secondary structures, but are generally avoided in primary structures on account of their strength, chemical interaction effects, and reliability (Viana, G et al. 2017). Bolted joints are still the dominant fastening mechanism used in joining of primary structural parts for advanced composites.

Threaded fasteners used to assemble mechanical products and structures are widely used due to their ease of disassembly for maintenance and their relatively low cost. The complex behaviour of connecting Fasteners plays an important role in the overall dynamic characteristics, such as natural frequencies, mode shapes, and non-linear response characteristics to external excitations.

Threaded fasteners are commonly used in assemblies due to the advantages they offer, such as the ability to develop a clamping force, and the ease of disassembly for maintenance and repair. Clamping force in a bolt is commonly developed by turning the engaged nut such that it moves against a clamped component and causes an axial elongation in the bolt. The resulting clamping force is a function of the joint stiffness and the bolt axial elongation (Ibrahim, RB and Pettit, CL 2005).

The tightening torque is mostly consumed during the process of overcoming two friction components: the underhead (or bearing) friction due to the sliding of the fastener head on the flanges and the thread friction between the male and female thread. The residual torque component produces the fastener tension by generating the joint clamping force. Inaccuracies in determining the friction components may lead to an overestimation or underestimation of the bolted joint performances.

Jiang, X et al., (2013), described that fasteners turn loose when subjected to dynamic loads in the form of shock, vibration or transverse cyclic loading. This reduces the preload force of bolt and leads to joint failure.

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Threaded fasteners can be subjected to dynamic shear loads due to several reasons. Some of the major causes of shear loading including bending, differential thermal expansion and impacts (Pai, PG; and Hess, DP., 2002). Of these, shear due to bending is most widespread in structures and assemblies and can subject threaded fasteners to large shear forces. This paper explores the influence of placement on vibration-induced loosening in assemblies undergoing bending deflections. The objective is to develop a procedure to identify regions in an assembly where the fastener would be least likely to fail due to loosening.

ManuneethiArasu, P et al., (2019), described that loosening of threaded fasteners subjected to dynamic shear loads. A fundamental analysis of loosening reveals that a fastener can loosen at lower loads than previously expected due to localized slip at the contact surfaces.

ASME/ANSI subcommittee was formed to study the problem of vibration- induced looseningManuneethiArasu, P et al., (2015). Apart of this committee, Kerley presented a comprehensive research plan for the study of loosening of threaded fasteners. One of the proposals of the plan was to identify mathematical relationships that govern loosening based on the study of simple joints, such as beams and apply them to the design of more. Complex structures such as a bent frame (Cha, YJ et al 2016). For instance, if shear were considered to be the primary cause of loosening, the shear load required to cause loosening can be determined for a beam and subsequently the mathematical relation obtained from analysis of the beam can be applied to design more complex structures, such as a bent frame, without the need for further testing. The analysis presented in this paper uses a similar approach.

The camlessvalvetrain allows control of the individual intake and exhaust valves of each cylinder and can beused to achieve throttled operation, and consequently, optimize the engine performance (Lang, O 2005). formulatethe speed control problem for this engine and show that it exhibits unstable open-loop behavior withassign"cant delay in the feedback loop. The instability is intrinsic to the throttled operation and specieto the camless actuation used to achieve the throttled operation.

Bhattacharya, Aet al., (2010) describes threaded fasteners have inherent and inevitable limitations that they loosen eventually under vibrating environment leading to higher frequency of routine maintenance of the components, the absence of which may result in fatal accidents.

The delay is caused by the discretecombustion process and the sensor/computer/actuator interface. Demonstrate the inherent systemlimitations associated with the unstable dynamics and the delay and provide insight on the structural (plant)design that can alleviate these limitations (Morari, M 1983). Finally, stabilizing controllers using classical and modern robustdesign techniques are presented and tested on a nonlinear simulation model.

