General Information about MC – Grinding Wheels

The grinding of difficult to machine materials causes considerable problems particularly when profile grinding. The development of grinding wheels using diamond or cubic boron nitride, which can be profiled by crushing. The excellent characteristics of these tools can be used for profiling and creep feed grinding of tungsten carbide, HSS, high temperature alloys, spray alloys and special ceramics etc.

For the processing of such materials diamond (DMC) or CBN (BMC) grinding wheels have advantages compared to working with conventional grinding wheels.

1. Complete profiles can be ground in one operation, because DMC and BMC wheels are suitable especially for creep feed grinding.
2. Higher material removal rates and better tool life.
3. Considerably reduced subsurface damage, due to cooler grinding.
4. Less re-profiling due to substantial longer profile life.
5. Lower ancillary time due to the application of creep feed grinding.

In total: Cost saving profile grinding, or creep feed grinding of difficult to cut materials.

Application example

Profile grinding of HSS thread cutters with creep feed grinding on a surface grinding machine

<table>
<thead>
<tr>
<th>Material dimensions</th>
<th>25 x 12 x 75 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thread form</td>
<td>DIN M8 (pitch 2.5 mm)</td>
</tr>
<tr>
<td>Smallest radius</td>
<td>0.15 mm</td>
</tr>
<tr>
<td>Material</td>
<td>DM05 (M2)</td>
</tr>
<tr>
<td>Grinding wheel</td>
<td>MC 700-300-27-5 127 B64</td>
</tr>
<tr>
<td>BMC V180 (layer depth 5 mm)</td>
<td></td>
</tr>
<tr>
<td>Crushing roller</td>
<td>12 % Cr-Chromium steel hardened</td>
</tr>
<tr>
<td>Coolant</td>
<td>Oest, Meba SF 2 %</td>
</tr>
<tr>
<td>Amount</td>
<td>approx. 200 l/min</td>
</tr>
</tbody>
</table>

Application data

<table>
<thead>
<tr>
<th>No. of pieces per operation</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral wheel speed</td>
<td>approx. 45 m/sec</td>
</tr>
<tr>
<td>Table speed</td>
<td>300 mm/min</td>
</tr>
<tr>
<td>Feed speed</td>
<td>4,000 mm/min</td>
</tr>
<tr>
<td>Back speed</td>
<td>1.9 mm</td>
</tr>
<tr>
<td>Depth plus profile depth</td>
<td>9.5 mm³/mm · s</td>
</tr>
<tr>
<td>Stock removal rate</td>
<td>320 parts</td>
</tr>
<tr>
<td>Total Number of pieces</td>
<td>24,000 mm</td>
</tr>
</tbody>
</table>

DMC and BMC grinding wheels are best suited for normal creep feed grinding as well as for peel grinding because of the specially created bond structure.

Range of applications for crushing and grinding

The crushing device should be part of the machine, at least it should be installed direct to the machine. By doing so the advantages of profiling without annoying tool changing can be utilised. Pre-forming of the layer to the required profile is also possible.

The crushing can be carried out with a powered grinding wheel which drives the profiling roller or with a powered profiling roller driving the grinding wheel (if no notice is taken at this point the wear of the profile-roller becomes too great).

The profile crushing should always be done under the supply of coolant, the grinding-wheel as well as the crushing roll has to be wet. Additionally during crushing the layer has to be cleaned with a WINTER-stone No. 2 or No 5. This will reduce profile distortion that may occur due to dragging along wheel particles.
Basic information for Crushing

1. Crushing roller

1.1 Material for the roller:
Tungsten carbide, HSS, 12% Chromium steel, hardened cold working steel.
Steel roll types are hardened to a min 64 HRC, to get the least possible roller wear.
Crushing with soft steel rollers is possible, but the wear is much higher, and narrow tolerance profiles cannot be produced.

1.2 Number of rollers required:
This is dependent on profile depth and type of profile, for crushing starting with a plain cylindrical wheel, a minimum two but three rollers would be better.

1.3 Design of the roller profile:
As for conventional wheels, it will be necessary when using MC wheels to correct the roller profile according to the wear, so radii at the tip and route should be made smaller in the roller by about 0,02 mm, flank angles will also have to be in the lower tolerance.

The roller should not be segmented, in tests we found that a segmented roller results in lower life time for the grinding wheel profile. Additional vibrations and higher loads results in lower life for the bearing.

1.4 Roller-wear:
The longest roller life will be reached with approx. 1m/s peripheral speed of the grinding wheel during crushing.

The higher the peripheral speed, the higher the profile relative speed, that is why the roller wear becomes greater.

The lower the peripheral speed is, the longer the time will be for reaching the required profile depth, and therefore we reach a time related roller wear.

2. Positioning of the roller and running accuracy

2.1 Radial and axial run out of the roller will lead to axial and radial run out of the wheel profile. Larger axial run out errors will result in high axial forces which in the extreme can damage the wheel. Axial and radial run out tolerance of the roller should not exceed 0,01 mm.

2.2 Any changing of the profile roller, for instance after pre-profiling , the roller profile has to be positioned exactly in line with the wheel profile. The steeper the flanks and the greater the profile depth the greater the need for accuracy. This means that steep profile flanks influence the cost effectiveness in a negative way. The positioning can be checked either by optical control or guaranteed by reference measurement from roller profile to a locating face.

