Case Study on Bolt Torque, Preload, and Strength

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Abstract— Bolts come in various shapes and strengths. The Unified National Series (UNS) specifications mandate the standards for English-system bolts and screws. A similar ISO standard covers the SI side of things. Nearly every mechanical design book features a slew of data about bolt and thread geometry and characteristics. Three particular pieces of data are of interest for this case study, which cares with the strength of bolts under tensile load.

Keywords: Bolts, Strength, Load

I. INTRODUCTION

One among the smallest amount glorious but most vital aspects of mechanical design is that of fastener selection. You can't make your earth shatteringly fantastic product if you can't put the pieces together. The utilization of bolts and screws as fasteners seems so commonplace on be uninteresting, but repeatedly the failure of such a fastener is that the cause for the failure of a product as an entire.

II. GOALS OF CASE STUDY

- To develop a pity the strength of a 1/4-20 bolt.
- To better understand the various bolt grades.
- To be ready to translate preload torque into preload tension.
- To understand difference between ultimate lastingness and proof strength for a bolt.
- To be ready to do a quick determination of an inexpensive bolt preload for both static and dynamic situations.

III. THEORY

Bolts are available various shapes and strengths. The Unified National Series (UNS) specifications mandate the standards for English-system bolts and screws. an identical ISO standard covers the SI side of things. Nearly every mechanical design book features a slew of data about bolt and thread geometry and characteristics. Three particular pieces of data are of interest for this case study, which cares with the strength of bolts under tensile-load.

The first is that the tensile area, At, of the bolt. The threaded portion of a bolt are often characterized by two sizes, the main and pitch diameters. the main diameter is that the diameter measured between the outermost a part of the threads. The pitch diameter is that the diameter measured approximately halfway through the threads threads. A bolt subjected to a tensile load behaves as if its cross-section features a diameter of effectively the typical of the main and pitch diameters. The tensile area is that the cross-sectional area calculated using this value. eFunda.com (Engineering Fundamentals) features a nice chart of those values for UNS Coarse series bolts. This tensile should be used for stress determination.

The second is that the grade of the bolt. Different bolt grades are made up of different materials with different heat treatments, and, accordingly, they need different strengths. The Society of Automotive Engineers (SAE) has the foremost commonly used grading system for UNS steel bolts. Different grade bolts have different head markings on them to permit for easier sorting/identification of a bolt's estimated strength. Unified Engineering Incorporated features a good chart of hex head bolt markings, which grades they correspond to, and also their ultimate tensile strengths.

Another notable measure of a bolt's strength is its proof strength which Norton defines because the strength at which the bolt begins to require a permanent set and which is on the brink of but less than the yield strength of the bolt material. Norton recommends that maximum preload be 90% and 75% of a bolt's for statically- and dynamically-loaded assemblies, respectively. Both Norton and Shigley tabulate proof strengths for various bolt grades.

The third is that the torque necessary to supply a specified tensile load during a bolt. Shigley and Mischke develop an expression relating preload torque T to preload force F via the bolt's nominal diameter d and a quantity called a torque coefficient K, which is said to the frictional aspects of the contact between the bolt and therefore the material surrounding it. The expression relating these quantities is T=KFd where K are often searched within the table below which Shigley provides.

Bolt Condition	*K*
Non-plated, black finish	0.30
Zinc-plated	0.20
Lubricated	0.18
Cadmium-plated	0.16
With Bowman Anti-Seize	0.12
With Bowma-Grip nuts	0.09

In this case study, a fast and dirty determination of the last word strength of a specific grade of 1/4-20 x 3/4 UNS coarse bolts is examined. Both Shigley and Norton enter far more detail on bolt loading, and therefore the student is inspired to review a number of their material to form up for gaps during this (very) brief introduction.

IV. EXPERIMENT PROCEDURE

A description of the procedure for this experiment is as follows:

A. *Equipment*

This experiment will require:
20 bolts, 20 washers, and 40 nuts. The bolts should be 1/4-20 x 3/4 inch long, and therefore the washers and nuts should fit accordingly. The bolts used here had the top markings shown to the left.

- A dial wrench.
- Light oil for lubrication
- Also: A 1/4" socket and a vise

B. Procedure for Breaking the Bolts

Assemble the bolts, washers, and nuts as shown above within the equipment list. Use a two new nuts and a replacement washer for every bolt. Put a number of the grease along the threads and between the bolt head and the washer (a little goes an extended way). Place the bolts, one by one. make sure that there is a small gap between the washer and therefore the vise, and also that there is a little gap between the nuts. The flats of both nuts should be flush against the vise jaw faces.

Use the wrench to interrupt the heads off the 20 bolts and record the utmost torque required. An audible clank usually accompanies the bolt failure. the utmost is torque recorded for one among the bolts.

V. EXPERIMENTAL DATA

Maximum torque at failure for twenty bolts in foot-pounds:

12.1	12.0	11.7	12.2	13.5
13.5	11.9	11.5	12.3	12.0
11.6	10.4	11.9	12.9	13.6
14.0	13.0	11.9	13.6	12.2

A representative sample of the mode of failure for the bolts is shown to the left.

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