Hobs & Form Relieved Cutters: Common Sharpening Problems

Pfauter-Maag Cutting Tools, L.P.

Fig. 1 shows the effects of positive and negative rake on finished gear teeth. Incorrect positive rake (A) increase the depth and decreases the pressure angle on the hob tooth. The resulting gear tooth is thick at the top and thin at the bottom. Incorrect negative rake (B) decreases the depth and increases the pressure angle. This results in a cutting drag and makes the gear tooth thin at the top and thick at the bottom

In order to maintain correct tooth form, hobs and formed cutters must be resharpened with correct flute alignment (Fig. 2). Straight flutes should be sharpened parallel with the work axis and helical gashes should be sharpened with the correct lead. Gears cut by a hob with a flute lead error will not have the correct involute form. The teeth are unsymmetrical, each side of the teeth having a different pressure angle. The teeth are said to be "leaning" or have "cross bearing."

If the hob or cutter is not mounted true on the arbor, runout will result, and unequal amounts of stock will be ground from the faces of the teeth. Therefore, before sharpening and after the hob has been mounted on the machine, always check the hobs for runout. Runout produces errors and causes unsymmetrical profiles in the cut gear. Three forms of runout are shown in Fig. 3.

Runout can result from either a dirty and/or burred center, loose fit on the arbor or a sprung arbor. It could also be caused by machine misalignment, a worn index plate or pawls, a glazed wheel or improper finishing procedures.

Hobs sharpened with unequally spaced flutes have high and low teeth, which will produce unequal generating flats on the gear tooth as indicated in Fig. 4. High teeth (B) will produce low flats or hollows; low teeth (A) will cause high spots or bumps.

Fig. 5 shows gear tooth forms produced with correctly sharpened hobs and resulting teeth when errors are introduced into the sharpening of the same hobs.

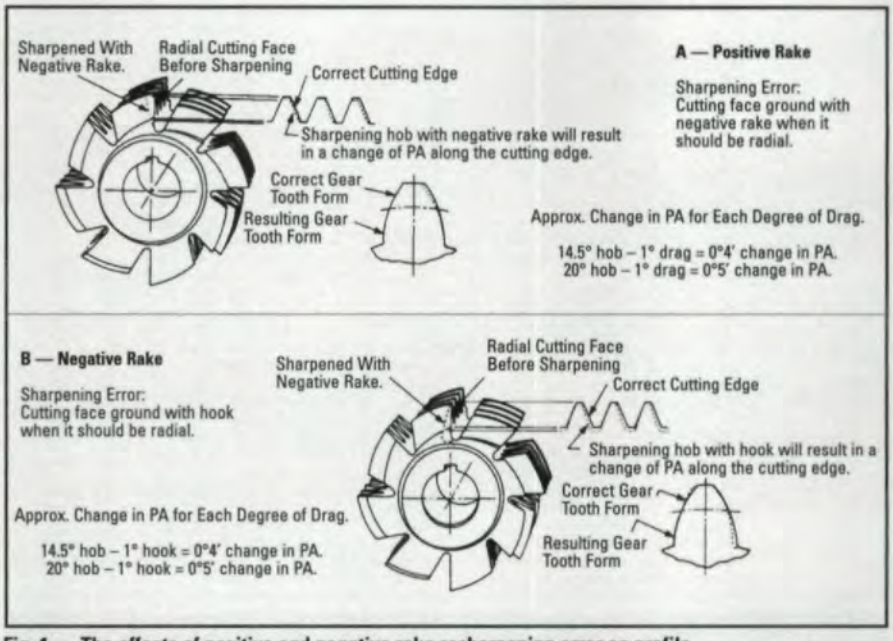

Fig. 1 — The effects of positive and negative rake resharpening error on profile.

