How Torque Affects Fastenings

Unit: Occupational Skills

Problem Area: Fasteners

Lesson: How Torque Affects Fastenings

Student Learning Objectives.

Instruction in this lesson should result in students achieving the following objectives:

1. **Describe torque.**
2. **Explain how torque affects fastenings.**

Resources.

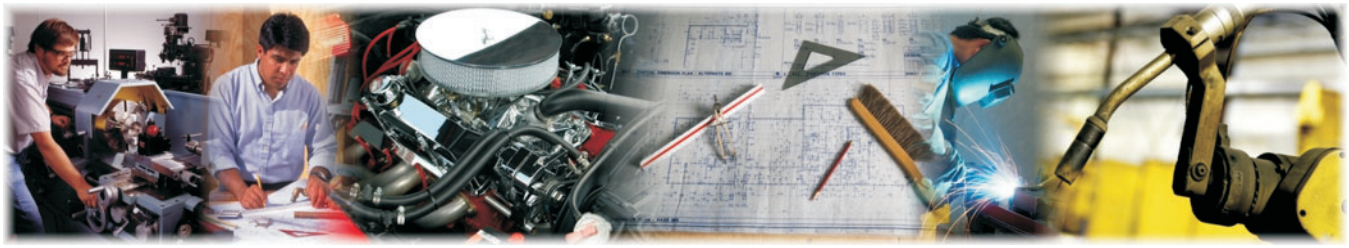
The following resources may be useful in teaching this lesson:

Barrett, Richard T. *Fastener Design Manual.* University Press of the Pacific, 1990.

"How Does a Torque Wrench Work?" *Tegger.com*. Accessed June 16, 2011. <http://www.tegger.com/hondafaq/torque_wrench/index.html>.

Nice, Karim. "How Force, Power, Torque, and Energy Work," *HowStuffWorks.com*. Accessed June 16, 2011. <http://auto.howstuffworks.com/auto-parts/towing/towing-capacity/information/fpte6.htm>.

"Terminology Related to Nuts and Bolts," *Boltscience.com*. Accessed June 16, 2011. <http://www.boltscience.com/pages/glossary.htm>.



Equipment, Tools, Supplies, and Facilities

- ✓ Overhead or PowerPoint projector
- ✓ Visual(s) from accompanying master(s)
- ✓ Copies of sample test, lab sheet(s), and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

Key Terms. The following terms are presented in this lesson (shown in bold italics):

- angle-control tightening
- bolt stretch method
- fulcrum
- lever length
- over-torquing
- torque-control tightening
- torque
- under-torquing
- yield-controlled tightening

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations.

> *Explain all the different applications in which we use torque daily (e.g., to close and open doors, to lift things with our arms or wrist, and to drive because all car engines rely on torque).*

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Describe torque.

Anticipated Problem: What is torque?

I. ***Torque*** is a force that can rotate or turn things.

A. Torque is generated every time a person applies a force on something to twist it, such as when a wrench is used on a nut.

1. The force applied at one end of the handle is transferred through the wrench to the other end and creates a torque.

2. The torque is what turns the nut.

B. The amount of torque generated depends on the amount of force and its distance to the point of rotation.
   1. The point of rotation for torque is the ***fulcrum.***
   2. The distance from the force to the fulcrum is the ***lever length.***

C. The basic equation for torque is the force times the distance.
   1. If someone applies 20 pounds of force on a lever (or wrench) that is 1 foot long, the torque is 20 foot/pounds.
   2. The same amount of torque can be achieved by doubling the length and by cutting the applied force in half.
   3. For example, if 10 pounds of force is applied on a lever that is 2 feet long, the torque is 20 foot/pounds.

D. Torque is designated in foot/pounds, inch/pounds, or in the SI unit system Newton-meter.

Teaching Strategy: *Bring in a set of wrenches that differ in length or a socket set with an added breaker bar. Have the students experiment regarding how much easier it is to turn a longer wrench because it increases the torque.*

Objective 2: Explain how torque affects fastenings.

