

# Operating Pressure Angle

Email your question—along with your name, job title and company name (if you wish to remain anonymous, no problem) to: [jmcguinn@geartechnology.com](mailto:jmcguinn@geartechnology.com); or submit your question by visiting [geartechnology.com](http://geartechnology.com).

## QUESTION

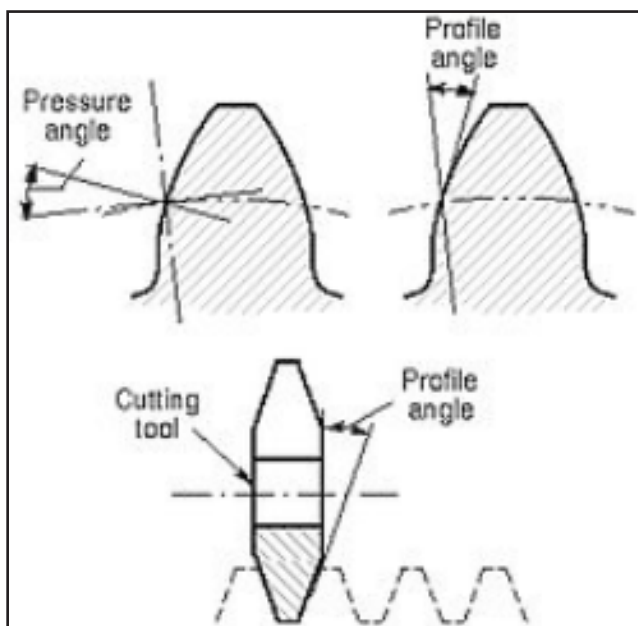
What is the difference between “pressure angle” and “operating” pressure angle?

**Answer provided by John Mayhan, Xtek, Inc.**

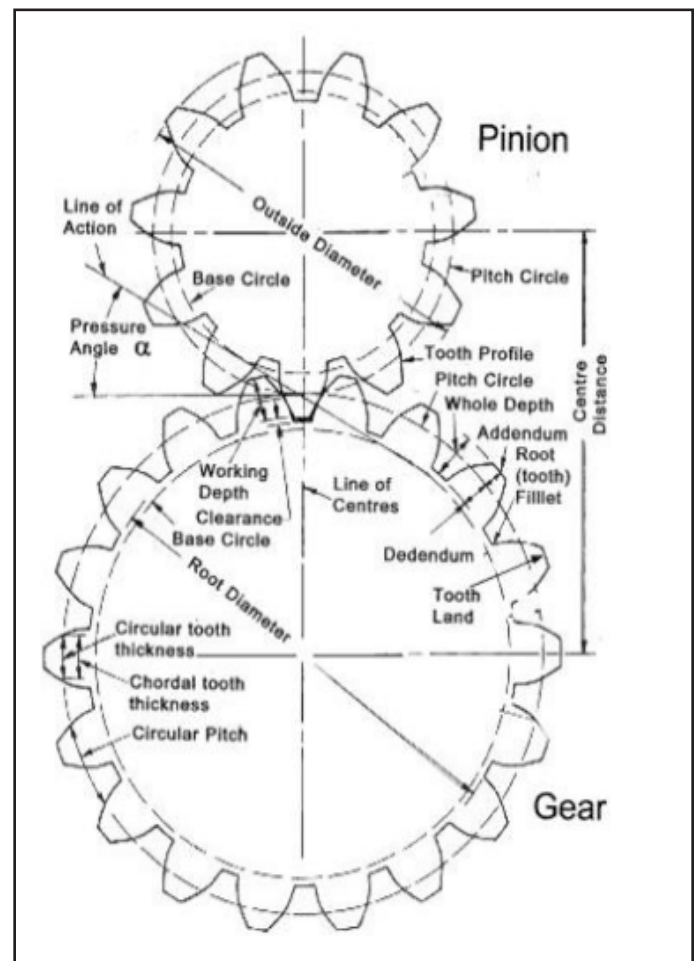
The *pressure angle* of a standard gear is defined as the angle formed by a line tangent to the pitch circle, and the line normal to the tooth profile at the pitch circle. The *profile angle* is defined as the angle formed by the line tangent to the tooth surface, and the line normal to the pitch surface at a *specified* pitch point. The profile angle is determined by the tool used to form the involute curvature of the gear teeth. For a standard gear profile, these angles are equal (Fig. 1).