Figure1. Pictorial view of testing rig

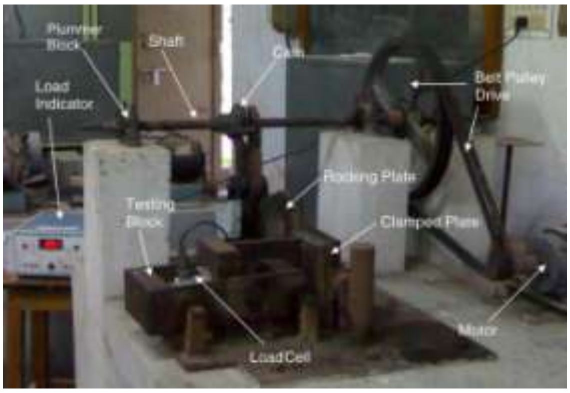
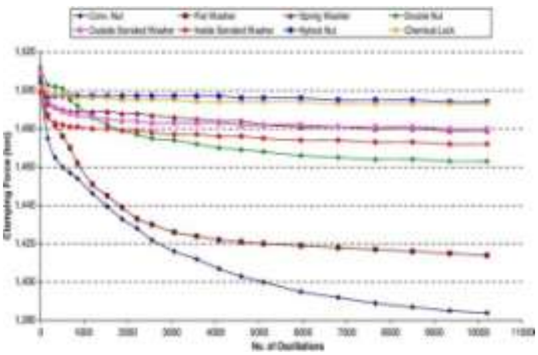


Figure 2. Comparison of loosening for Metric High Tension Steel Bolt (M16) with different nuts.



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II. EXPERIMENTAL SETUP

FEA static structural analysis is carried out for the curvic coupling assembly. The goal of the static structural analysis in structural mechanics is to determine the shear stress and normal stress for bolt in standard hexagonal nut and nylock nut. To examine the self-loosening behavior of in the curvic coupling assembly using FEA static Structural with ANSYS workbench 15.

Table 1: Material Property

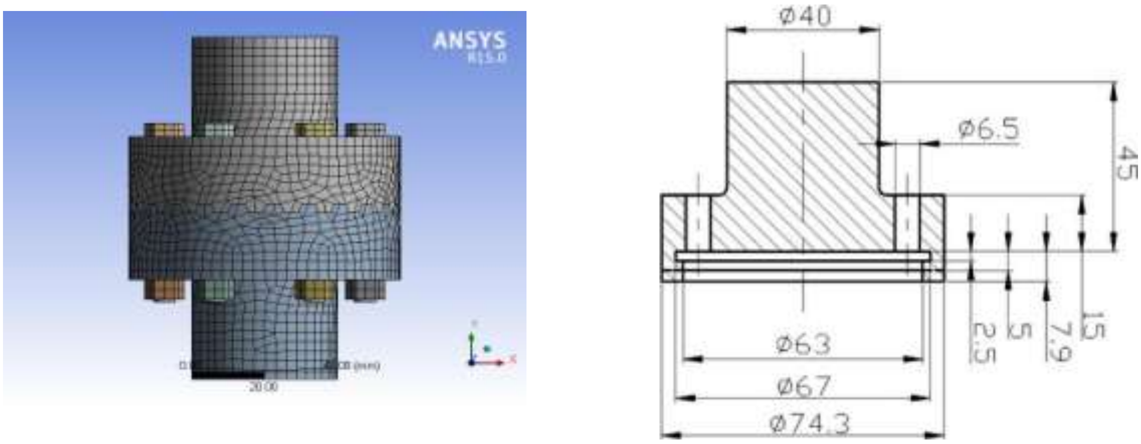
MATERIAL	YOUNG'S MODULUS	DENSITY	POISSON'S RATIO
MildSteel	209 GPa	7850kg/m^3	0.3

Specifications

- Thickness of disc : 22.9 mm
- Diameter of disc : 74.3 mm
- Bolt : M6x1P
- Bolt length : 54 mm
- Hexagonal and nylock nut : M6x1p

The study then used ANSYS finite element code. Fig. 3.3 shows the meshed model of assembly. Eight nodes solid 185 elements were used to mesh the assembly. Meshing consist of 89635 nodes and 25574 elements. The meshing model of assembly is shown below.

Figure 3: Detailing of curvic coupling and Curvic coupling dimension using AUTO CAD



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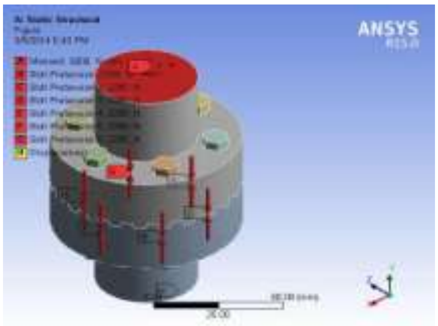
III. BOUNDARY CONDITION

Boundary condition of the complete assembly is shown in the fig.3.4. During analysis one end of the coupling is fixed and other end has torque applied at 5000 Nmm. The bolts are pretension at force of 2290 N. three-dimensional model is established with the software package PRO-E wildfire 5. It can be found that the curve coupling is comprised of two discs and six bolts and nuts, and thereare twenty four curves in each disc. Curve coupling discs are assembled by using six bolts and nuts in symmetric manner.

