Bevel Gear Analysis

ME325 Mindworks Poster

#75 Bryan Blakey
#73 Luke Rust
#11 Brian Chamberlin

The bevel gear poster begins with a basic overview of the purpose of bevel gears, namely, to transfer power between two intersecting shafts. There are several different types of bevel gears, including straight, spiral, and hypoid bevel gears. Each serves a different and unique purpose, but our analysis will deal primarily with straight bevel gears as the most general case.

Prior to beginning analysis we take a look at some of the important measurements and terms associated with bevel gear geometry. There are several diagrams depicting key lengths and angles necessary to bevel gear analysis, with accompanying definitions. It is important to understand what these terms refer to, as well as how to find the values they represent for each particular gear.

The first step to analyzing a bevel gear is to determine the forces that act on the midpoint of the gear tooth. We use the midpoint of the tooth not because it is actually the location that all the forces resolve to, but because it is easier, and the error is not particularly substantial. The force located at the midpoint can be resolved to three components, a tangential force, an axial force, and a radial force. We can solve directly for the tangential force using equation 13-26 from the Shigley-Mischke textbook. This equation requires us to know the power to the gear as well as the pitch line velocity. Pitch line velocity can be calculated if the average pitch radius and the speed of the gear are known. Once we have determined the tangential force the radial and axial forces can be calculated with the pitch angles and the pressure angle. The point of finding these three forces is to allow us to calculate the bearing and shaft loads. Once the forces at the midpoint of the tooth are calculated it is a simple mater of statics to finding the reacting forces at key locations.

The majority of the poster is devoted to determining the stresses in bevel gears. The American Gear Manufacturers Association (AGMA) is the leading authority in the field of designing and analyzing gearing, and their methods are the standard used throughout the country. The poster seeks to give a general set of equations used to determine bending stress and strength and contact stress and strength in bevel gears, and explain how or where each of the variables in these equations can be calculated or found, respectively. Unfortunately, there are so many different geometries and cases of bevel gears that it would be impossible to include even a fraction of the necessary charts and graphs that represent these variables. However, there are numerous resources available both in print and online that can provide the pertinent graphs and charts. The main difficulty in performing the stress analysis is obtaining the various values from these charts using the given bevel gear geometry, but once each value has been obtained, solving each equation is mathematically straightforward. Overall, the purpose of the stress analysis is to design gears that resist bending failure of the teeth and resist pitting or failure of tooth surfaces. These failures occur when the respective stresses acting on the tooth exceed the allowable stresses of the tooth, which is why it is necessary to compute both the stress acting on the tooth, as well as the allowable stress that can be sustained by the tooth.

This poster will provide the basic steps needed to find the forces and stresses acting on a bevel gear. The actual numerical data from the AGMA charts is not provided but those charts are easily found in textbooks, or other reference books. The Source Book on Gear Design, Technology and Performance, compiled by the American Society for Metals, has the charts and diagrams necessary to calculate the stresses in several different types and configurations of bevel gears. This book can be found at the U of I library. The American Gear Manufacturers Association also has a website located at www.AGMA.org.

Sources:

www.AGMA.org –American Gear Manufactures Association Website.

Source Book on Gear Design, Technology and Performance, American Society for Metals.

Mechanical Engineering Design Fifth Edition, Joseph Shigley, Charles Mischke