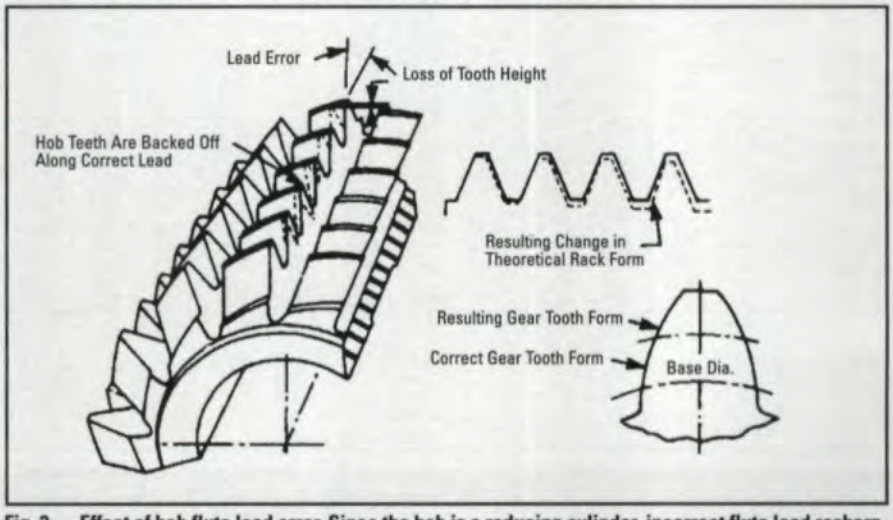

Fig. 2 — Effect of hob flute lead error. Since the hob is a reducing cylinder, incorrect flute lead resharpening destroys the integrity of the hob cylinder end to end, typically causing changes in workpiece size as the hob is shifted across its length.

Pfauter-Maag Cutting Tools, L.P.,
Loves Park, IL, is a leading manufacturer of cutting tools for gear manufacturing.

Table I — Common Sharpening Problems

Problem	Cause	Correction
Worn Index	Worn index plate or latch.	Replace worn item.
	Loose index plate.	Tighten retaining nut.
	Centers (work holding) misaligned.	Align centers.
Incorrect Radial Position and Rake Offset	Diamond positioned incorrectly.	Reposition diamond.
	Dull diamond.	Turn or replace diamond.
	Incorrect wheel position.	Reposition wheel.
	Excessive feed or wheel breakdown.	Reduce feed and dress wheel.
	Work eccentric or loose on arbor.	True between neutral centers on proper sized arbor. Do not use shims.
	Dirt on faces of collars and nut or in centers.	Clean faces and centers.
	Faces of collar and nut not parallel.	Grind faces parallel.
	Worn index plate or latch.	Replace worn item.
	Loose index plate.	Tighten retaining nut.
	Centers (work holding) misaligned.	Align centers.
Curved or Stepped Flute	Incomplete wheel dressing	Dress wheel and be sure diamond traverses entire cone face.
	Wheel not properly lowered into flute.	Lower wheel.
	Excessive feed or wheel breakdown.	Reduce feed and dress wheel.
	Wheel head swivelled incorrectly.	Set wheel head at proper helix angle.
Incorrect Lead	Tangent bar set incorrectly or not clamped.	Reset and clamp.
	Wheel "sings."	Dress with sharp diamond or faster traverse.
	Excessive table speed.	Reduce speed.
	Work eccentric or loose on arbor.	True between neutral centers on proper sized arbor. Do not use shims.
	Dirt on faces of collars and nut or in centers.	Clean faces and centers.
	Faces of collar and nut not parallel.	*Grind faces parallel.*
	Worn index plate or latch.	Replace worn item.
	Loose index plate.	Tighten retaining nut.
	Centers (work holding) misaligned.	Align centers.
Index Errors	Work arbor incorrectly tensioned between centers.	Tension correctly.
	Excessive feed or wheel breakdown.	Reduce feed and dress wheel.
	Wheel "sings."	Dress with sharp diamond, one pass only.
	Feeding at same flute each revolution.	Change feed cam setting.
	Work eccentric or loose on arbor.	True between neutral centers on proper sized arbor. Do not use shims.
	Dirt on faces of collars and nut or in centers.	Clean faces and centers.
	Face of collar and nut not parallel.	Grind faces parallel.
Burned Teeth	Improper coolant action.	Increase flow, redirect flow or change to different coolant.
	Glazed wheel.	Turn or replace diamond.
	Excessive feed.	Reduce feed.
	Insufficient table speed.	Increase speed.
	Sparking out too long.	Reduce number of revolutions of sparkout.
Rough Finish	Dressing too rapidly.	Dress wheel more slowly
	Wheel is too soft.	Use harder wheel.
	Excessive feed or wheel breakdown.	Reduce feed and dress wheel.
	Excessive table speed.	Reduce table speed.

