Gear Macrogeometry

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

QUESTION #1

I have outsourced gear macrogeometry due to lack of resources. Now I received the output from them and one of the gears is with −0.8× module correction factor for m = 1.8 mm gear. Since bending root stress and specific slide is at par with specification, but negative correction factor −0.8× module — is quite high — how will it influence NVH behavior/transmission error? SAP and TIF are very close to 0.05 mm; how will that influence the manufacturing/cost?

Expert response provided by Chuck Schultz, P.E.

Taking your last question first: SAP (Start of Active Profile) and TIF (True Involute Form) are essentially different names for the same gear feature. The formulas used vary slightly, but it would be surprising if the results were too far apart. This shouldn't affect manufacturing cost as long as the cutting tool used is designed to keep the top of the root fillet and undercut below the TIF/SAP diameter.

It is very difficult to predict NVH results from gear geometry alone. That said, rack offset coefficient influences Profile Contact Ratio (*Mp*), which has a huge influence on the smoothness of power transmission. Higher *Mp* tends to give smoother transmission, as does lower pressure angle and higher Face Contact Ratio (*Mf*) in helical gears. Without knowing the specifics of your gearset, we cannot calculate *Mp* or *Mf*.

Rack offset coefficients (X1 and X2) can be higher than 1.0 and lower than -1.0, and still provide smooth running gears. Kiralla (Fig. 1) felt having all recess action (X1 = 1.0 and X2 -1.0) provided great benefits but most designers try to keep X1 less than or equal to .50, with a corresponding X2 of greater than -.50 (Fig. 3). The involute curve allows for conjugate action over the full range of 1.0 to -1.0, so your -.80 for X2 (Fig. 2) is extreme to some eyes but nothing unusual for others.

Some basic reminders on rack offset coefficient:

- As X increases, the operating pressure angle increases
- On "standard centers" the summation of X1 and X2 is zero (Fig. 5)
- If both X1 and X2 are positive, the operating centers will be larger than standard

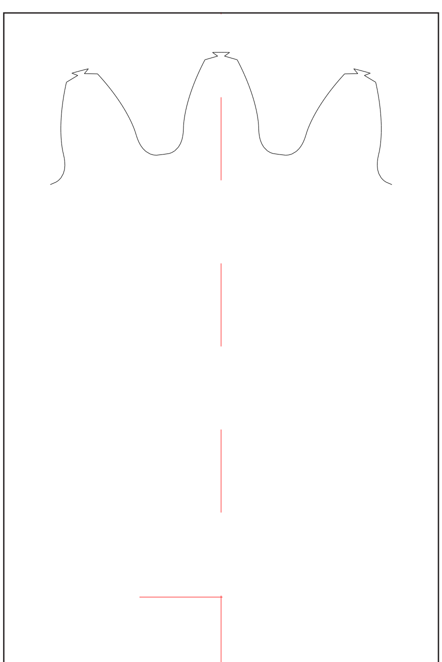

Figure 1 1×24.d×f is x1=1.0/x2=-1.0 — as Kiralla advises.

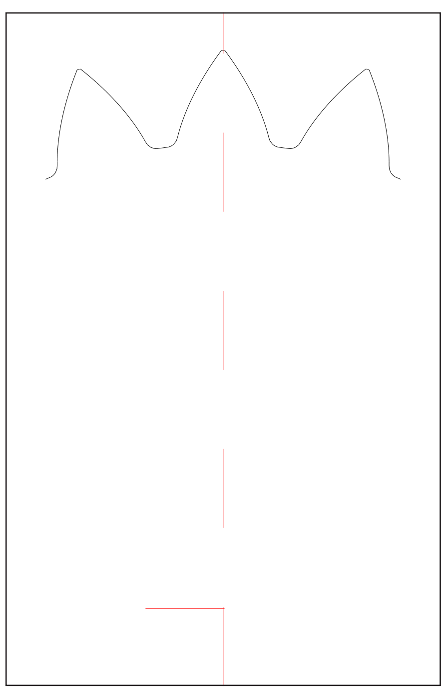

Figure 2 × 824.d×f is x1=.8/x2=-.8 — as Reader question has.

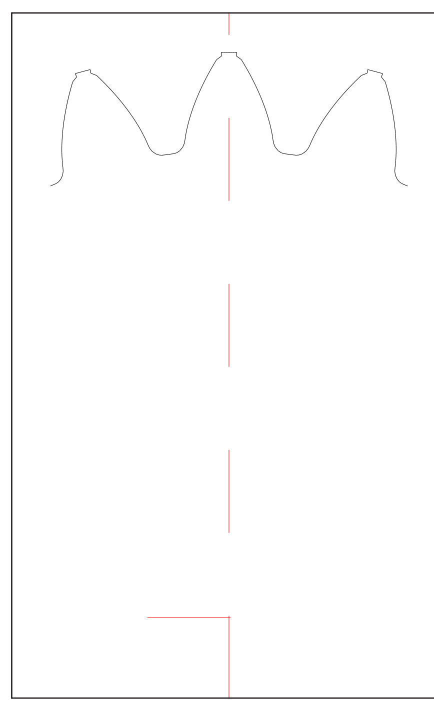

Figure 3 5×24, d×f is x1= .5/x2=- .5 — the "acceptable limit" for most designers.

