Innovative Tool Sales
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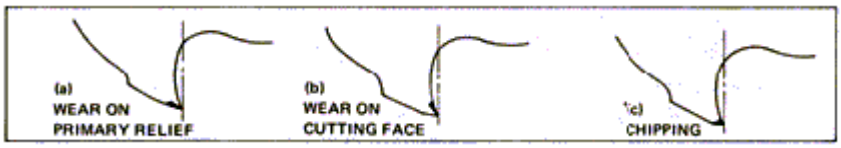
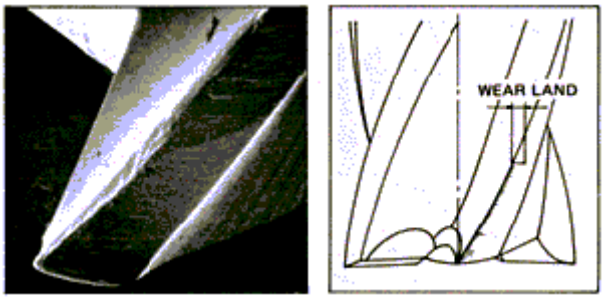
Technical Support Page

RESHARPENING & INSPECTION

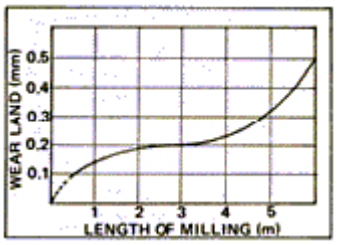
Case for Resharpening:
When the product finish becomes worse, the cutting edge must get dulled, chips become smaller and the cutting sound gets louder. In such cases, an end mill must be resharpened. Following are images of damaged end mills when resharpening is required.

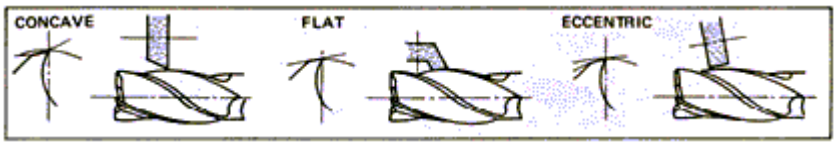


The wear on primary land is seen often. And sharpening the primary land makes the end mill perform almost the same as new one. The width of the wear land develops very fast after a time period of use, resulting in rough surface finish and chipping. Resharpening must be done before it occurs. In general, when the width of wear land become 0.2 - 0.4 mm (in case of roughing end mill: 0.5 mm) resharpening is required.



How to resharpen primary land:
There are three types of resharpening according to three types of primary relief. Hereafter we know how to resharpen eccentric relief, which is superior both in cutting edge strength, surface finish and tool life.

