A Study on Anti-Loosening Characteristics of Different 3/8 BSW Threaded Fasteners

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Abstract

A significant advantage of the threaded fastener is its capability of being dismantled using simple tools. However, threaded fasteners have an inherent and inevitable limitation that they loosen eventually under vibrating environment. The loosening of screw fasteners is caused by two factors mainly. One is the relative slip between the bolt and nut screw threads, and the other is the relative slip between the nut or bolt surface and the surface of the fastened material. In the present work, the anti-loosening ability of various 3/8 BSW locking screw fasteners with nylock nut, flat washer, nylon washer, serrated washer and spring washer are tested under accelerated vibrating conditions. The experiment has been carried out in an indigenously made testing machine. The initial clamping force given has been around 0.82 ton. Under vibrating condition, the loss of tightening force has been measured at regular intervals to adjudge the loosening of threaded fastener. From the results, it is observed that only small improvement has been obtained using flat washer over conventional nut. Outside serrated, spring and nylon washers show marginal anti-loosening ability. **N**ylock nut is seen to have better resistance to loosening than the other popularly known anti-loosening fastening elements tested, and hence, may be quite effective to use in vibrating conditions. However, other popularly known anti-loosening nuts or washers are found not to be that effective.

Keywords: Threaded fasteners, anti-loosening, nut and bolt, washer and vibrating condition.

1 Introduction

A significant advantage of the threaded fastener is its capability of being dismantled using simple tools. But, threaded fasteners have a limitation of loosening eventually under vibrating environment. The loosening of screw fasteners is caused by two factors mainly. One is the relative slip between the bolt and nut screw threads, the slip causing torsion of the bolt. The other is the relative slip between the nut or bolt surface and the surface of the fastened material, the slip causing slackening of the torsion.

Goodier and Sweeny [1], Hongo [2], Paland [3] and Junker [4] tested various types of threaded fasteners with respect to its loosening tendency, and the latter described the mechanism of loosening on the basis of friction between the flank surfaces. According to Junker [4], the cause self-loosening of nut and bolt is explained by the well-known law of physics related to the effect of friction on two interacting solid bodies.

Sase and others [5-7] tested the effectiveness of different screw threads, spring washers, nylon inserted nuts, double nuts and eccentric nuts of varying sizes with regards to resistance to loosening. Test results showed that the popularly known anti-loosening fasteners do not possess much resistance to loosening. In the year of 1998, Sase and others [6] introduced Step Lock Bolt (SLB) showing its desirable anti-loosening performance using a displacement based loosening device. The displacement and turning angle of the bolts and the nuts were examined in loosening tests.

Following the experimental procedure and conclusions drawn by Sase et al. [5-7], a testing rig was designed and fabricated by a team lead by Das [8-11], where a constant vibrating force at a constant frequency and amplitude is applied perpendicular to the bolt axis. In this set-up, several tests were carried out with different screw fasteners of different materials to compare their loosening tendencies. Takemasu and Mihayara [12] and Kasai [13] have also done some experimental works on loosening of threaded fasteners and the former has proposed a rolled double threaded bolt to arrest loosening.

In the present work, the anti-loosening ability of various 3/8 BSW locking screw fasteners with nylock nut, flat washer, nylon washer, serrated washer and spring washer are tested under accelerated vibrating conditions obtained in an indigenously made testing machine.

2 Experimental Details

In the present investigation, a loosening test rig is used where vibration is created in the direction perpendicular to the longitudinal axis of the bolt for accelerated tests. Details of the test rig developed, has been discussed in [11], and a schematic diagram of the same is shown in Fig.(1).

In the testing machine developed, controlled vibration is generated, and the loss of clamping force is measured to assess the amount of loosening. With this machine, 3/8 BSW (16 TPI) high tension steel bolts with standard and anti-loosening nuts and washers are tested. The initial tightening torque given is around 0.82 ton. Actual

clamping forces given on the fastener are shown in Table 1. Up to 12,000 oscillations, the decrease in clamping force is measured. The frequency of applying repetitive forces has been maintained to be 290 strokes per minute that is made higher than that reported in [11].