The *operating* pressure angle is defined as the angle formed by the line tangent to both base circle diameters of the mating gears, and the line normal to their intersecting pitch circles. It is common to design mating gears with base circles that differ from the standard dimensions, and that operate at center distances different from the standard center distance. In these cases the pressure angle generated by the tool will differ from the pressure angle at which the gears will operate (Fig. 2).

**John Mayhan**, vice president, engineering for Xtek Inc.;  
11451 Reading Road; Cincinnati, Ohio 45241;  
Phone: (513) 733-7993.



**Figure 1** Standard gear profile with equal angles (Figures courtesy Xtek, Inc.).

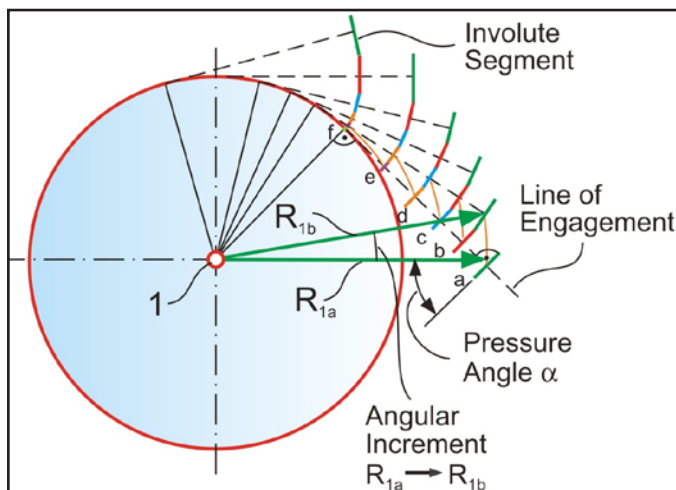


**Figure 2** A pressure angle generated by the tool will differ from the pressure angle at which the gears will operate.



**Answer provided by Dr. Hermann J. Stadtfeld, Gleason Corp.**

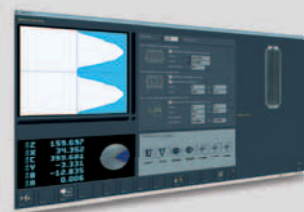
If a cylindrical gear with a certain positive addendum modification is mated with a cylindrical gear having the same amount of negative addendum modification (*V0* gearing), then the center distance will be the same as that of a gear set with no modifications (module times half the sum of pinion and gear teeth). The pitch lines in both cases (no modification or a *V0* profile shift) will be the same, and the pitch diameter is, in both cases, calculated as module times the number of teeth. The relationship between the two pitch diameters (or the pitch radii) is equal to the relationship of the tooth count of the two members (ratio). For involute gearing, the pitch circle is defined from the location, where the two interacting surfaces show no sliding, but pure rolling. This is where the line of engagement intersects the center connecting line, as shown in the involute development in Figure 1.  $R_{1a}$  (Fig. 1) is the pitch radius, and the pressure angle is defined between the orthogonal to the line of engagement and the pitch radius  $R_{1a}$  in the pitch point.



**Figure 1** Line of engagement and pressure angle (Figures courtesy Gleason Corp.).

## A quantum leap for the overall inspection of hob cutters!

The »hobCheck« combines leading ZOLLER measuring technology with the proven user-friendly and worldwide unrivalled software »pilot 3.0«.



Worldwide unrivalled software »pilot 3.0«



»hobCheck«

You want to know more?



[www.zoller-usa.com](http://www.zoller-usa.com)

**ZOLLER**  
expect great measures

If one of the two cylindrical gears has an addendum modification (Fig. 2) and the mate does not, then the center distance changes. It is calculated as module times half the sum of pinion and gear teeth, plus module times  $\times$  (where  $\times$  is the addendum modification factor or profile shift factor). It is interesting that in such a scenario the original pitch circles of the two gears “lose their function.” The interaction of the involutes of two differently profile-shifted gears (not V0 gearing) will lead to a new line of engagement (Fig. 3; red line of engagement for  $a+\Delta a$ ) and a new working pitch point between them where the sliding velocity is zero and the relationship between the radii from the center of the two gears to that point is again equal to the relationship of the tooth count of the two members (ratio).

The new profile dividing line is called the operating pitch line. The pressure angle, which was based on the nominal pitch lines during the manufacturing of the individual gears, can now be determined at the operating pitch line location. In Figure 2, the pressure angle can be found in the pitch point, and the operating (or working) pressure angle is defined in the working pitch point. Figure 3 clearly shows the difference between the two lines of engagement (which is equal to the difference between the pressure angle and the operating pressure angle). The operating pressure angle is more relevant to the gear set’s operating performance and is also required to calculate the bearing forces. The pressure angles of the tools are independent from operating conditions, but reflect the nominal pressure angles.