Table II — Gear Hob Sharpening Tolerances—Total Indicator Reading

		Normal Diametral Pitch										
	Class	1–1.999	2–2.999	3–3.999	4–4.999	5–5.999	6–8.999	9–12.999	13–19.999	20–29.999	30–50.999	51 and finer
Spacing Between Adjacent Flutes	AA			.0020	.0015	.0010	.0008	.0008	.0006	.0006	.0006	.0006
	A	.0040	.0030	.0025	.0020	.0015	.0010	.0010	.0010	.0010	.0010	.0010
	B	.0050	.0045	.0040	.0030	.0020	.0015	.0015	.0010	.0010	.0010	.0010
	C	.0050	.0045	.0040	.0030	.0020	.0015	.0015	.0010	.0010	.0010	.0010
	D	.0060	.0060	.0050	.0050	.0030	.0025	.0025	.0020	.0017	.0017	.0015
Spacing Between Non-Adjacent Flutes	AA			.0040	.0035	.0025	.0015	.0015	.0015	.0015	.0015	.0015
	A	.0080	.0060	.0050	.0040	.0030	.0030	.0030	.0025	.0025	.0020	.0020
	B	.0010	.0090	.0080	.0060	.0050	.0050	.0050	.0040	.0035	.0030	.0025
	C	.0010	.0090	.0080	.0060	.0050	.0050	.0050	.0040	.0035	.0030	.0030
	D	.0120	.0120	.0100	.0100	.0080	.0080	.0070	.0060	.0050	.0040	.0035
Cutting Faces Radial to Cutting Depth	AA			.0010	.0008	.0006	.0005	.0005	.0003	.0003	.0003	.0003
	A	.0030	.0015	.0010	.0008	.0006	.0005	.0005	.0003	.0003	.0003	.0003
	B	.0050	.0025	.0015	.0010	.0008	.0007	.0007	.0005	.0005	.0005	.0005
	C	.0050	.0025	.0015	.0010	.0008	.0007	.0007	.0005	.0005	.0005	.0005
	D	.0100	.0075	.0050	.0040	.0020	.0020	.0020	.0015	.0015	.0010	.0010

	Face Width				
Class	0–1"	1–2"	2–4"	4–7"	7" and up
AA	.0008	.0010	.0015	.0020	.0020
A	.0010	.0015	.0025	.0030	.0050
B	.0010	.0015	.0025	.0030	.0050
C	.0010	.0015	.0025	.0030	.0050
D	.0015	.0023	.0038	.0045	.0075