Different types of nuts and washers used for the clamping of the fasteners were conventional nuts, nylock nut, flat washer, spring washer, outside serrated washers and nylon washer. All the experiments were repeated three times.

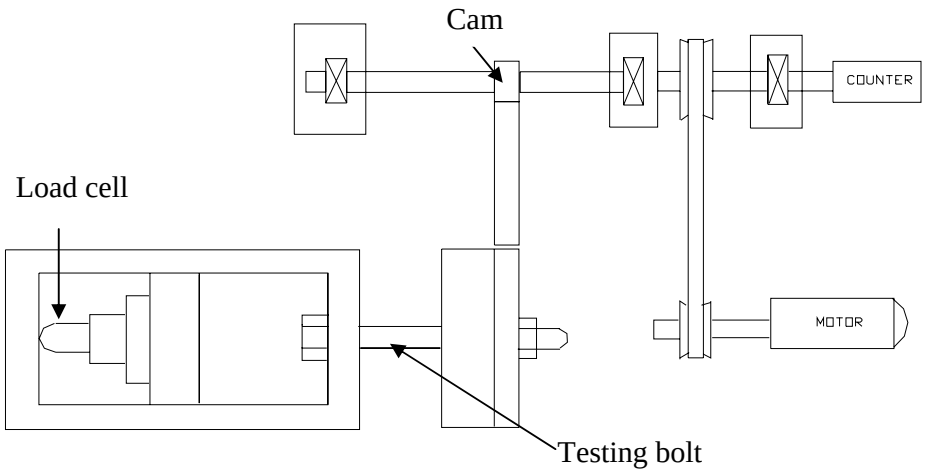

Figure 1. Schematic diagram of Test-Rig

Table-1 Details of clamping conditions for the test

Bolt	Nut and/or Washer Used	Initial Clamping Force (ton)		
		Expt-1	Expt-2	Expt-3
3/8 BSW High Tension Steel	Conventional Nut	0.822	0.822	0.828
	Flat Washer with standard nut	0.822	0.825	0.827
	Spring Washer with standard nut	0.826	0.822	0.825
	Outside Serrated Washer with standard nut	0.820	0.822	0.825
	Nylock Nut	0.823	0.821	0.828

3 Results and Discussion

Fig. (2) shows the comparison of loosening of standard 3/8 BSW threaded fasteners with high tension steel bolt corresponding to three repeat tests. From the figure, it is observed that for every experiment, initial loosening of clamping force is high. After a certain number of oscillations, the rate of loosening becomes slow. Results of repeat experiment Nos. 1 and 3 are quite similar, although initial clamping force for experiment 3 is slightly high; but results of experiment No. 2 shows substantially more loosening (to the tune of 10% after 12000 oscillations) than the other repeat tests. This kind of variation may often occur for negligible product variability, etc.

Fig. (3) depicts loosening tendency of conventional nut with flat washer. In this case also, the initial rate of loosening is high. While repeat experiments 2 and 3 results are quite close to each other, loosening in experiment No. 1 is somewhat high compared to the other two repeat tests. Loosening of these fasteners with flat washer does not show clear benefits over conventional fasteners. In some cases, flat washer shows good retention of clamping force, while in other repeat situation, it loosens to a comparatively higher extent. Thus flat washers are not offering substantial anti-loosening effects. This observation is in line with the observations reported earlier [5-7].

