

GEAR HEEL PITCH DIAMETER.

On bevel gears the pitch diameter is commonly calculated on heel (larger side of the bevel tooth). The pitch diameter can not be measured. It is a theoretical number that is used for gear design. Commonly the pitch diameter (PD) is calculated by the formula: $PD = m * z$, m – transversal module, z – number of teeth. Note that transversal module (m) is not the same along the tooth on a bevel gear. Transversal module on the heel should be used for calculation of the gear heel pitch diameter. Often, the gear drawing provides the heel pitch diameter. However, the module is often given in normal to the tooth spiral. It is called normal module. Transversal module can be calculated from normal module and spiral angle. But finding a spiral angle on the heel is often not easy from the drawing.

The best way to calculate the pitch diameter on the heel would be to solve the triangle of the cone distance and the pitch angle. The gear heel pitch diameter will be: $PD = 2 * (\text{cone distance}) * \sin(\text{gear pitch angle})$.

If the back cone line of the tooth heel is not perpendicular to the pitch cone line the CAD surface of the tooth should be made little longer so it covers the entire length of the tooth. But, if larger pitch diameter is used the GEAR FACE WIDTH needs to be increased so the middle of the tooth remains in the same location. The software calculates the spiral angle in the middle of the tooth. For correct calculation, the middle of the tooth length in the software input has to be in the same location that on the gear drawing.

RATIO

The ratio does not need to be correct on the Step 1. It is only used to recommend the number of teeth on Step 3.

HAND OF SPIRAL

Input the hand of spiral on the gear. It will be “LEFT” or “RIGHT”. The hand of pinion spiral is opposite to the gear hand of spiral. Input the hand of the gear spiral.

GEAR FACE WIDTH

This is the length of the tooth measured in projection to the axial section of the gear. It is common to call out the face width on gear drawings. Often, the root of the tooth has larger width compare to the tip of the tooth and it is different from the face width on the pitch cone. Input the face width so it covers entire tooth or even longer. Note that the software will calculate the spiral angle in the middle of the face width entered.

Practically, extend the face width (from the drawing) for equal amount in both directions (to the heel and to the toe) in order to cover entire tooth.

PRESSURE ANGLE

Input the pressure angle in normal section to the tooth line. It is often 20 degrees. But 22.5 degrees is common on automotive gears. If the number of teeth is under 15 it is better to reduce the pressure angle in order to reduce the undercut on the pinion toe root.

In addition of increasing the pressure angle the undercut can be reduced by increasing of spiral angle or/and increasing of “GEAR COEFFICIENT OF ADDENDUM”.

GEAR TRANSVERSAL TOOTH THICKNESS ON HEEL

This is a circular length of the arc from one side of the tooth to the opposite side in transversal section on the heel. Gear drawings often give normal tooth thickness. In order to calculate the circular transversal thickness the spiral angle and the curvature of the pitch diameter has to be taken into account. The spiral angle is not constant along the tooth of a spiral bevel gear. When calculating the transversal tooth thickness on the heel the spiral angle on the heel should be used. (Chordal tooth thickness) = (normal tooth thickness) / $\cos(\text{spiral angle})$. (Circular tooth thickness on pitch diameter) = (pitch diameter) + $\arctan((\text{chordal tooth thickness})/(\text{pitch diameter}))$.

If it seems difficult to calculate it with formulas one can check the tooth thickness on the first 3d CAD model (not exact tooth thickness) and then correct the input if needed for the second and correct iteration.

ANGULAR BACKLASH ON GEAR

The backlash is input as an angle in order to avoid confusion. Often the spiral bevel gear drawings call out for the normal backlash on heel. On some drawings “normal” means normal to the tooth surface, on other drawings “normal may mean normal to the tooth line. The correct calculation of the angular backlash requires correct calculation of the pressure and spiral angles on the heel. Note that both, the pressure and the spiral angle on the heel are different from the drawing call out of the mean value on the middle of the tooth. The program suggested value for the backlash will work for most designs. When gear and pinion 3d CAD models are completed they should be assembled in 3d CAD in order to verify the backlash. Then the backlash can be corrected during the second iteration.

GEAR COEFFICIENT OF ADDENDUM

(Gear coefficient of addendum) = (gear addendum on heel) / (normal module). Often, the gear coefficient of addendum = 1. If the mating pinion has low quantity of teeth (<15) the gear coefficient of addendum will often be higher in order to avoid undercut on the pinion root. If the gear drawing does not call out for the addendum the addendum can be calculated from the drawing. The addendum is the normal distance from the tip of the tooth on the heel to the pitch cone.