Accuracy of Flutes Straight and Helical

Table III — Effect of Sharpening Spacing Errors*

12° Cam Clear**		Lead Error Pressure Angle				
Sharpening Error	O.D. Runout	14 1/2°	20°	25°	30°	45°
.0005	.000106	.000027	.000039	.000049	.000061	.000106
.00075	.000159	.000041	.000058	.000074	.000092	.000159
.0010	.000213	.000055	.000078	.000099	.000123	.000213
.00125	.000268	.000069	.000098	.000125	.000155	.000268
.0015	.000319	.000082	.000116	.000149	.000184	.000319
.00175	.000372	.000096	.000135	.000173	.000215	.000372
.0020	.000425	.000110	.000155	.000198	.000245	.000425
.00225	.000478	.000124	.000174	.000223	.000276	.000478
.0025	.000531	.000137	.000193	.000248	.000307	.000531
.00275	.000585	.000151	.000213	.000273	.000338	.000585
.0030	.000638	.000165	.000232	.000298	.000368	.000638
.00325	.000691	.000179	.000252	.000322	.000399	.000691
.0035	.000744	.000192	.000271	.000347	.000430	.000744
.00375	.000797	.000206	.000290	.000372	.000460	.000797
.0040	.000850	.000220	.000309	.000396	.000490	.000850

*Pfauter-Maag Cutting Tools Standards

** 12° is a common clearance for unground hobs. Ground hobs are normally manufactured with 8° to 10° cam clearance; therefore, the amount of error for corresponding pressure angles will be less than shown above.

The above table can also be used to determine the pressure angle change due to radial face error at a given depth. PA Error = (Radial Face Error) x (Tan PA) x (Tan OD Cam Clearance)

Table IV — Form Milling Cutter Sharpening Tolerances*

		Cutter Diameter					
	Class	Up to 1" Incl.	1–2" Incl.	2–3" Incl.	3–4" Incl.	4–5" Incl.	Over 5"
Spacing Between Adjacent Flutes	Grd.	.0010	.0010	.0010	.0010	.0015	.0015
	Acc. Ung.	.0010	.0010	.0010	.0015	.0020	.0020
	Com. Ung.	.0010	.0010	.0015	.0020	.0020	.0020
Spacing Between Non-Adjacent Flutes	Grd.	.0020	.0020	.0025	.0030	.0030	.0040
	Acc. Ung.	.0030	.0030	.0030	.0040	.0040	.0050
	Com. Ung.	.0030	.0035	.0040	.0045	.0050	.0050

		Face Width of Cutter				
	Class	Up to 1" Incl.	1–2" Incl.	2–4" Incl.	4–7" Incl.	Over 7"
Accuracy of Flute Straight or Helical	Grd.	.0010	.0015	.0025	.0030	.0050
	Acc. Ung.	.0010	.0015	.0025	.0030	.0050
	Com. Ung.	.0010	.0015	.0025	.0030	.0050

		Depth of Form					
	Class	Up to 1/4"	1/4–1/2" Incl.	1/2–3/4" Incl.	3/4–1 1/4" Incl.	1 1/4–2" Incl.	Over 2"
Cutting Faces Radial To Cutting Depth	Grd.	.0003	.0005	.0008	.0010	.0020	.0030
	Acc. Ung.	.0005	.0007	.0012	.0015	.0028	.0040
	Com. Ung.	.0010	.0012	.0020	.0025	.0035	.0050

*Pfauter-Maag Cutting Tools Standards

Table V — Multiple Thread Milling Cutter Sharpening Tolerances — Total Indicator Reading*

		Cutter Diameter					
	Class	0–1"	1.001–2"	2.001–3"	3.001–4"	4.001–5"	5.001–6"
Spacing Between Adjacent Flutes	AT	.0010	.0010	.0010	.0010	.0015	.0015
	BT	.0010	.0010	.0010	.0015	.0020	.0020
	CT	.0010	.0010	.0010	.0015	.0020	.0020
	DT	.0010	.0010	.0010	.0015	.0020	.0020
Spacing Between Non-Adjacent Flutes	AT	.0020	.0020	.0025	.0030	.0030	.0040
	BT	.0020	.0030	.0030	.0030	.0035	.0045
	BT	.0030	.0030	.0030	.0040	.0040	.0050
	CT	.0030	.0035	.0040	.0045	.0050	.0050

