TOOTH TIPS

BRIAN DENGEL
GENERAL MANAGER • KHK-USA

I have a question about your gears!

Providing good information isn't always easy – especially if the answer is based on bizarre questions and misconceptions about gearing.

The concept of using a wheel to redirect motion has been part of the human experience for thousands of years. The simple design of a rope and a pulley to pull an object is the most basic form of this concept. The addition of teeth to the pulley resulted in the first gear. This simple gear was able to hold more load than the simple pulley and thus birthed the industrial automation industry.

As I mentioned in a previous column, the topic of gearing is usually discussed as one single lecture, in the Machine Design class taught during just one semester of an engineering student's four-year education. Thus, the lack of knowledge regarding gearing leads to many questions, some of which are misconceptions and others that are just plain bizarre.

Question: Can this gear that I selected from your catalog operate at 30,000 rpm?
Answer: What is your definition of operate? If the question is: Can this gear spin at 30,000 RPM? The answer, then, is yes, it can. The only limitation on rotational speed is whether the shaft to which the gear is assembled to is being rotated at 30,000 RPM. If the shaft is spinning at a given speed, then the gear to which it is attached will be spinning at the same speed.

However, if the question is: Can this gear rotate at 30,000 RPM under my specific load conditions? The answer, then, is less obvious. Firstly, you would need to advise what those anticipated operating conditions will be. Secondly, you would need to advise the desired life of the gearing.

Questions that you need to ask yourself if you plan to operate gears at high speeds include: How will I lubricate the gear set operating at this speed? Can I maintain shaft alignments to permit this speed? Will my bearings operate at these speeds? What is the maximum allowable torque for this gear at my speed?

Question: Can you quote this gear for me?
Answer: The real question that is being asked is: "Can I manufacture the gear that I have designed? If the gear has been designed using standardized sizes, then the answer should be, yes, it can. However, if the gear has been designed for a particular application, without consideration of standard machining practices, then the answer most likely is no.

Gears are produced using standard pitch sizes. In diametral pitch gearing the sizes are detailed as DP, and for metric gearing the sizes are detailed as Module. DP gearing considers the number of teeth present in a unit circle. As such, a 16DP gear with 16 teeth will have a one-inch pitch diameter. Similarly, a 24DP gear with 48 teeth will have a two-inch pitch diameter. You could certainly design a gear that has 19 teeth and a one-inch pitch diameter, but since the tooling is not readily available to cut the teeth of that gear, you would be looking at a several thousand-dollar tooling expense along with a 12-16 week lead time to produce such a tool.

Another design issue to consider is the face width of the gear. For each Module, there is a recommended face width. The standardized sizes for face width are equal to 10 millimeters multiplied by the Module. As such, a Module 1.5 gear should have a face width of 15 millimeters. This size gives the gear a reasonable amount of surface area on the tooth face to transmit the applied load. You can certainly design a Module 5 gear with a 5-millimeter face width, but the gear would not be practical as the maximum allowable torque would be minuscule. Additionally, a Module 5 gear with 30 teeth and a 5-millimeter face width would no longer operate as a gear. The shape of this gear would bend and twist, and the resulting object would resemble a wave washer.

Question: Can you open the bore and add some additional machining to this gear?

Answer: It all depends on the size of the bore that you require and what the additional machining entails. Most gears are produced with a hub. If the bore is going to be enlarged, will there be sufficient material remaining between the bore diameter and the hub outer diameter? If there is going to be a keyway added, is there sufficient material remaining between the corners of the key slot and the outer diameter of the hub. For both of these considerations, the recommended minimum thickness is equal to the tooth height of the gear. For example, if the gear is a module 2, then the minimum wall thickness between the hub outer diameter and the inner bore diameter is 4.5 millimeters.

Additional machining could involve removing the hub. If the material has not been heat treated, then removing the hub is possible. If the material is hardened, then machining by wire EDM will be required.

Additional machining could involve adding tapped holes to the hub. If the size of the tap is reasonable in comparison to the bore size, then this is possible. If the requirement is to tap an M8 thread into a 6 millimeter bore, then we would politely decline this request. If the requirement was to place a 10 millimeter through hole into the face of the gear, it would be possible, provided that attention was given as to the locations of the hole. If the hole does not interfere with the hub, then it should not be a problem. However, if the location of the hole is too close to the tooth root, then it would not be acceptable. The recommended minimum distance for either the bore or a tapped hole in relation to the tooth root is 2.5 times the tooth height. In the case of a Module 3 gear, this would be 16.875 millimeters.

Question: I need a gear that can handle 250HP and is less than 2 inches in diameter. What do you recommend?

Answer: While we wait for the development of Unobtanium, the extremely lightweight alloy with a hardness greater than that of a natural diamond and a co-efficient of friction less than 0.001, which is dimensionally stable in all environments, neither corrodes nor rusts, is easily machinable, and has a raw material cost of less than $0.01 per pound, we recommend that you realize that the only way to increase torque capacity when the diameter is restricted is to increase the face width. For each increase in face width, the strength of the gear increases proportionally Thus, a 10 percent increase in face width, will result in a 10 percent increase in gear strength.

There are many considerations that a gear designer must review while developing the best gear system for their application, but ultimately, manufacturability will be the final and most important one. Just because you can draw a gear design in CAD does not mean that it can be manufactured in the real world.

ABOUT THE AUTHOR
Brian Dengel is general manager of KHK-USA, which is based in Mineola, New York. Go online to www.khkgears.us