Anticipated Problem: How does torque affect fastenings?

II. Torque and fastenings

A. A frequent cause for bolt or nut failure is inaccurate tightening.
   1. This is a result of not applying the correct amount of torque.
   2. If the initial load placed on a bolt or joint is too great or too little, a whole range of problems can develop.
      a. Too much torque, known as ***over-torquing***, results in a situation that can cause the head to fail in shear (break right off).
      b. Over-torquing can cause the nut to strip the threads, which will also lead to failure.
      c. Not enough torque, known as ***under-torquing***, results in a situation that can cause the fastener to cycle and vibrate and to have improper clamping.
      d. This can shorten the fatigue life, which can result in failure.

B. Torque values are used to determine the proper clamping force for fasteners.
   1. There are standardized torque values that depend on the size and material of the fastener to achieve the most optimum hold. These values are developed through testing.
   2. Several factors can affect torque and tightening.

3. During fastening, a bolt (or screw) head that is against a material surface uses almost 50 percent of the applied torque to overcome friction.
4. There is also a loss of almost 40 percent of the torque used to overcome the friction between the threads.
5. Friction caused by the surface finish on the fastener can affect the amount of torque required to achieve a specific clamp force (or hold).
    a. If the material has a rough surface, it will have a lower clamping force.
    b. A smooth material will have a higher clamping force than a rough material.
    c. A plated metal material will have the highest clamping force.
6. There are different torque specifications for dry and lubricated installations.
    a. Lubrication lowers the friction.
    b. Lower friction allows for less torque to achieve the desired hold.
    c. Some lubricant types are oil, grease, hard wax, and sealants.

C. Several methods are used to avoid bolt failure from over- or under-torquing.
1. ***Angle-control tightening*** is a method in which the fastener is tightened to a specified (predetermined) angle.
2. The ***bolt stretch method*** is a method that utilizes a threaded puller attached to the bolt to extend the bolt.
    a. This is a common method on very large bolts since they require such a large amount of tightening torque.
    b. The nut is applied first. Once the bolt is stressed, the nut is tightened to a greater degree.
3. ***Torque-control tightening*** is a common method that determines the preload torque from tables or calculations.
    a. The tables consider various factors.
    b. When a fastener is tightened, there is an elongation force placed on the shank and torsional stress caused by the threads.
    c. Controlling the torque is necessary because so much of the applied torque is lost to friction, which can cause changes in the bolt (or fastener) loads.
4. ***Yield-controlled tightening*** is a method that uses sensors to detect torque and angle during the tightening process.
    a. The method uses a control system, as the bolt is being tightened, that is sensitive to changes in torque.
    b. The yield point of the bolt is indicated by a change in the torque gradient, and the tightening process is stopped.
5. Some other methods are tension-indicating methods and heat tightening.
    a. Devices can be used to measure the tension on a bolt.
    b. Some bolts, nuts, and washers are designed to give an indication physically when they have reached their ideal setting.
    c. Heat tightening is not very common and is time consuming.

Teaching Strategy: *Have a class discussion about bolt failure. Bring in examples of bolts that have reached failure because of incorrect torque settings, and explain how important torque can be on fasteners. Use VM–A to review. Assign LS–A.*

- **Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may also be used in the Review/Summary.

- **Application.** Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

- **Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

- **Answers to Sample Test:**

Part One: Completion

1. over-torquing
2. inaccurate
3. bolt stretch method
4. distance
5. under-torquing
6. torque

Part Two: True/False

1. T
2. T
3. F
4. F
5. T
6. T

Part Three: Short Answer

Answers will vary. See “Content Summary”: II.C.1–5.

