Using Hobs for Skiving; A Pre-Finish and Finishing Solution

William E. McElroy

Our company manufactures a range of hardened and ground gears. We are looking into using skiving as part of our finishing process on gears in the 4-12 module range made from 17CrNiMO6 material and hardened to between 58 and 62 Rc. Can you tell us more about this process?

Bill McElroy replies: Skiving is basically a process which allows one to cut hardened materials with a thin, curled chip and produce a smooth finish. It is a method of finishing or pre-finishing hardened gears which may be more cost-effective than grinding. It can be used on spur or helical gears heat treated to between 50 and 62 Rc. Skiving improves gear quality by reducing errors from distortion. Moreover, compared to grinding, skiving (as a continuous generating process) can eliminate most cumulative spacing and concentricity errors. Quality levels of up to AGMA 11 can be achieved with skiving. In addition, for large DP gears (coarser than five), taking into account distortion, etc., skiving can reduce grind times by 50-70%.

Skiving can be done on conventional hobbing machines, however, the quality is totally dependent on machine rigidity, both static and dynamic. Newer machines which offer better machine rigidity, CNC controls to regulate feeds, speeds, and shifting, better chip removal, and better quality cutting tools are a better prospect for use in skiving.

Types of Skiving Hobs

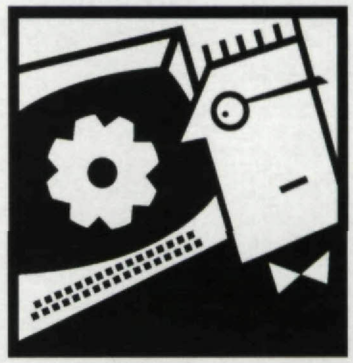
Depending on circumstances, one of four types of hobs can be used for skiving. Solid carbide hobs are used for small modules (fine DPs) or for gears with a specified outside diameter. Inserted blade hobs with brazed tips are very economical, reducing hob costs while providing excellent quality. Solid hobs with brazed tips are also economical and should be used for applications with big modules (large DPs). Inserted carbide blade hobs have the advantage of increased tool life, based on their usable length. They can also improve the quality of the surface of the tooth flank.

Negative Rake Angle

When skiving it is important to use the hob to cut only on the involute profile of a gear, not into the root fillet area.

The negative rake angle of a skiving hob reduces the cutting force and shock resistance, as well as the vibration in the hobbing operation. Because of this angle, the cutting becomes easier, since the tool gradually penetrates into the gear.

Generally speaking, the rake angles vary between -15° and -30°, depending



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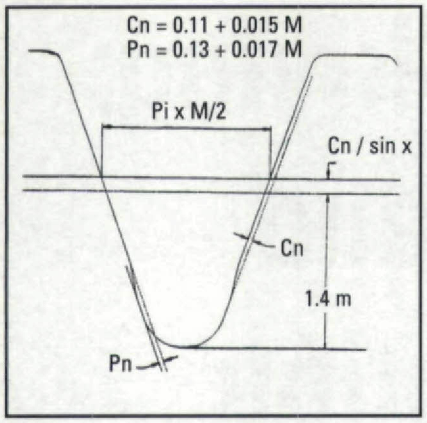

Fig. 1

on the tool geometry and module (DP).

The sharpening of the tool should be done with a diamond dressing wheel and coolant. The position of the dressing wheel will be determined by the value of the rake angle and skiving hob outside diameter. Table 1 shows the dressing wheel positions for resharpening all through the tool life.

Tool Reference Profile

The skiving process requires that some prior hobbing conditions be met. The pre-skiving operation, before heat treatment, should be done with a hob which has a protuberance on the tip of the tooth and with an addendum of 1.3 to 1.4 times the module, in such a way that an under-cutting at the bottom of the gear tooth is produced, avoiding any work on the tip of the skiving tool that would cause it to chip or break. (See Fig. 1.)

The skiving hob only removes the excess stock on the tooth flanks, thus reducing the cutting forces and guaranteeing a better finishing quality.

The cutting force generated during the skiving operation is 15-20% of that generated from normal gear hobbing operations.

Carbide Grade Quality

The selection of suitable carbide grade depends on the application of the skiving operation. The most useful grades are the cementation steels with hardness of 90-92 HRc. (See Table 2.) In our experience, the most used grades are K10 and M10. The K10 grade is the most universal one, due to its great tensile strength. The M10 has less ten-

sile strength, but more wear resistance.

For a cutting oil, it is best to use one of low viscosity, 10-20 cst for 40° as coolant, if possible with a molybdenum additive. Dry (no coolant) cutting is also possible.