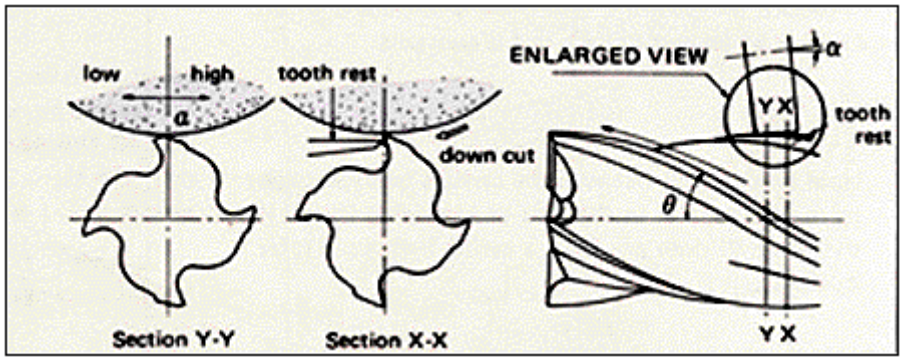




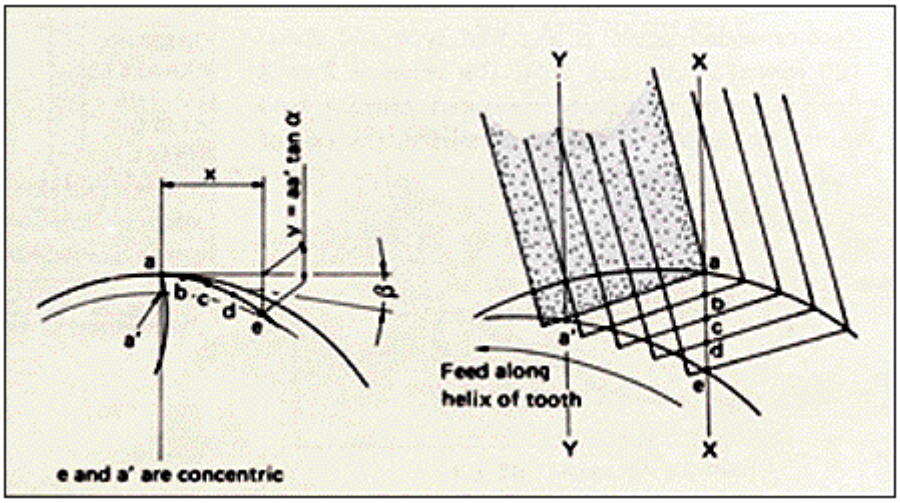
The principle of eccentric relief:

When a end mill and a wheel are set up as per Figure (see) and a wheel is advanced to the radial direction, in the section x-x, the top of the end mill's cutting edge (a) is on the high side of the wheel and the end mill is supported by a tooth rest. At the same time, in another section y-y, the top of the cutting edge is shifted out of the centerline of the wheel by the helix of the end mill flute and the wheel has contact with the point (a').

At this section, the top of the cutting edge is positioned lower than the tangent line of the wheel. Therefore, point (a) is ground in lower position than point (a) by aa' tan alpha.



If the cutting edge of the end mill is advanced, in the helixed axial direction, being supported by the wheel transverses the points (a), (b), (c), (d), (e). The curved line connecting the point (a), (b), (c), (d), (e) is the tangent line of eccentric relief. As Figure (see) the point (e) is ground to be lower than the point (a), and the point (e) and the point (a') are positioned concentric.



In relation to the eccentric relief, the following formula is made up.

$$\tan\alpha = \tan\beta \times \tan\theta$$

θ: Angle

θ: Helix angle of end mill
β: Primary relief angle

And when the checking distance is x and the relief amount (drop) is y, the following formula are made up.

$$\beta = \tan^{-1} \frac{360^\circ \left\{ \frac{D}{2} - \sqrt{\left(\frac{D}{2} - y\right)^2 + x^2} \right\}}{\pi D \tan^{-1} \left(\frac{x}{\frac{D}{2} - y} \right)}$$

α: Angle of wheel inclination
D: Mill diameter

A helical tooth is required to generate eccentric relief, theoretically any helix angle, but actually the helix must be more than 15° - degree to be successful.

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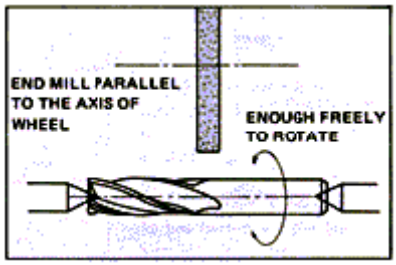
RESHARPENING & INSPECTION

How to resharpen (resharpening order)

To produce an eccentric relief, the positioning of an end mill, a wheel and a tooth rest is constant.

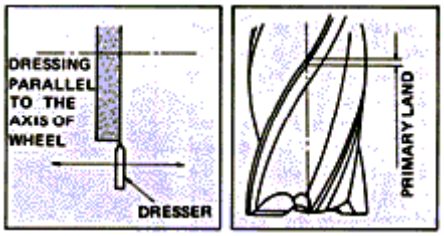
1. Setting

Hold an end mill between the centers freely enough to rotate, parallel to the axis of a grinding wheel. If the end mill does not have a center hole, hold it by its shank



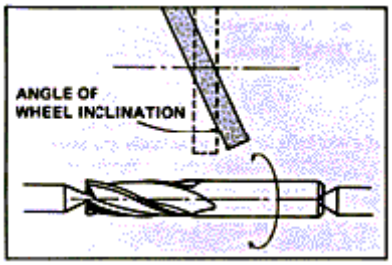
2. Selection of a wheel & dressing

Recommended wheel is alundum type and about 120 mm diameter cup type. The wheel is 2 or 3 times as wide as axially measured primary land width. The wheel is dressed parallel to the axis of wheel by a diamond dresser.