Figure 4: Nylock nut meshing



IV. CONTACT STATUS ANALYSES UNDER CYCLIC LOADING

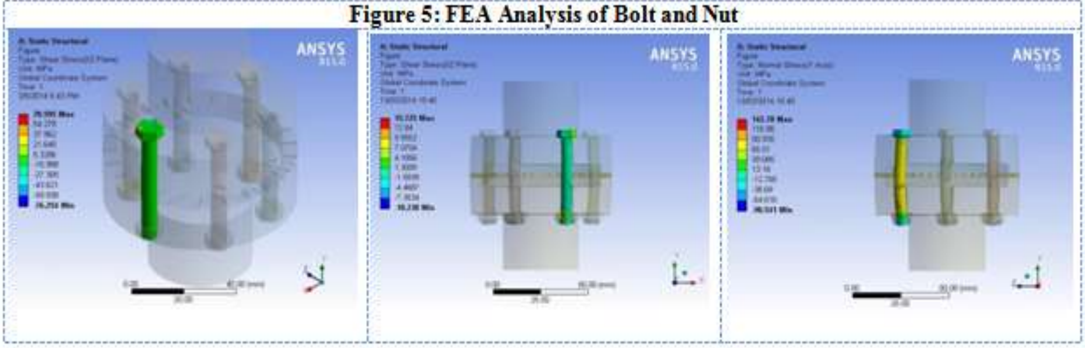
slip–stick status or localized slip of contact surface is the critical factor to determine the loosening process of bolt in curve coupling, which could be depicted by a proportional coefficient ƞ that is a relationship ratio between the tangential stress Ʈ and the contact pressure p, and can be expressed as follows:

$$\eta = \frac{Fs}{Fn} = \frac{\tau}{p} \quad (1)$$

Where Fs is the magnitude of frictional shear force per contact element; Fn is the magnitude of frictional normal force per contact element. If the proportional coefficient ƞ is significantly less than the friction coefficient of the corresponding contact surface, it means that the contact status is stick. However, the contact status can be thought to be complete slip when ƞ is equal or close to the friction coefficient. In addition, ƞ is impossible to be larger than the friction coefficient of contact surface in theory.

For FEA analysis hexagonal nut is replaced by nylock nut. The Nylock nut is designed to stop nut and bolt disengagement during use. The internal nylon ring deforms around the threads as the nut is twisted onto the bolt, ensuring a tight, vibration resistant grip on the bolt. The deformation of the nylon ring holds the fastener in place even under extreme vibration. The Nylock nuts permit a complete

Figure 5: FEA Analysis of Bolt and Nut



The automation of installation because of constant quality and very low scatter of the locking torque. This allows installation without concerns of defective or non- conforming nuts and reduces the cost of monitoring and tight inspection. From fig .3.9 normal stress for bolt with nylock nut is analysed using ANSYS workbench, the normal stress result obtained is 142.78 MPa. Using the equation (1), the slip-stick status will be found by using following data's from the analysis result. From the analysis, proportional coefficient is very less than 0.3. Therefore, stick will be taking place at contact status in standard hexagonal nut.

V. STATIC STRUCTURAL ANALYSIS OF BOLT AND NUT

The static structural analysis of bolt in standard hexagonal nut and nylock nut is shown in table 4.1.Table 4.1 Compare the structural analysis between Hexagonal and Nylock nut. From this table, the proportional coefficient of nylock nut is less than the proportional coefficient of standard hexagonal nut.

$$\eta = \frac{T}{P} = \frac{15.725}{142.78} = 0.10$$

Table 2: FEA test result

NUT USED	SHEAR STRESS (MPA)	NORMAL STRESS (MPA)	PROPORTIONAL COEFFICIENT
Standard hexagonal nut	70.595	297.51	0.24
Nylock nut	15.725	142.7	0.10

VI.CONCLUSION

From the work, the following conclusions were arrived that the current investigation is focused on the prevention of self loosening of bolt and nut in curvic coupling under cyclic transverse loading.

From analysis result table proportional coefficient for standard hexagonal nut and nylock nut are 0.24 and 0.10 respectively

By comparing contact status for hexagonal nut and nylock nut, slip is very less in nylock nut. When using nylock nut there is stick in contact status. Because there is increase in coefficient of friction between bolt and nylock nut due presence of nylon in nut.

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