Speeds and Feeds

Tables 3-5 allow you to calculate the speeds and feeds needed to skive a variety of gears. The data is based on test results from hobs actually in use. They provide basic parameters, which will have to be altered to suit the particular conditions at the time of skiving.

A number of points should be kept in mind when skiving.

- The higher the feed rate, the less the wear.
- It is absolutely necessary to remove the same amount of material from

Table I - Hob Sharpening Data

Part No.: HM.V22/12 — Hob S/N: 2950

Tip
dk 48.300
DESPX -8.550
hr 2.000

h : 2.950
EPS : -20° 44'04"
ST : 4.70

Number of Resharpenings	Outside Diameter dk mm	S	DESP X mm	Angle EPS
1	48.300	0.000	-8.5500	-20.734 (-20° 44' 04")
2	48.100	0.551	-8.5024	-20.703 (-20° 42' 12")
3	47.900	0.548	-8.4572	-20.678 (-20° 40' 12")
4	47.700	0.544	-8.4146	-20.659 (-20° 39' 34")
5	47.500	0.541	-8.3744	-20.647 (-20° 38' 48")
6	47.300	0.538	-8.3366	-20.640 (-20° 38' 25")
7	47.100	0.534	-8.3012	-20.640 (-20° 38' 24")
8	46.900	0.531	-8.2683	-20.646 (-20° 38' 46")
9	46.700	0.527	-8.2379	-20.659 (-20° 39' 31")
10	46.500	0.524	-8.2099	-20.678 (-20° 40' 41")

Table II - Carbide Composition

ISO	Rockwell Hardness	Deflection Resistence	W	Co	Ti	Ta	C
P20	90	90	60 83	5 10	5 15	0 15	6 9
M10	91.5	100	70 86	4 9	3 11	0 11	6 8
M15	89.5 93	120 220	75 95	5 9	0 10	0 12	5 7
K05	89 93	150 230	85 97	3 8	0 3	0 7	5 7
K10	90.5	120	84 90	4 7	0 1	0 2	5 6

Table III

Feed Module (DP)	Rough mm (in)	Finish mm (in)
> 12 [< 2]	3 - 4mm/rev (.120 - .160"/rev)	2 - 3 mm/rev (.080 - .120"/rev)
> 12 [< 2]	2 - 3.5mm/rev (.008 - .140"/rev)	1.5 - 2.5mm/rev (.060 - .100"rev)

Table IV

Hardness HCR	Speed mm/min (in/min)
50-55	70 + 90 (220 - 290)
55-60	60 + 70 (190 - 220)
60-65	50 + 60 (160 - 190)

Table V

Module DP	Speed mm/min (in/min)
1 + 5 (5 - 25)	60 + 90 (190 - 290)
6 + 12 (2 - 4)	50 + 70 (160 - 220)
> 12 (< 2)	30 + 50 (96 - 160)

both flanks. The hob *must* be centered to the workpiece.

- The cutting speed will depend on the machine running condition, workpiece hardness (HRc) and module (DP).
- The cutting speed range should be between 30-90m/min (90-290 ft/min).
- Flank wear can be reduced by decreasing the cutting speed.
- The number of passes (1 or 2) will depend on workpiece heat-treat distortion and the quality required.
- Climb hobbing is the recommended method for less wear.
- Use plenty of coolant (cutting oil), even though the work can be done without coolant (dry), since the generated temperature is low.
- TiN coating offers higher wear resistance.
- The stock material to be removed by the skiving hob should be 0.11-0.15mm (.0044-.0060") per flank. It could be as much as 1mm (.040") in case of major heat-treat distortions. In those circumstances multiple cuts will be required.

Hob RPM Calculations

The hob rpm calculations are performed as follows:

Given that 1m = 3.281 feet and that the recommended speed is between 30-90m/min,

30M x 3.281 = 98 feet/minute
90M x 3.281 = 295 feet/minute

The relationship between hob diameter (if in inches, convert to feet) and circumferential distance is calculated as follows:

12" OD x (3.14) = 37.68"
12" = 3.14'
(If in feet, multiply by 3.14 ONLY)

To calculate the RPM:

$$\text{RPM} = \frac{98 \text{ ft/min.}}{3.14 \text{ ft}} = 31 \text{ low end}$$

$$\text{RPM} = \frac{295 \text{ ft./min.}}{3.14 \text{ ft.}} = 94 \text{ high end}$$

Feed rate/revolution = 1.5mm to 3mm
= .060" to .120" ■