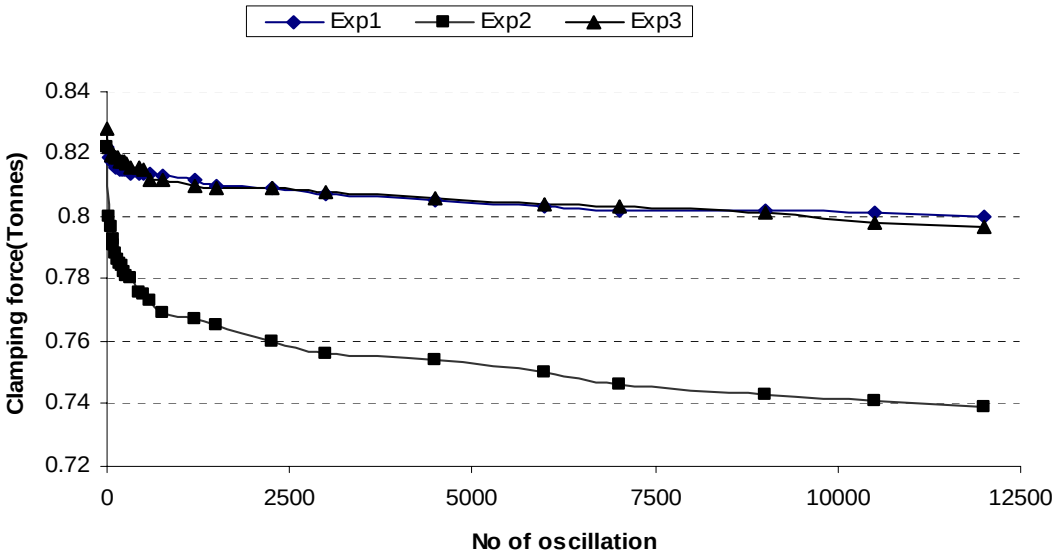

Fig. 2: Test results for 3/8 inch BSW high tension steel bolt with conventional nut

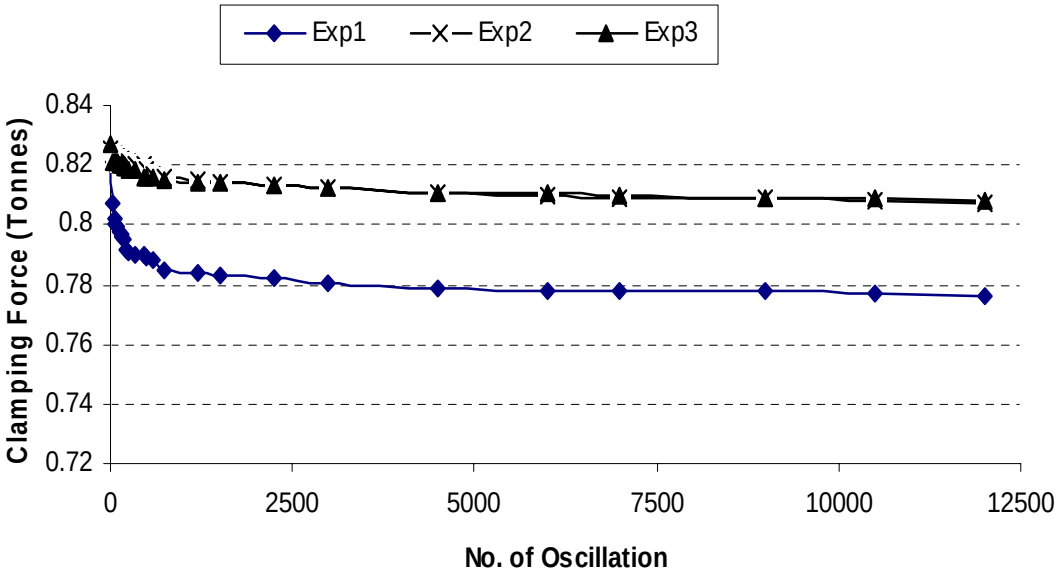

Fig. 3: Test results for 3/8 inch BSW high tension steel bolt with flat steel washer