3. Angle of wheel inclination

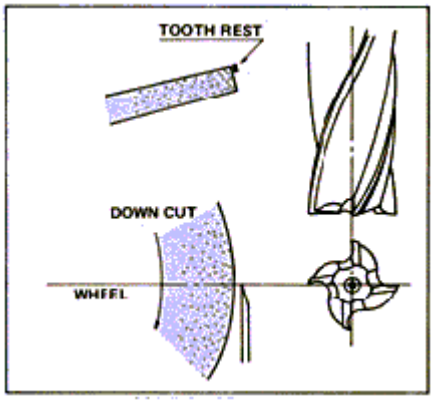
The wheel is positioned with its axis at a slight angle to the cutter axis, the degree of relief is varied by changing the angle of wheel inclination.



MILL DIAMETER		PRIMARY RELIEF ANGLE	ANGLE OF WHEEL INCLINATION
OVER	UNDER		
4.75	6	11.8 ~ 19	8.5
6	7.5	11.2 ~ 18	8
7.5	9.5	10.6 ~ 17	7.5
9.5	11.8	10 ~ 16	7.1
11.8	15	9.5 ~ 15	6.7
15	19	9 ~ 14	6.3
19	23.6	8.5 ~ 13.2	6
23.6	30	8 ~ 12.5	5.6
30	37.5	7.5 ~ 11.8	5.3
37.5	47.5	7.1 ~ 11.2	5
47.5	60	6.7 ~ 10.6	4.75
60	75	6.3 ~ 10	4.5

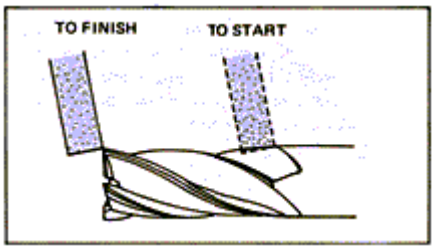
4. To set tooth rest

The high point of the tooth rest must contact the tooth face at the high side of the wheel and be the same height as the wheel and work centers. But, as usual end mills have a positive rake angle, the high point of the tooth rest is positioned a little higher than the height of the wheel and work centers.



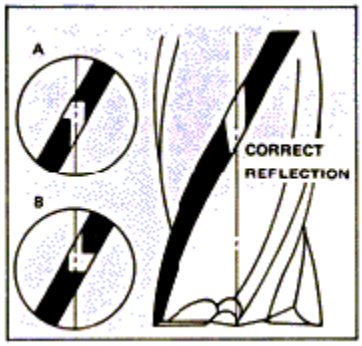
5. Trial grinding

The grinding should be done from end mill's shank side to end teeth. Do down grinding not to make the tooth drop from the tooth rest which makes the cutting edge dull. The work is rotated against the tooth rest as the cutter grinder table is transversed. And it is done at constant speed.



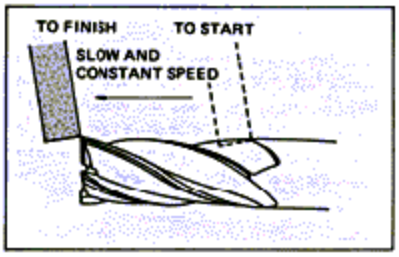
6. Checking eccentric relief & adjustment of height of tooth rest

Watch the primary relief after trial grinding, to check that the reflectional light or primary relief surface is parallel to axis of the end mill. If the reflection is not correct, adjust the height of tooth rest (see figure 30).
In case of "A" - Make the tooth rest in lower position.
In case of "B" - Make the tooth rest in higher position.



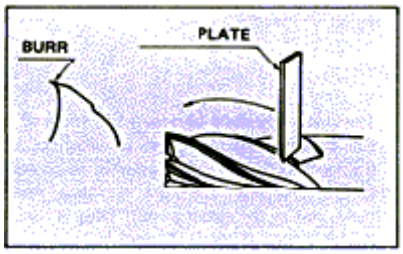
7. Grinding

Grind the primary relief until all of the wear has been removed, taking care to avoid excessive diameter loss and burring. The amount of stock removed is 0.01 mm per pass. (Roughing: 0.02 mm). Light finishing cuts are required to produce smooth cutting face.