2.3 Alignment of roller to grinding wheel
Any error in vertical and horizontal Alignment leads to profile distortion. In order to prevent a side movement of the spindle due to crushing-forces, especially for wider wheels the roller and wheel spindles should be supported from both sides by bearings.

3. Peripheral speed 1m/sec during crushing

It is very important to have a slip free contact between wheel and roller.
Basic information for Crushing

3.1 Ideal condition is a powered grinding wheel.
3.1.1. Because of the diameter and respective greater torque,
3.1.2. Because of the contact from the Winter stone for the
cleaning of the wheel surface,
3.1.3. Because the roller can be driven easily (without drive),
3.1.4. It is also possible to drive the roller and have a driven
wheel.

Disadvantage of 3.1.4:
1. In most cases a smaller diameter roller has to drive a larger
diameter grinding wheel.
2. The force of the Winter-stone on the wheel has to be
overcome. Especially during first profiling when the contact area
between wheel and roller is still small, slipping can occur
which leads to greater wear.

4. Crushing support Winter-stone 2 or 5

During the contact time between the crushing roller and
grinding wheel the Winter stone has to be used in order to
keep the wheel surface open and to remove any debris.
Towards the end of the crushing process the contact between
the grinding wheel and Winter stone can be stopped, this
will help to attain best profile tolerance.

4.1 It is a necessity to use a wet Winter-stone.
4.2 The infeed has to be carried out continuously.
4.3 Especially for fine profiles a vibration free infeed is
necessary.

4.4 The infeed may be carried out mechanically or
pneumatically. The easiest way is an infeed by swinging arm
and dead weight, where the force can be adjusted by a
counterweight.

5. Application condition during crushing

5.1 Surface speed at the contact zone of the roller and grinding
wheel approx. 1 m/s

Infeed speed of the crushing roller 0.5-1 µm/wheel
revolution (the single infeed values can be 2-5 µm/infeed). The crushing pressure must decrease before another
infeed is applied.

In-feed speed for Winter-stone
5-10 µm/wheel revolution, i.e. 10 times greater than the
crushing roller (faster feedrate of the Winter-stone gives
no influence to the crushing process, this stronger
cleaning however leads to a minor increase in layer
removal rate at the wheel. If the force becomes too strong
the material of the Winter stone can load the grinding
wheel surface. In extreme this can damage the grinding
wheel).

During the crushing time the Winter stone has to be fed
continuously and kept wet with coolant but not as much
as required for grinding.

In tests of crushing DMC (diamond grinding wheels) and
BMC (CBN grinding wheels) there has been no significant
differences found.
6. Application conditions during grinding

6.1 Diamond grinding wheel DMC:

\[ v_s = 25 \text{ to } 30 \text{ m/sec}, \text{ specific removal rate } Q'_w \text{ maximum } 5 \text{ mm}^3/\text{mm} \cdot \text{sec} \]

(under economic aspects dependent on wheel diameter)

For grinding wheels with approx. 125 mm diameter calculation should be carried out with
\[ Q'_w = 2 \text{ to } 3 \text{ mm}^3/\text{mm} \cdot \text{sec}. \]

**Normal wheel specification:**
Grit size D 46 to D 126 (according to required radii)
(Example: Smallest possible convex Radius with D46 R=0.09mm; with D126 approx. R=0.30mm)

Bond : DMC, other grade of hardness (XT/XF) is possible, for first test norm DMC

Concentration : C 75 to C100 (according to material removal rate and grinding task)

6.2 CBN grinding wheel BMC:

\[ v_s = 35 \text{ to } 60 \text{ m/sec} \] (in which with 60m/sec better life of the wheel can be reached if no vibration occurs).

Specific removal rate \[ Q'_w \text{ maximum } 7 \text{ mm}^3/\text{mm} \cdot \text{sec} \]
(dependent on wheel diameter)

For grinding wheels with approx. 125 mm diameter the specific removal rate should be chosen with approx. 3 \text{ mm}^3/\text{mm} \cdot \text{sec} .

Grit sizes B46 to B126 (according to requested radii)

Bond B-MC

Concentration V180 to V300 (according to material removal rate and requested grinding performance)

6.3 Deep grinding

All MC bonds are creep grinding bonds. If the grinding is carried out with high peripheral speed and respectively high table speeds the grinding process becomes less economic.

6.3.1 Example for creep grinding with DMC wheels

In a test for profile creep grinding of tungsten carbide K20 with a grinding wheel specification D64 DMC C100 with a wheel diameter of 150mm it turned out that with sufficient coolant flow even a peripheral speed of 45 m/sec still gives outstanding performance, material removal rate, and profile life.

With a specific removal rate of \[ Q'_w = 1.15 \text{ mm}^3/\text{mm} \cdot \text{sec} \] a specific power of 0.585 KW/\text{mm}^2 is required. Dependent on coolant flow and required profile accuracy at an in feed of 1 mm a feedrate of 150 mm/min and up to 300 mm/min is possible. The G-ratio varies within 350 to 1500 dependent on application data.

7. Coolant for grinding and crushing

For a successfull grinding and crushing application the coolant has to be of considerable importance.

Main demand: The coolant has to keep the wheel surface open and has to flush it clean. In general emulsions have been succeeded by the use of fully synthetic oil or with pure grinding oils. All tests with emulsions, i.e. oil mixed in water have been problematic, because of the permanent danger of a clogged and gummed wheel surfaces. Due to this fact the crushing forces and the spindle driving power needed for the grinding will increase.