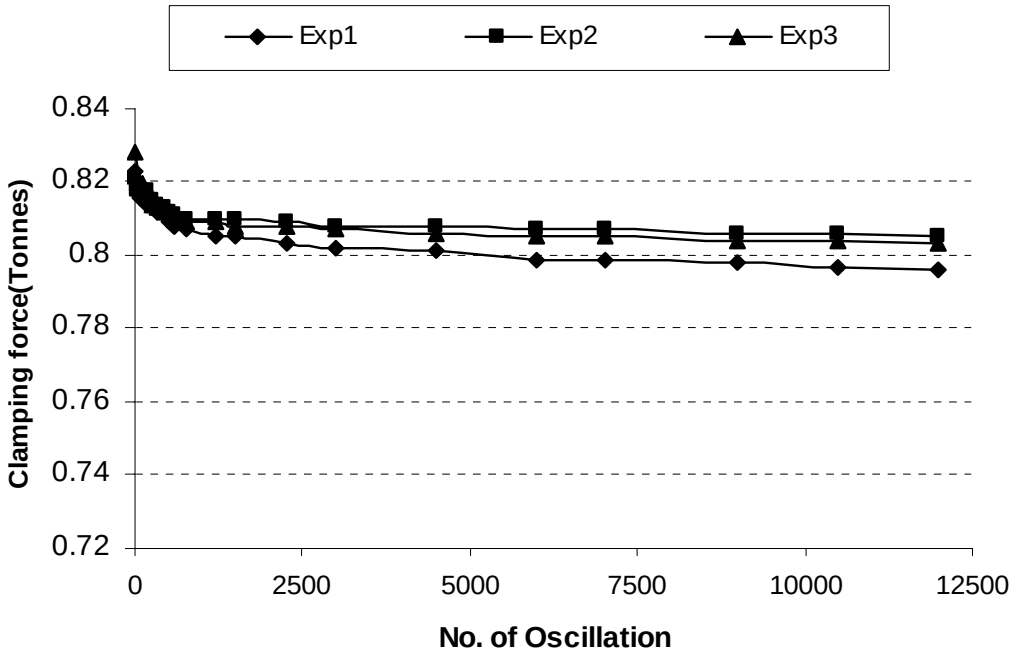

Fig. 4: Test results for 3/8 inch BSW high tension steel bolt with nylon washer

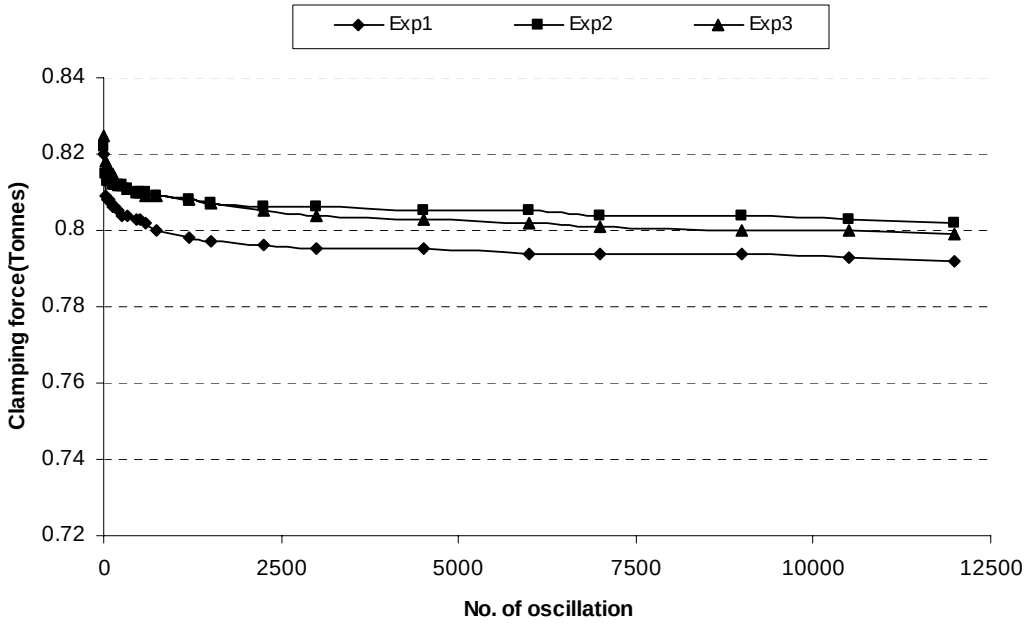

Fig. 5: Testing results for 3/8 inch BSW high tension steel bolt with outside serrated washer