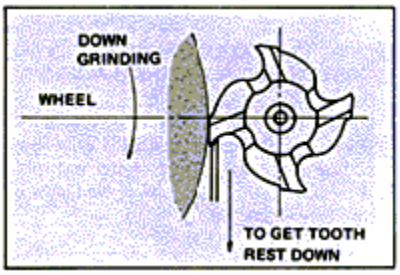


8. Removing Burrs

The grinding will produce burrs on the cutting edge. The burrs are removed, soon after milling is started. But, if good surface finish is required, they must be removed before milling starts again. To remove them, a acrylic or aluminum plate is softly touched along the helical teeth.



Note: When a primary land is wide, regrinding of secondary clearance face should be done first to avoid grinding burn. Get the tooth rest down without any other set-up change, and grind the secondary clearance face to concave form. In case of the cutting edge chipped, cylindrical grinding should be done before primary relief grinding.

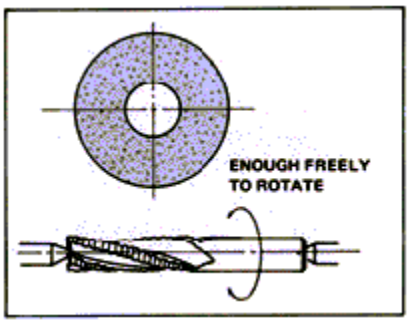


Regrinding cutting face

Slight grinding will do, removing welded materials in case of regrinding cutting face of finishing end mills. But, in roughing end mills, as it is not resharpened on primary relief, cutting face must be reground until wear land on primary relief is completely removed. Generally recommended cutting angle is 12°- 18° degree.

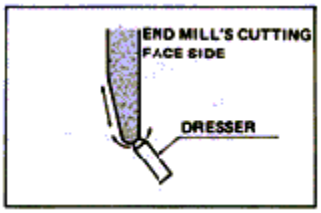
1. To hold end mill

Mount on the table an end mill perpendicular to axis of wheel and hold it between centers concentric but loosely enough to rotate, as primary relief grinding holding between centers is better.



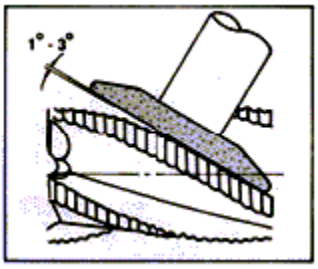
2. Selection of wheel and dressing

Use alundum tube, 100 - 130 diameter, saucer type wheel, Dress the wheel with diamond dresser carefully not to make radial run-out.



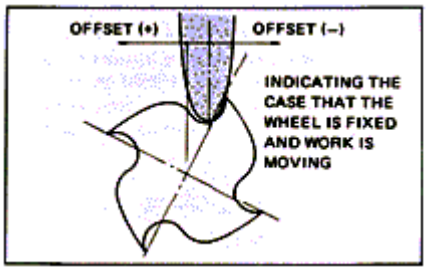
3. Angle of wheel inclination

The angle of wheel inclination should be 1°- 3° degree larger than the helix angle of the end mill to make a slight clearance between the end mill's cutting face and the wheel.



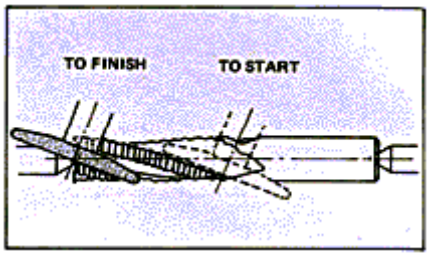
4. Adjustment of offset

Adjust offset amount to make wheel face have contact with whole cutting face of the end mills (from dotting edge to bottom of flute). Increase offset, when the wheel contacts cutting edge side only (cutting angle gets smaller), and reduce offset, when the wheel contacts bottom of flute only (cutting angle gets longer).



