RESEARCH PAPER | Engineering | Volume : 3 | Issue : 1 | January 2013 | ISSN - 2249-555X

Evaluating the Relationship Between Bolt Grade and Breaking Point

KEYWORDS: Bolt, Grade, Breaking Point

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ABSTRACT *The objective of this experiment was to study the effect of bolt grade on breaking point. The basic assumption was that if one can used a higher grade bolt, then the torque at the bolt's breaking point would significantly increase. There are no controllable factors in this experiment because there is not a standard bolt. The constants in this experiment were mechanic, tools, and hardware installed on each bolt. The independent variable in this experiment was bolt grade. The dependent variable in this experiment was torque at breaking point. The results show that the assumption is that if you use a higher grade bolt, then the torque at its breaking point will significantly increase was not supported.*

1.0 INTRODUCTION

Bolts are among the lowest cost-per-unit items in a company's parts inventory, and their importance in keeping the chain of production intact is easy to overlook. But each bolt in that expensive piece of loading, hauling or process equipment is part of the unit's overall design, specified for a purpose. Improper bolt substitution or misapplication of tightening force on a bolted connection can result in failure, reduced performance, warranty problems, or even unintended disassembly of a vital component. There are thousands of bolt types and sizes, but the basic specifications and performance expectations for any kind of bolt are defined in a handful of characteristics that include: the type of metal it's made of and how that metal is plated or otherwise protected against corrosion; bolt head and thread type; thread lubricant recommended or required; torquing force needed to secure the bolt; and whether the application requires a washer or locking device.

Assembly with threaded fasteners is an essential element of modern industrial production, and bolts are among the most common and widely used types of threaded fasteners. Bolts, like all threaded fasteners, are ideal for recycling and conform to standard safety practices. Because bolted joints are so widely used, their economic importance cannot be overstated. The principles of bolted joints, and the commonly used methods of controlling the tightening process, are deceptively simple. A bolt is just a threaded fastener, with a thread that does not extend all the way to the head, designed for use with a nut. But tightening the bolt correctly is a complex undertaking that requires understanding the characteristics of the bolted joint and the various tightening methods. Without a working load, the bolt is merely a clamping device. In a bolted joint, the parts are clamped in place between the bolt and nut. The bolt preload is equal but opposite to the preload of the clamped parts. In the assembled state without an external load, the assembly preload is equal to the bolt force. The assembly preload in the clamped parts is equal to the clamp force.

2.0 Designing the Joint

Bolted joint design is an iterative process, in that the designer will rely on trial and error, past experience and personal judgment to make some design decisions. As experience and knowledge increases, the designer is able to make better judgments regarding the effect of certain design parameters and decisions.

However, regardless of the size, application or operating parameters of a joint, there are some steps which are commonly undertaken. These steps includ.

1. Define 8the purpose of the joint. In this step, define what the joint is designed to do, environmental conditions, cost targets, size and operating parameters, desired life, critical nature, potential failure modes and any other factors involved in the purpose of the joint.
2. Design the joint. Determine the layout of the joint, including joint members, size, shape and material(s).

3. Estimate service loads.

Estimating service loads is a difficult, but very important step, especially in critical joints. The static and dynamic loads to be considered include weight, pressure, shock, inertial affects, thermal affects, etc. Load intensifiers, such as prying and eccentricity, should also be considered.

4. Define bolts to be used.

With the joint geometry and service loads established, the bolt size, number and strength can be determined. Bolt selection should include material, diameter, thread pitch, length, tensile strength, head style, drive style, thread style, hardness and plating.

5. Determine required minimum and maximum preload and minimum and maximum clamp load.

The minimum and maximum preload at assembly should be selected to achieve the desired minimum and maximum clamp load for proper function of the joint throughout the life of the product. The minimum clamping force should be great enough to overcome vibration loosening, joint separation, slippage, fatigue, leakage and other similar type failures. Maximum clamp force should not be great enough to cause bolt yielding, joint crushing, stress cracking, fatigue failure, tensile failure or other similar failures in service.