Three repeat tests have also been performed with nylon washer (Fig. (4)), outside serrated washer (Fig. (5)) and spring washer (Fig. (6)). Fig. (4) is for loosening characteristics with nylon washer along with the conventional nut. After tightening, the nylon washer is deformed by the pressure of nut and shows a small loosening. Fig. (5) shows the results for outside serrated washer, where also small loosening similar to that of nylon washer is observed. For all the three repeat experiments, it is observed that the teeth of the serrated washer get substantially deformed, and hence, an outside serrated washer cannot be used repeatedly. A spring washer is

deformed and stretched in circumferential direction, and this is often believed to result in anti-loosening effect. However, it is observed in Fig. (6) that the use of spring washer does not effectively reduce loosening tendency, rather, it loosens at a higher rate than nylon and outside serrated washers. Similar phenomenon also happened with spring washer in the experiments done by Fuji and Sase [2] on a different fastening material.

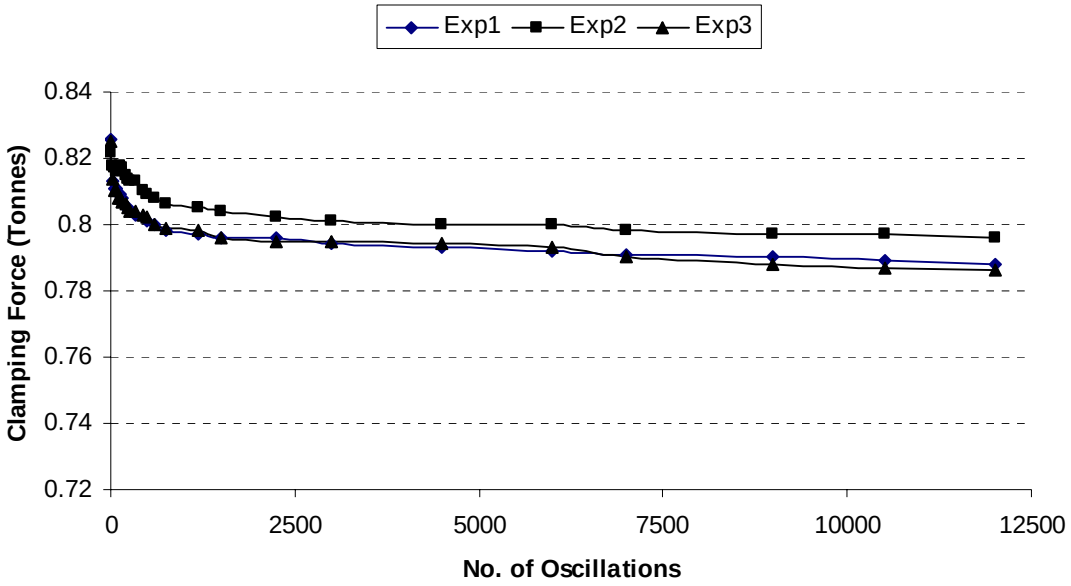

Fig. 6: Test results for 3/8 inch BSW high tension steel bolt with spring washer

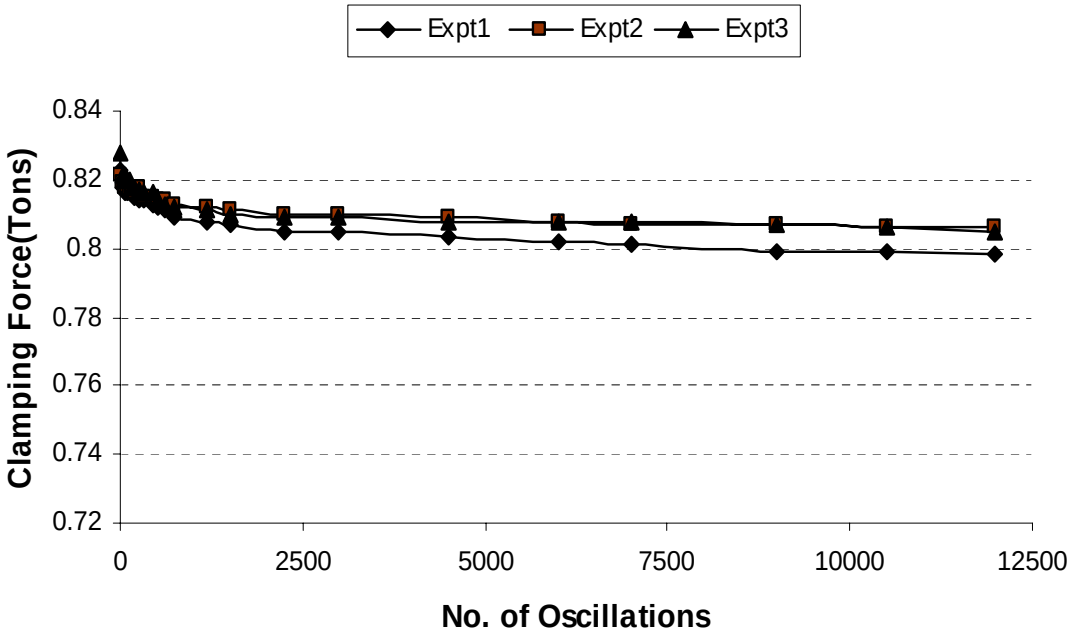

Fig. 7: Test results for 3/8 inch BSW high tension steel bolt with nylock nut

Results of nylock nut are shown in Fig. (7). It is seen that for all the three repeat experiments, nylock nut shows the least tendency to loosen up to 12,000 oscillations of all the tests made in this study, and a loosening of only 2% of clamping force is observed. All three curves are close to each other, and the loosening effect is seen at the initial stage of the experiment as is observed in all the tests made at present. Hence, it can be stated that nylock nut has consistency in offering considerable anti-loosening property.

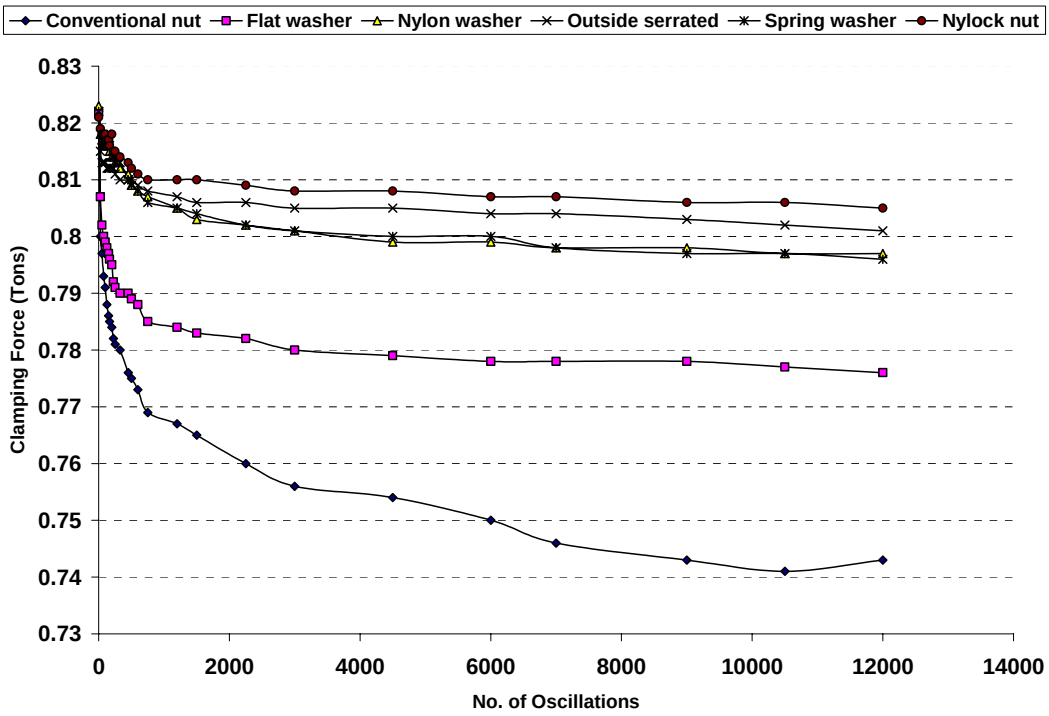

Fig. 8: Comparison of loosening for 3/8 inch BSW high tension steel bolt with different nut and washers