COEFFICIENT OF TOOTH HEIGHT

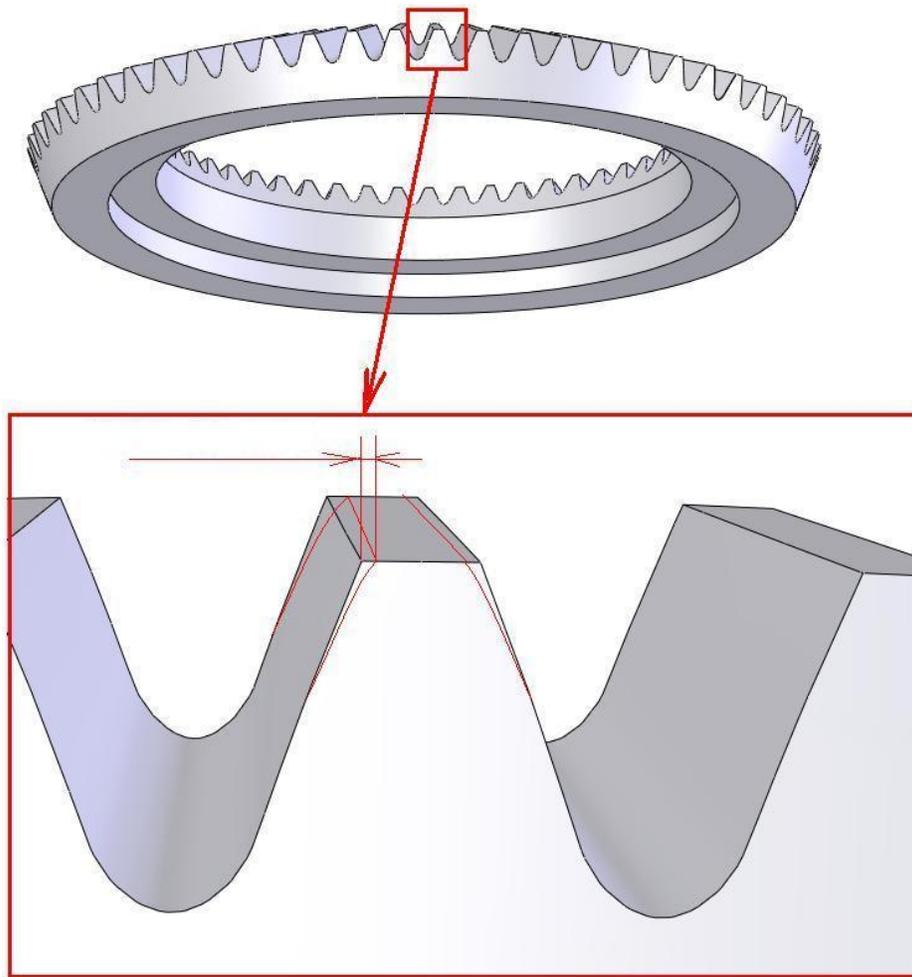
(Coefficient of tooth height) = (tooth height on heel) / (normal module)

The best way to find the tooth height is the drawing of the gear and the pinion. Draw the pinion on the gear drawing as it was in assembly. Add clearance on the root of the tooth. The clearance is often equals 0.25 (or 2.0 or 1.8) * (normal module).

SPIRAL TOOTH GENERATING DIAMETER

Traditionally, spiral bevel gear teeth are cut by a circular cutter. In general machining it may call a “fly cutter”. But the gear cutter has, not one, but many blades attached to a disc cutter head. The distance from the cutter to the axis of the tool rotation determines the curvature of the tooth line on the finished gear. Normally the gear design drawing does not specify the tool diameter. Because the traditional cutting tools are expensive, the drawing, often, allows the manufacturer to use an existing cutter head. CNC milling of gears requires a different cutting tool. The spiral tooth generating diameter does not apply to the CNC milling, but it still needs to be entered into the calculation in order to produce more or less curved tooth. The smaller the generating diameter the more curved the finished tooth will be.