5. Grinding

Grind the cutting face from shank side toward cutting end, having a soft contact to cutting face. The feed of the wheel must be as slow and constant as possible, because it affects the surface roughness of cutting face. Particularly when the wheel passes through the end of mill, help the rotation of end mill by hand, carefully not to make the cutting edge dull.



6. Buffing

After grinding, remove burrs.

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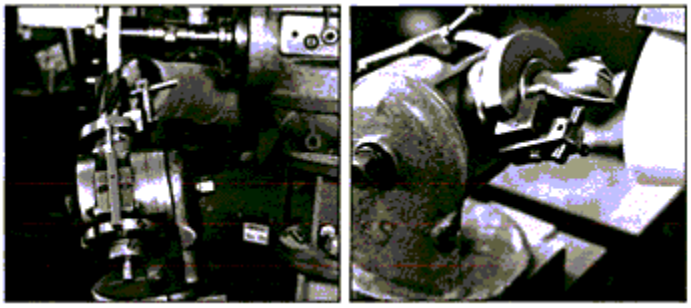
RESHARPENING & INSPECTION

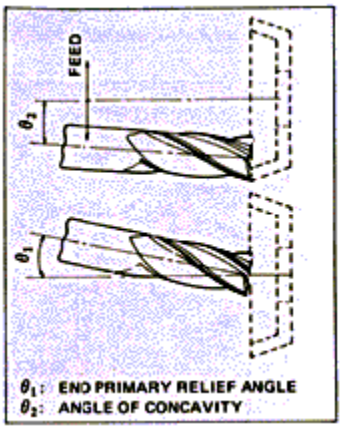
Resharpening end teeth

Primary land is first to be resharpened. And the necessity of resharpening secondary clearance face and end gash depends on seriousness of damages. In any cases, indexing equipment is required.



1. Sharpening primary land

Set up a end mill and a cup wheel as per Figure (see). The end mill is set inclined at the angle of axial primary relief and end cutting edge concavity. Table (see) indicates usual degree of the mentioned two angles.

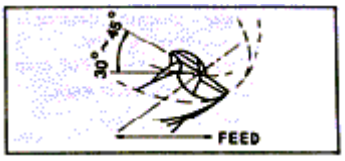


Milled material	0_1	0_2
Steels	3 - 7°	1 - 3°
Non-ferrous metals	8 - 12°	3 - 5°

For the end mill only for drilling, the angle should be 8 - 12°

2. Resharpening end gash

When the removed amount of regrinding on end primary land is big, it becomes wide and chip room becomes smaller. In such case the end gash should be resharpened by cup type wheel, setting the end mill inclined at gash angle.



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RESHARPENING & INSPECTION

Inspection

Although the regrinding is done, if the specifications are changed, the milling performance as a new end mill cannot be regained and the regrinding work is evaluated as wasted.

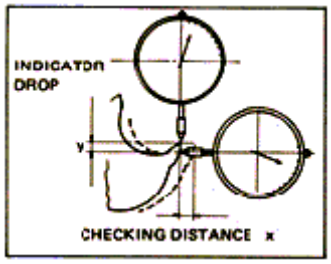
The following are necessary checking points.
1. Primary relief angle.
2. Cutting angle
3. Radial run-out of peripheral teeth and axial run-out of end teeth.
4. Surface roughness.

Inspection of primary relief angle.

After confirming the primary relief is eccentric, the primary relief angle must be checked. The angle is calculated by using the formula (see up). But as it is too much work, it is better to apply the procedure to check with indicators.

Procedure to check Radial Relief Angles with Indicators.

1. Mount the cutter to rotate freely with no end movement.
2. Adjust the sharp pointed indicator to bear at the very tip of the cutting edge, pointing in a radial line, shown in Figure (see).

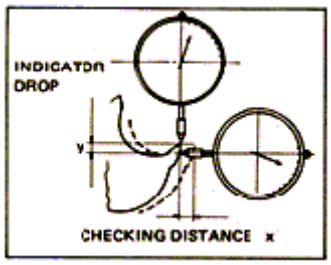


3. Roll the cutter the tabulated amount given under "checking distance" using the second indicator as a control.
4. Consult for amount of drop for the particular diameter and relief angle.

