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Gear mesh and tooth modifications

The involute gear form allows for a fluid mesh of the teeth as they slide along one another.

As we march through this thing that we all call life, we look to find our perfect partner — that singular person that perfectly meshes with our personality, improves our weaknesses, and complements our strengths. Sometimes we will make enhancements to our physical self in order to iron out some of our perceived surface flaws. As with life, the same is true about gearing.

The most common tooth form in gearing is the involute tooth form. This form allows for a fluid mesh of the teeth as they slide along one another. In Figure 1, a pair of standard involute gears are meshing together. The contact point of the two involutes, as Figure 1 shows, slides along the common tangent of the two base circles as rotation occurs. The common tangent is called the line of contact, or line of action.

A pair of gears can only mesh correctly if the pitches and the pressure angle are the same. The requirement that the pressure angles must be identical becomes obvious from the following equation for base pitch P_b:

$$P_b = \pi m(\cos\alpha)$$

where

m = module, and

α = the pressure angle.

Thus, if the pressure angles are different, the base pitches cannot be identical.

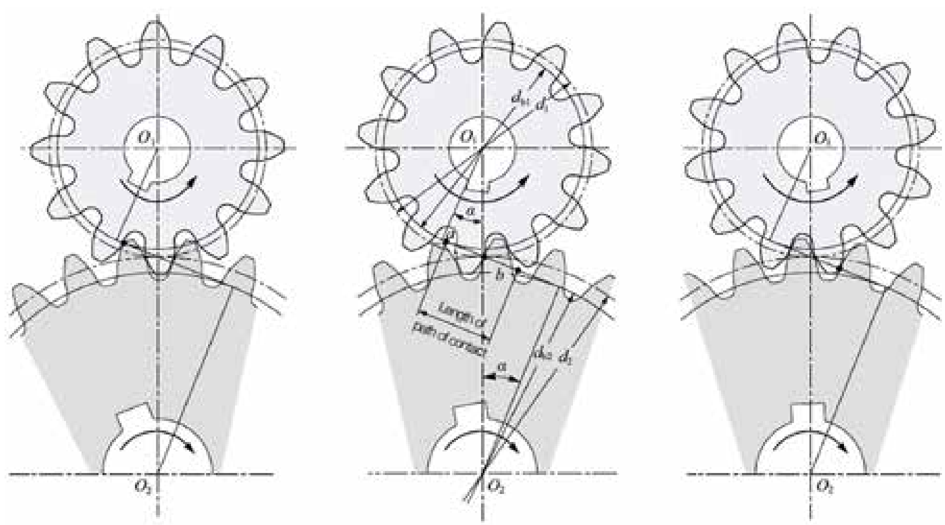


Figure 1: Meshing of involute gear.

The contact length *ab* shown in Figure 1 is described as the "Length of the path of contact." The contact ratio can be expressed by the following equation:

$$\text{Transverse Contact Ratio } \varepsilon_\alpha = \frac{\text{Length of path of contact } ab}{\text{Base pitch } P_b}$$

In practice, you should always aim to maintain a transverse contact ratio of 1 or greater. Module, m, and the pressure angle, α, are the key items in the meshing of gears.

In order to improve the mesh, there are three common methods of modifying the tooth form: the tooth profile modification, crowning and end relief, and topping or semi-topping.

In most gear literature, tooth profile modification generally means adjusting the addendum. However, tooth profile adjustment can be done by chamfering the tooth surface in order to make an incorrect involute profile on purpose. This adjustment enables the tooth to vault when it gets the load, so it can avoid interfering with the mating gear. This is effective for reducing noise and creating a longer surface life. However, too much adjustment can create bad tooth contact as the result functions the same as a large tooth profile error. An example of this modification is seen in Figure 2.

Crowning is the removal of a slight amount of the tooth from the center of the tooth on outward to the tooth edge, making the tooth surface slightly convex. This method allows the gear to maintain contact in the central region of the tooth and creates an avoidance of edge contact. Crowning should not be larger than necessary, as it will reduce the tooth contact area, thus weakening the gears' strength. End relief is the chamfering of both ends of the tooth surface. An example of these modifications is seen in Figure 3.

In topping, often referred to as top hobbing, the top or tip diameter of the gear is cut simultaneously with the generation of the teeth. This type of gear generation is produced usually when using rack type cutters. An advantage is that there will be no burrs on the tooth top. Also, the tip diameter is highly concentric with the pitch circle.

Semitopping is the chamfering of the tooth's top corner, which is accomplished simultaneously with tooth generation. Figure 4 shows a semitopping cutter and the resultant generated semitopped gear. Such a tooth end prevents corner damage and has no burrs.

The magnitude of semitopping should not go beyond a proper limit; otherwise, it would significantly shorten addendum and contact ratio. Figure 5 shows a recommended magnitude of semitopping. Topping and semitopping are independent modifications but, if desired, can be applied simultaneously.

With each gear pair there is a unique mesh that will provide the optimum result. It may include any or all of the tooth modifications above in order to reach that ideal.

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

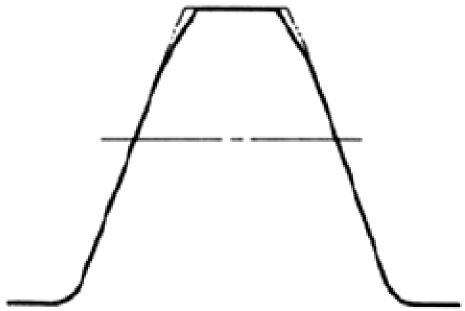


Figure 2: Tooth profile modification.