		Face Width of Cutter				
	Class	0–1"	1.001–2"	2.001–4"	4.001–7"	7.001" & Over
Accuracy of Flute Straight or Helical	AT	.0010	.0015	.0025	.0030	.0050
	BT	.0010	.0015	.0025	.0030	.0050
	CT	.0010	.0015	.0025	.0030	.0050
	DT	.0010	.0015	.0025	.0030	.0050

		Depth of Form			
	Class	.034" or Less	.034–.096"	.097–.170"	.171" & Over
Cutting Faces Radial To Cutting Depth	AT	.0003	.0003	.0003	.0003
	BT	.0003	.0004	.0004	.0004
	CT	.0003	.0005	.0010	.0010
	DT	.0005	.0010	.0015	.0015

*Metal Cutting Tool Institute Standards

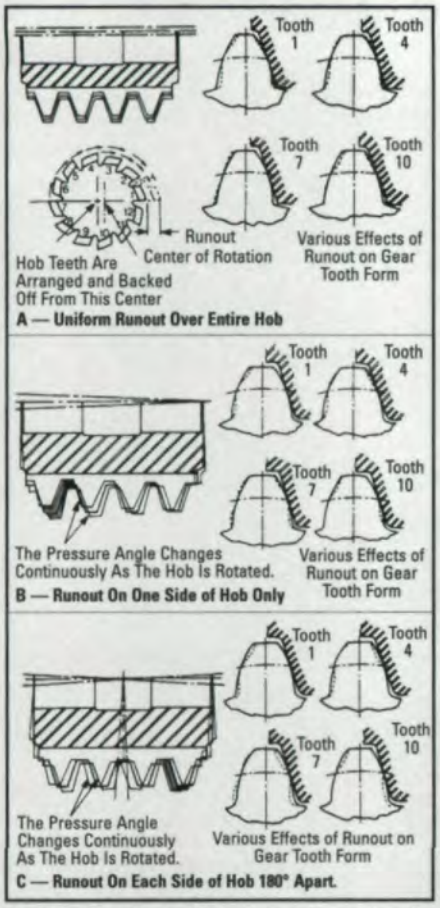

Fig. 3 — The effect of three types of runout on the hobbed profile.

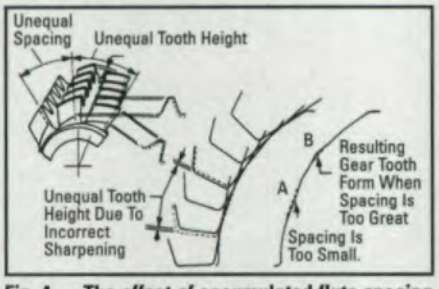

Fig. 4 — The effect of accumulated flute spacing error on profile.

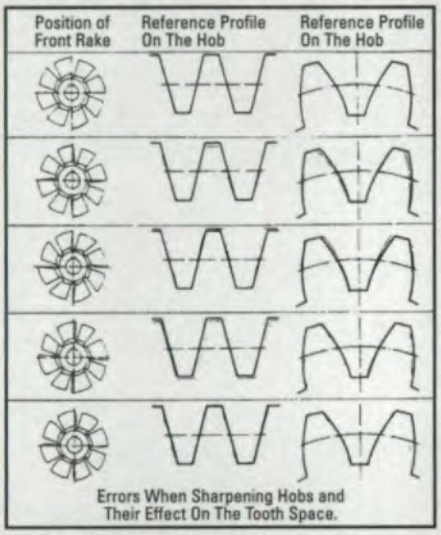

Fig. 5 — The effect of hob resharpening errors on the hobbed tooth profile relative to the basic rack profile of the hob.

True radial or rake faces, parallel gashes or correct lead and precision indexing are controlled by positive mechanical or CNC means on modern hob sharpening machines. This method is recommended as the only effective means of positively duplicating the accuracy required on precision cutting tools. Freehand sharpening should be avoided at all times, as it not only produces poor and inaccurate results, but also reduces tool life. ⚙

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