Mill dia (mm)	Primary relief angle	Checking distance	Indicator drop
5	11.8 ~ 19	0.250	0.066 ~ 0.102
6	11.8 ~19	0.274	0.071 ~ 0.110
7	11.2 ~18	0.269	0.072 ~ 0.111
8	10.6 ~17	0.317	0.073 ~ 0.112
9	10.6 ~ 17	0.336	0.076 ~ 0.118
10	10 ~ 16	0.354	0.076 ~ 0.116
12	9.5 ~ 15	0.388	0.078 ~ 0.118
14	9.5 ~ 15	0.419	0.083 ~ 0.126
15	9.5 ~ 15	0.434	0.086 ~ 0.130
16	9 ~ 14	0.448	0.084 ~ 0.126
18	9 ~ 14	0.475	0.088 ~ 0.132
20	8.5 ~ 13.2	0.501	0.088 ~ 0.131
22	8.5 ~ 13.2	0.525	0.092 ~ 0.137
24	8 ~ 12.5	0.549	0.090 ~ 0.135
25	8 ~ 12.5	0.560	0.092 ~ 0.138
26	8 ~ 12.5	0.571	0.093 ~ 0.140
28	8 ~ 12.5	0.593	0.096 ~ 0.145
30	8 ~ 12.5	0.613	0.099 ~ 0.149
35	7.5 ~ 11.8	0.663	0.100 ~ 0.152
40	7.1 ~ 10.6	0.708	0.101 ~ 0.146

2. Inspection of cutting angle

To measure the cutting angle, the procedure using dial indicators as per image below is easy.



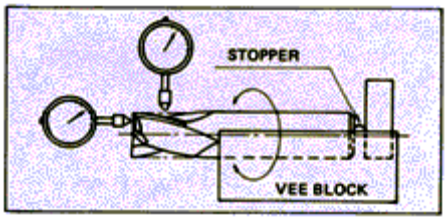
Measuring the indicator drop (y) within the checking distance (x), consult table (see).

θ \ X (mm)	0.15	0.20	0.30	0.40	0.50	0.60	0.70	1.00
4	0.010	0.014	0.021	.028	.035	.042	.049	.070
5	0.013	0.017	0.026	.036	.044	.052	.061	.087
6	0.016	0.021	0.032	.042	.053	.063	.074	.105
7	0.018	0.025	0.037	.049	.061	.074	.086	.123
8	0.021	0.028	0.042	.056	.070	.084	.098	.141
9	0.024	0.032	0.047	.063	.079	.095	.111	.158
10	0.026	0.035	0.053	.071	.088	.106	.123	.176
11	0.029	0.039	0.058	.078	.097	.117	.136	.194
12	0.032	0.043	0.064	.085	.106	.128	.149	.213
13	0.035	0.046	0.069	.093	.115	.138	.162	.231
14	0.037	0.050	0.075	.100	.125	.150	.175	.249
15	0.040	0.051	0.080	.107	.134	.161	.188	.268
16	0.043	0.057	0.086	.115	.143	.172	.201	.287
17	0.046	0.061	0.092	.122	.153	.183	.214	.306
18	0.049	0.065	0.097	.130	.162	.195	.227	.325
19	0.052	0.069	0.103	.138	.172	.207	.241	.344
20	0.055	0.073	0.109	.146	.182	.218	.255	.364

Since the cutting face is hook form, it is better to measure twice at different checking distance and to get the average. Generally the checking distance is MILL DIAMETER x 0.025.

3. Inspection of cutter run-outs

A cutter performs best when the cutting edge of all teeth runs true with the axis. Then each tooth does its share of work. Radial and axial run-outs should be checked with an indicator after each sharpening. Put a end mill on a Vee block and measure run-outs of peripheral teeth and end teeth with indicators, rotating the end mill. If the end mill has center holes on both ends, it can be held by centers. Table (see) indicates the tolerance of run-outs.



End mill \ Run-out	Peripheral teeth (mm)	End teeth (mm)
Finishing mill	**under 0.03**	**under 0.05**
Roughing mill	**under 0.05**	**under 0.05**

4. Surface roughness

Use Profilometer. Surface roughness must be under than 6s. Rough surface finish may cause bad surface finish of work piece and chipping of curving edge.