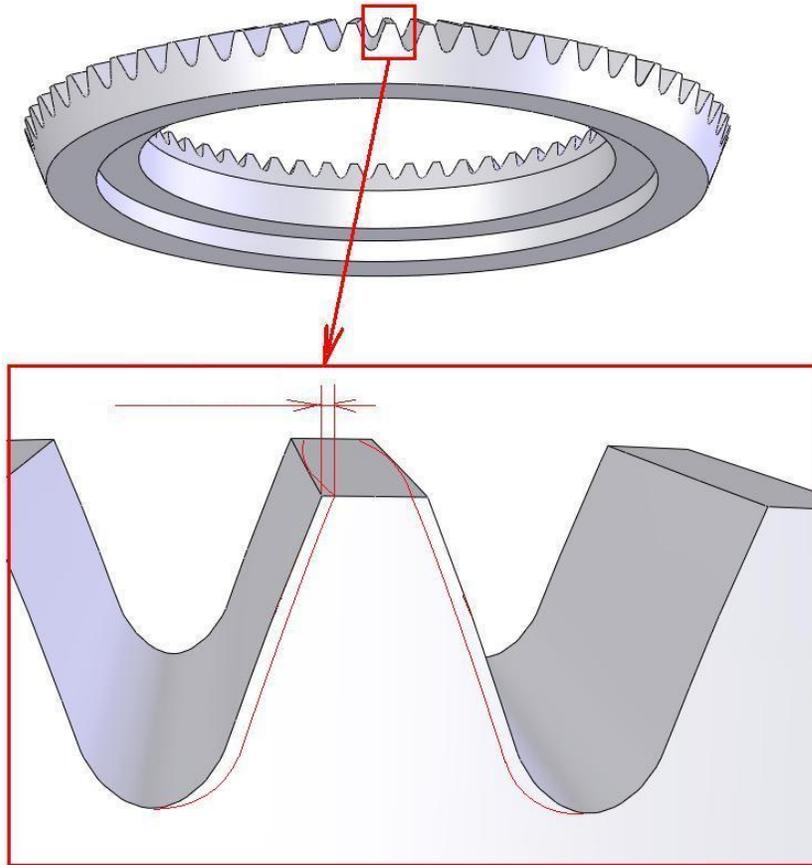
PROFILE CROWNING



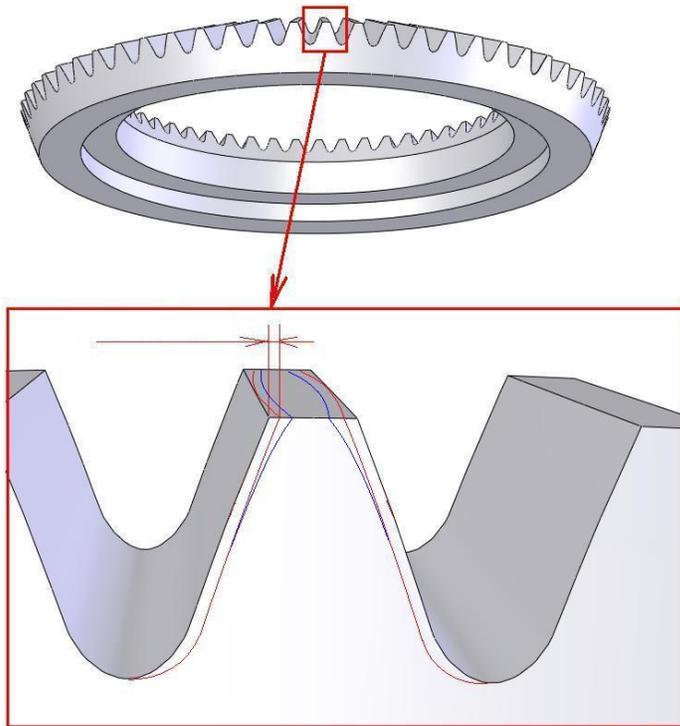
Profile crowning is used together with LEAD CROWNING in order to localize the tooth contact pattern. The localized tooth contact pattern reduced sensitivity of the gear set for assembly errors. Higher crowning allows more errors in assembly but reduces the life of

the gear. The program adds the crowning on the tip of both members: the gear and the pinion.

LEAD CROWNING



Lead crowning is used with profile crowning for reduction of sensitivity for misalignments and other errors. But more crowning reduces the gear life. Picture below shows both: lead and profile crowning.



NUMBER OF STARTS ON GENERATING TOOL

This is applied only for gears that are traditionally machined by face hobbing method and commonly known as Klingelnberg gears. A traditional Klingelnberg cutter has three or more cutter groups (starts) on a round cutter head. Each start cuts a different slot on the gear. Depending on the number of the groups the curvature of the tool line will be different. Fewer starts produce more curved tooth line on the toe, which may be beneficial on pinions with number of teeth under 15 in order to avoid undercut on the root. Because the difference is very minor the number of the starts is not as important as the previously described the diameter of the generating tool.