6. Determine tightening methods and assembly line accuracy.

During assembly, there are different fastener assembly methods and tightening strategies which must be considered. With these come variances in the accuracy of achieving desired preloads, K factors and the required tightening torque to achieve the bolt preload range. Among the potential tightening strategies and their preload accuracy are:

Torque : ± 35 % , Torque - Angle : ± 15 % , Torque - to -Yield : ± 7 %

These should be considered before finalizing the joint design so necessary adjustments can be made to ensure the joint remains reliable during service life in determining torque for achieving desired preload.

7. Finalize joint design.

At this point, it may be necessary to make changes in joint material, bolt preload range, bolt selection, tightening meth-

Volume : 3 | Issue : 1 | January 2013 | ISSN - 2249-555X

ods, etc. depending upon what was determined during the other steps of the joint design process.

The strength of screw threads are dependent on three stress areas:

1. The tensile stress area is equivalent to the cross sectional area of a theoretical cylinder made from the same material, which would support the same ultimate load in tension. This area is an assumed cross sectional area through the thread, which is used in the computations of fastener tension loads.
2. The thread root area is the cross sectional area through an external thread at its major diameter. This area is used when computing a fastener's strength in torsion or transverse shear.
3. The thread shear areas are the effective areas through the thread ridges, parallel to the thread axis, and for full length of thread engagement, which resists the stripping out of the threads when a shear load is applied.

Table 1 : Different bolt grades and properties

Class No.		3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9
(e.g., 4.6: X=4 and Y=6 Su = X*100 Mpa and Sy = 0.1*Y*Su)											
Size Range			M5-M36	M1.6-M16		M5-M24		M1.6-M36	M1.6-M16	M5-M36	M1.6-M36
Su (Mpa)		300	400	420	500	500	600	800	900	900	1200
Sy (Mpa)		180	240	340	300	400	480	640	720	720	1080
Sp (Mpa)				310		380		590	650	650	970
Hardness Kg/mm^2	min	95	120	130	155	160	190	230	280	310	372
	max	220	220	220	220	220	250	300	360	382	434
% Elongation		25	22	14	20	10	8	12	10	9	8
% Reduction of Area		--	35	--	--	--	--	35	--	--	35

3.0 EXPERIMENTS

To conduct this experiments 3 bolts for each grade i.e. grade 4.6, 5.8, 8.8 and 10.9 of size M6 was taken. These bolts were firmly held in the test setup as shown in figure 1. They have been tighten using digital torque wrench (refer figure 2) till they will reach the breaking point. The results of breaking point in terms of N-m is recorded in table 2.

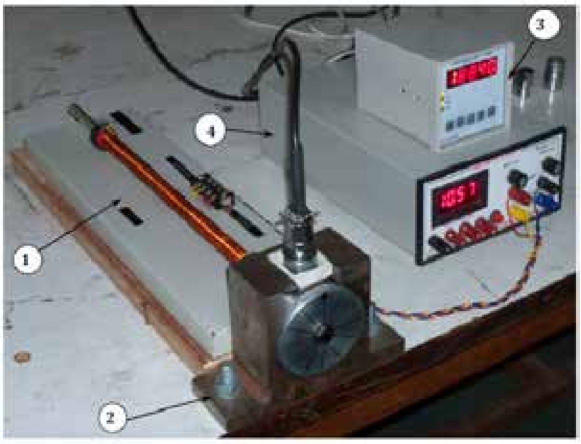
[1] LVDT [2] TEST FIXTURE WITH LOAD CELL [3] LOAD CELL INDICATOR [4] LVDT INDICATOR

Figure 1: Test Setup

Figure 2 : Torque applying instruments

Table 2 : Results

	Breaking Point N-m			
Bolt Grade	Test 1	Test 2	Test 3	Average
4.6	17.8	21.9	19.7	19.8
5.8	21.9	22.0	21.4	21.76
8.8	22.2	22.7	23.0	22.64
10.9	24.4	24.9	25.2	24.84

4.0 CONCLUSION

The objective of this study was to understand the effect of bolt grade on its breaking point. The major observations were that the various bolt grades had only minor changes in torque at each breaking point due to the difference in the composition of material of each bolt. The assumption was that if one can used a higher grade bolt, then the torque at the bolt's breaking point would significantly increase was not validated. Probable reasons for the observations were that the higher grade bolts started to fracture first in turn lowering the torque at the actual breaking point. Recommendations for improving this possibility is are that one should run more trials to get better findings and test higher grades of bolts.

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