Fig. (8) shows the comparison of loosening for 3/8 BSW high tension steel bolt for different threaded fasteners. Data of one of the three repeat tests for each set of fastener are used to construct the plots. From the figure, following observations are made.

a) Very little improvement has been found using flat washer over conventional bolt and nut.

b) Nylon washer and spring washer have similar resistance to loosening that is better than flat washer.

c) Antiloosening property of outside serrated washer is somewhat encouraging.

d) The nylock nut is found to have the best anti-loosening characteristics of others.

4 Conclusion

From the result obtained on the experiment observed on loosening characteristics of different combinations of fasteners with 3/8 inch BSW high tension steel bolt, it may be concluded that

- Marginal improvement has been observed using flat washer over using only conventional nut and bolt
- Nylock nut has better resistance to loosening than others tested
- Outside serrated, spring and nylon washers have small anti-loosening ability.

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The study experimentally examines the loosening mechanisms of fasteners and assesses the anti-loosening performance of the three tested coatings based on their tightening characteristics, loosening curves, and the damage of thread surface. Additionally, the anti-loosening performance of the three coatings is compared under different load forms. The results indicate that the PTFE and MoS2 coatings have significant anti-loosening effect, whereas the anti-loosening performance of TiN coating is not satisfactory. It is also found that an appropriate increase of the initial tightening torque can significantly improve the anti-loosening effect. Although threaded fasteners are generally considered a mature technology, significant problems exist with their use. This study has investigated a number of issues with the tightening and self-loosening of threaded fasteners. o It was found that upon repeated tightening of electro-zinc plated fasteners significant. wear of the contact surfaces of the bolt/nut thread and nut face occurred. This wear was accompanied by an increase in the friction coefficient causing a reduction in the clamp force provided for an assembly when tightened to a specific torque value. o The self-loosening characteris... Fasteners your guarantee of quality industrial fasteners 7 Breaking & Yield Loads F A S T E N E R S When bolts are broken in tension, diameters of the thread. This breaking will normally occur in calculation gives a figure which is the threaded section, and it might known as the â€œStress Areaâ€, and be expected that the breaking load this is now generally accepted as could be calculated on the basis of the basis for computing the the material strength and the area strength in tension of an externally at the root.Â 11/4 BSW 0.8942 0.980 14.70 32920 146 27.40 61480 273 11/2 BSW 1.300 1.410 21.15 47370 211 39.45 88370 393 13/4 BSW 1.753 1.907 28.60 64060 285 53.39 119590 532 2 BSW 2.311 2.508 37.60 84220 375 70.21 157270 700 * See introductory paragraph to. Comparing the anti-loosening characteristics of locking solutions is also the object of many research articles [6â€“ 9] comparing the effect of parameters such as the clamping length, the surface finish and treatment, or various locking systems (e.g. wedge lock washers or chemical locking). The fasteners being compared are submitted to a standardised vibration test, such as ISO 16130 or DIN 25201-4 B. The results are displayed in a chart plotting the measured clamping force against the number of load cycles (Fig.Â Analysing the self-loosening behaviour of fasteners is a critical step to ensure the safety of assembled parts.Â Numerical study of self-loosening of a bolted assembly under transversal load Mechanics & Industry 17, 507 (2016). Rail fastener is a crucial component equipment to ensure the safe operation of the train, and it is very paramount to detect the loose state of the fastener. In this paper, the vertical vibration acceleration signal of wheelset is taken as the research object, and the loose state of fastener is identified by separating and calculating the key IMF energy entropy.Â Therefore, three typical simulation conditions are set up for the looseness of the fastener, as shown in the diagram. The cross line is the fastener loosening position in the picture, and there is one loose fastener on the first condition, there are two loose fasteners on the same section of the track in the second condition, and there are two loose fasteners on the same rail in the third condition.