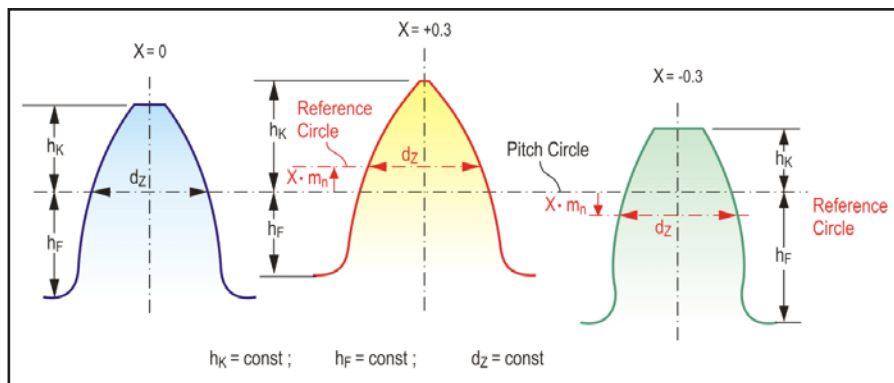


Figure 2 Principle of addendum modification (or profile shift X).

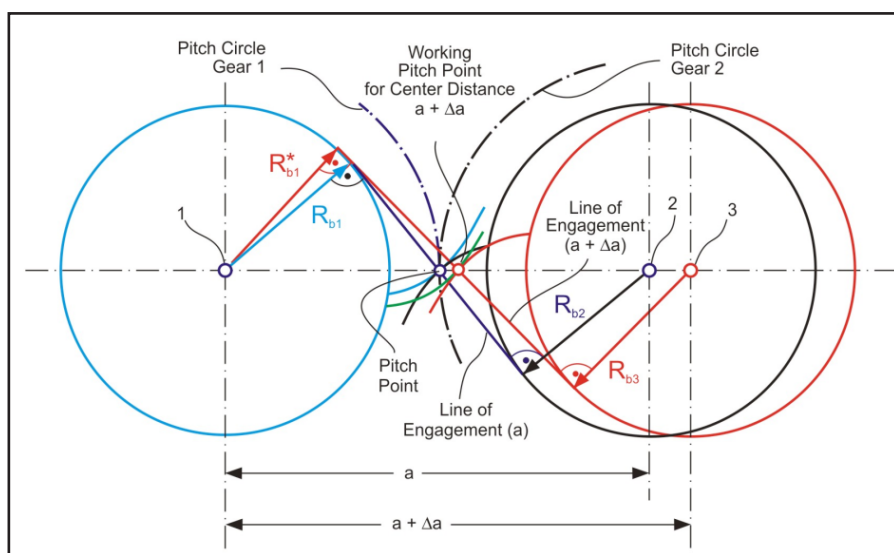
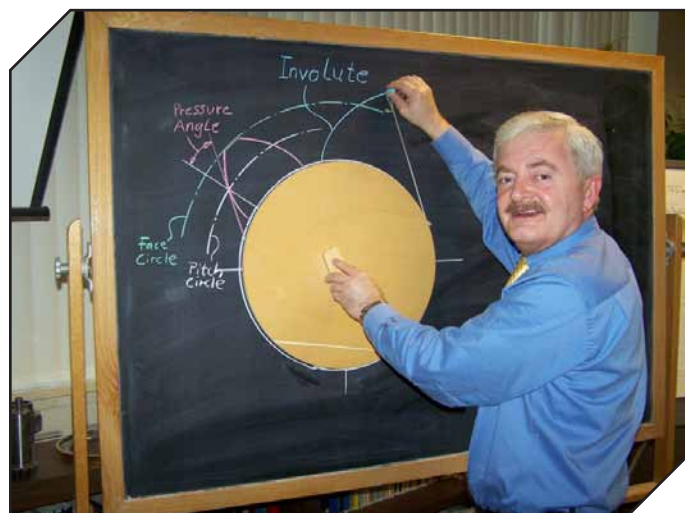


Figure 3 Pitch point and working pitch point after center distance change.

**Dr. Stadtfeld** is Gleason Corp. vice president, bevel gear technology, R&D



Dr. Hermann “The Expert” Stadtfeld, drawing involute and pitch line.

For Related Articles Search  
 pressure angle  
 at [www.geartechnology.com](http://www.geartechnology.com)