Sample Test

Name _____

How Torque Affects Fastenings

Part One: Completion

Instructions: **Provide the word or words to complete the following statements.**

1. Too much torque, known as _____, can cause the head to fail in shear.
2. A frequent cause for bolt or nut failure is _____ tightening.
3. The _____ utilizes a threaded puller attached to the bolt to extend the bolt.
4. The amount of torque generated depends on the amount of force and its _____ to the point of rotation.
5. Not enough torque, known as _____, can cause the fastener to cycle and vibrate.
6. There are different _____ specifications for dry and lubricated installations.

Part Two: True/False

Instructions: **Write *T* for true or *F* for false.**

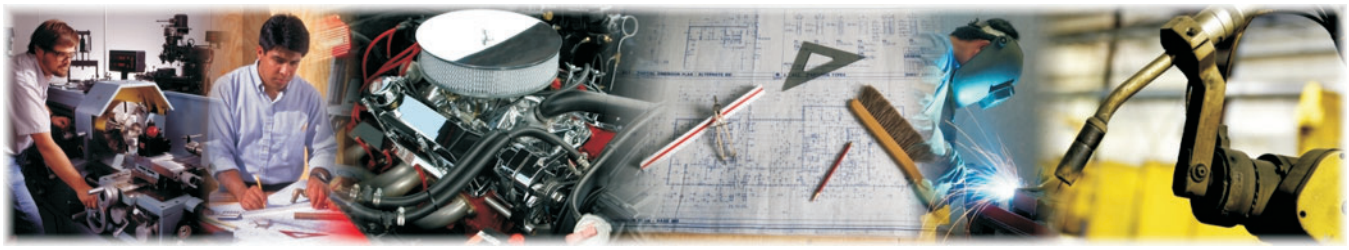
_____1. The distance from the force to the fulcrum is the lever length.

_____2. Yield-controlled tightening uses sensors to detect torque and angle during the tightening process.

_____3. The bolt stretch method compresses the bolt prior to installation.

_____4. Heat tightening is one of the most common methods to control torque.

_____5. Lubrication can lower friction when tightening a bolt or nut.



_____6. Angle-control tightening is a method in which the fastener is tightened to a specified (predetermined) angle.

Part Three: Short Answer

Instructions: **Answer the following.**

List three different methods used to avoid bolt failure from over- or under-torquing, and describe them.

DEFINITIONS

- **Torque** is a force that can rotate or turn things.
- The **fulcrum** is the point of rotation for torque.
- The **lever length** is the distance from the force to the fulcrum.
- **Over-torquing** is a situation that can cause the head to fail in shear—or break right off.
- **Under-torquing** is a situation that can cause the fastener to cycle and vibrate and to have improper clamping.
- **Angle-control tightening** is a method in which the fastener is tightened to a specified (predetermined) angle.
- **Torque-control tightening** is a common method that determines the preload torque from tables or calculations.
- The **bolt stretch method** is a method that utilizes a threaded puller attached to the bolt to extend the bolt.
- **Yield-controlled tightening** is a method that uses sensors to detect torque and angle during the tightening process.

Name _____

Torque and Fasteners

Purpose

The purpose of this activity is to develop understanding of how torque has an affect on fastening.

Objective

Develop knowledge of how torque can affect fastening.

Materials

- lab sheet
- writing utensil
- paper
- bolts
- nuts
- wrench, a short arm and a long arm (appropriate size to match bolts)
- block of wood with appropriate-sized holes for bolts

Procedure

1. First you will be given a block of wood, bolts, nuts, and a short arm wrench.
2. Tighten the bolt onto the wood with the nut as tight as you can with the short arm wrench.
3. After you are finished, you should note how far down into the surface of the wood you were able to press the bolt and nut.
4. Next you will be given a long arm wrench to tighten a new bolt and nut into the wood.
5. After you have tightened the bolt and nut onto the wood with the long arm wrench, note how much farther you were able to press it into the wood.
6. On your piece of paper, explain why this was possible as discussed in class in regards to torque.