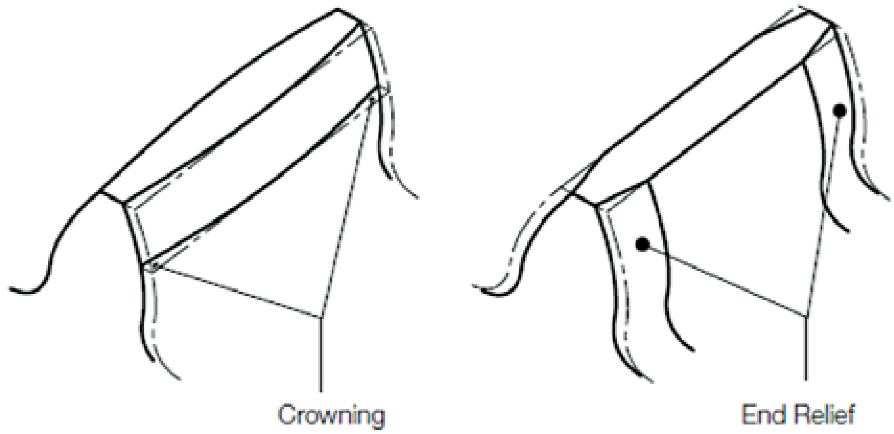


Figure 3: Crowning and end relief.

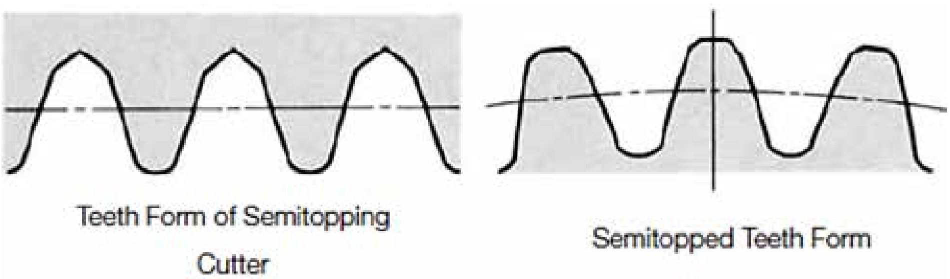


Figure 4: Semitopping cutter and the gear profile.

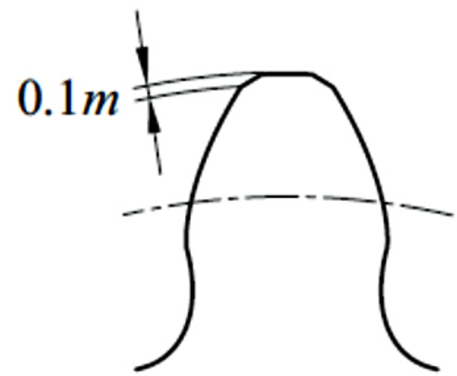
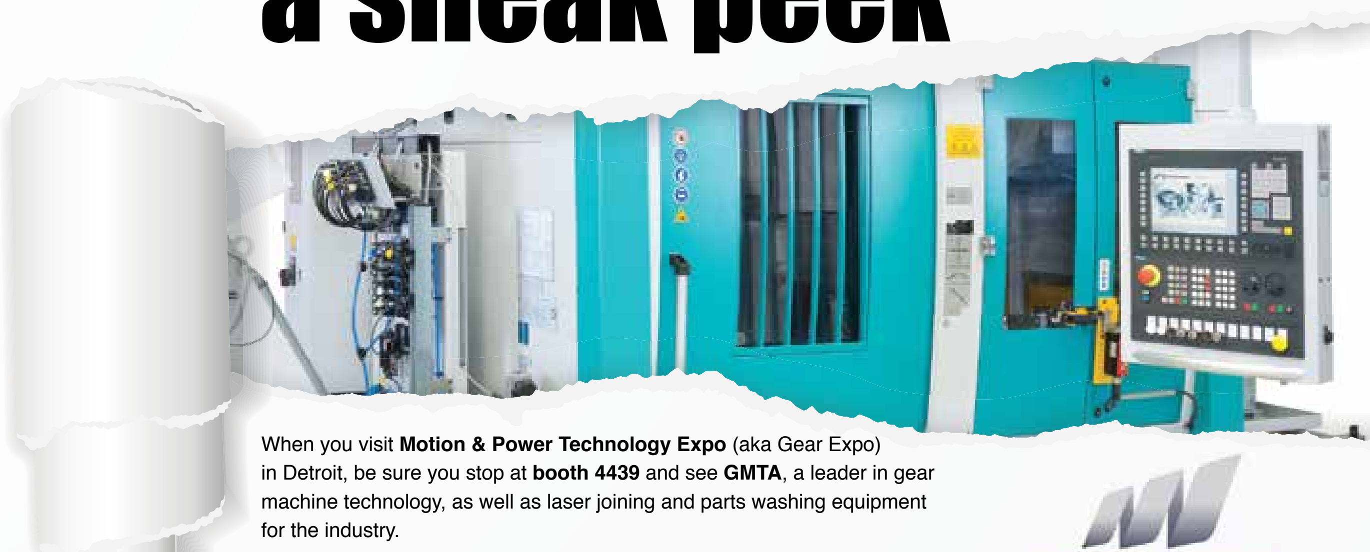


Figure 5: Magnitude of semitopping.

a sneak peek



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