- If both X1 and X2 are negative, the operating centers will be smaller than standard
- Pressure angle increases with higher X values and drops with negative X values

Gear Technology has published many papers on rack offset theory over the years that can be accessed from the website. It never hurts to ask your gear designer to explain the decisionmaking process that produced the final geometry. There is seldom only one "right" answer when it comes to gear design. This is part of what makes the trade so interesting and at the same time frustrating. Experience can help get to an acceptable solution faster, but it can also blind us to potential improvements available from a different approach.

Many companies have a general recipe that they follow in designing gearsets that gives them good results in a minimum design time with few potential risks. Sometimes these recipes are not completely understood legacies of a different time and different conditions. An example I recall is a colleague who insisted helical gears should never have helix angles over 20 degrees. Pressed for a scientific reason why, he reviewed all his reference materials and never found it written down anywhere. Perhaps it was related to bearing life, he decided. When shown that acceptable bearing life could be obtained with higher helix angles (Fig. 4), he removed the 20 degree limit from the "old family recipe." (**Chuck Schultz** is a *Gear Technology* technical editor and owner of Beyta Gear Service — *chuck@beytagear.com*.)

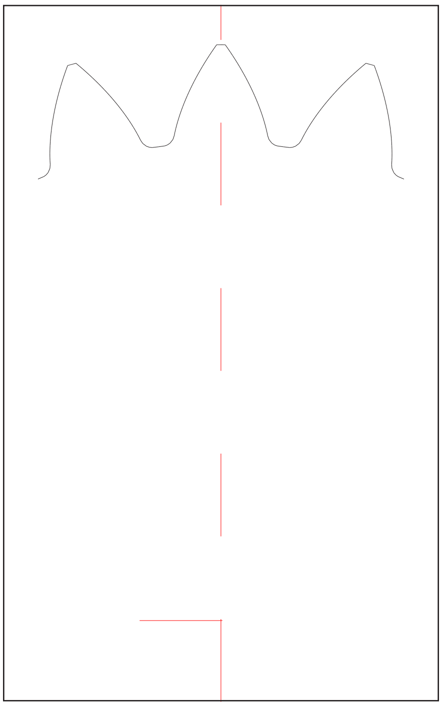

Figure 4 25×24.d×f is ×1=.25/×2= - .25 — or the conservative engineer limit.

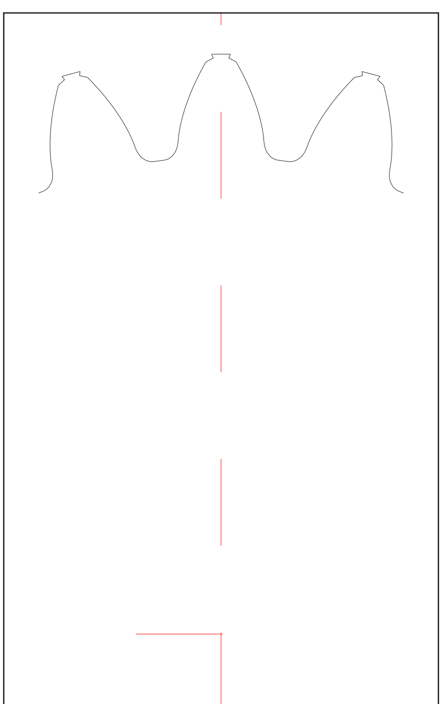

Figure 5 24 spur gear. d×f is x1=x2=0 — "standard" geometry.

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Liebherr/Barber Colman Hob Settings

QUESTION #2

I would like some instructions for setting the degrees and minutes on a Liebherr or Barber Colman hob. Our machines use a Vernier scale to match the lead angle of the cutter to the part to form straight teeth. There is a dispute on how to do this task, and I wanted insight from another professional.

Expert response provided by Hans Grass, vice president, Machine Tool Group, Star SU LLC.

Regardless of what model and brand of hobbing machine, the hob head angle is set to the same angle as the lead angle of the hob for spur gears. In other words, the angular position of the hob head is adjusted to line up the lead of the hob to be parallel to the axis of the work.

For example: for an RH hob, and the hob head is on the LH side of the work spindle for a vertical hobbing machine, the hob head angle is set CW from zero, looking from the center of the work spindle towards the hob head. This is the best definition without knowledge of the plus/minus marking of the Vernier scale, depending on the manufacturer of the machine.

Helical gear example: For an RH helix angle of the workpiece, the hob head angle is set to a CCW angle equal to the helix angle minus the hob lead angle for the above mentioned hob head arrangement and definition of rotational direction.

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Hans Grass, vice president, Machine Tool Group, Star SU LLC