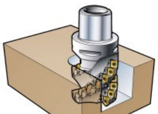
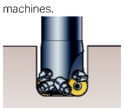
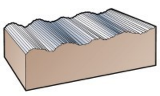
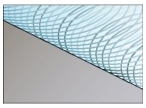
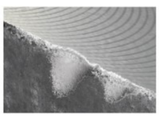
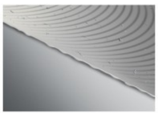
Milling troubleshooting

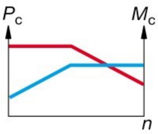
Milling troubleshooting tips about vibration issues, chip jamming, re-cutting of chips, un-satisfactory surface finish, burr formation, machine power and tool wear are presented in the following table.

	Cause	Solution
Vibration 	• Weak fixture	• Assess the direction of the cutting forces and provide adequate support or improve the fixture • Reduce the cutting forces by decreasing the cutting depth, a_p • Select a coarse and differentially pitched cutter with a more positive cutting action • Select a geometry with a small corner radius and small parallel land • Select a fine-grain, uncoated insert, or a thinner coating • Avoid machining where the workpiece has poor support against the cutting forces
	• Axially weak workpiece	• Consider a square shoulder cutter (90-degree entering angle) with positive geometry • Select an insert with L-geometry • Decrease axial cutting force – lower depth of cut, smaller corner radius and parallel land • Select a coarse-pitch cutter with differential pitch • Check tool wear • Check tool holder run-out • Improve clamping of tool
	• Too long tool overhang	• Minimize overhang • Use coarse-pitch cutters with differential pitch • Balance radial and axial cutting forces – 45 degree entering angle, large corner radius or round insert cutter • Increase feed per tooth • Use a light-cutting insert geometry • Reduce axial depth of cut, a_f • Use up milling in finishing • Use oversized cutters and Coromant Capto® coupling adaptors • For solid carbide end mills and exchangeable-head mills, try a tool with fewer teeth and/or a higher helix angle
	• Milling square shoulder with weak spindle	• Select smallest possible cutter diameter • Select a positive and light-cutting cutter and insert • Try up milling • Check spindle deflection to see if acceptable for machine
	• Irregular table feed	• Try up milling • Tighten machine feed mechanism: adjust the feed screw on CNC machine • Adjust the locking screw or replace the ball screw on conventional machines
	• Cutting data	• Reduce cutting speed, v_c • Increase feed, f_z • Change cutting depth, a_p
	• Bad stability	• Reduce overhang • Improve stability
	• Vibration in corners	• Program large corner radii with reduced feed rate
Chip jamming Common obstacle when full slotting – especially in long-chipping materials 	• Insert corner damage • Edge chipping and breakage • Re-cutting of chips	• Improve chip evacuation by using rich and well directed cutting fluid or compressed air • Reduce feed, f_z • Split deep cuts into several passes • Try up milling in deep slotting • Use coarse pitch cutters • Use solid carbide end mills or exchangeable-head mills with two or maximum three cutting edges and/or a higher helix angle
Re-cutting of chips Appears in full slotting and pocketing – especially in titanium. Also common when milling deep cavities and pockets on vertical machines. 	• Cutting edge fractures • Harmful for tool life and security • Chip jamming	• Evacuate chips effectively by compressed air or copious cutting fluid flow – preferably internal coolant • Change cutter position and tool path strategy • Reduce feed, f_z • Split deep cuts into several passes
Unsatisfactory surface finish 	• Excessive feed per revolution	• Set cutter axially or classify inserts. Check height with indicator • Check spindle run-out and cutter mounting surfaces • Decrease feed per rev to max. 70% of the width of the parallel land • Use wiper inserts if possible (for finishing operations)
	• Vibration	See section "Vibration" above
	• Built-up edge formation	• Increase cutting speed, v_c, to elevate machining temperature • Turn off cutting fluid • Use sharp cutting edge inserts, with smooth rake side • Use positive insert geometry • Try a cermet grade with higher cutting data
	• Back-cutting	• Check spindle tilt (approx. 0.10 mm/1000 mm (0.004 inch/39.370 inch)) • Axial run-out, TIR, of spindle should not exceed 7 microns during finishing • Reduce the radial cutting forces (decrease the depth of cut, a_p) • Select a smaller cutter diameter • Check the parallelism on the parallel lands and on wiper insert used (should not be standing on "heel or toe") • Make sure the cutter is not wobbling – adjust the mounting surfaces
	• Workpiece frittering	• Decrease feed, f_z • Select a close or extra-close pitch cutter • Re-position the cutter to give a thinner chip at exit • Select a more suitable entering angle (45-degrees) and lighter cutting geometry • Choose a sharp insert • Monitor flank wear to avoid excessive wear
Burr formation	• Material specific – HRSA/stainless steel • Notch main wear mechanism	• Use large radius giving low insert entry angle • Keep depth of cut below radius • a_p = 0.5 x radius



Machine power

Be aware of the power curve as the machine may lose efficiency if the rpm is too low.



The power requirements in milling vary with the:

- Amount of metal to removed
- Average chip thickness
- Cutter geometry
- Cutter speed

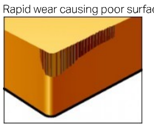
- Go from close to coarse pitch, i.e. fewer teeth
- A positive cutter is more power efficient than a negative cutter
- Reduce cutting speed before table feed
- Use a smaller cutter and make several passes
- Reduce depth of cut, a_p

Insert wear

To achieve optimized cutting data, best possible component quality and tool life, always remember to check the insert/cutting edge after machining. Use this list of causes and solutions to different forms of insert wear as a reference for successful milling.

Flank wear

Rapid wear causing poor surface finish or out of tolerance.

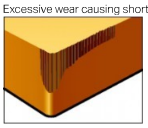


Cause
- Cutting speed too high
- Insufficient wear resistance
- Feed, f_z, too low

Solution
- Reduce cutting speed, v_c
- Select a more wear-resistant grade
- Increase feed, f_z

Flank wear

Excessive wear causing short tool life.

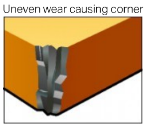


- Vibration
- Re-cutting of chips
- Burr formation on component
- Poor surface finish
- Heat generation
- Excessive noise

- Increase feed, f_z
- Use down milling
- Evacuate chips effectively using compressed air
- Check recommended cutting data

Flank wear

Uneven wear causing corner damage.

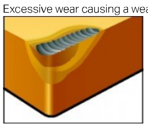


- Tool run-out
- Vibration
- Short tool life
- Bad surface finish
- High noise level
- Radial forces too high

- Reduce run-out below 0.02 mm (0.0008 inch)
- Check chuck and collet
- Minimize tool protrusion
- Use fewer teeth in cut
- Choose a larger tool diameter
- For solid carbide end mills and exchangeable-head mills, select a higher helix geometry ($g_p \geq 45°$)
- Split axial cutting depth, a_p, into more than one pass
- Reduce feed, f_z
- Reduce cutting speed, v_c
- HSM requires shallow passes
- Improve clamping of tool and workpiece

Crater wear

Excessive wear causing a weakened edge. Cutting edge breakthrough on the trailing edge causes poor surface finish.

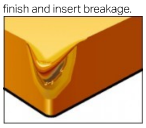


- Diffusion wear due to cutting temperatures that are too high on the rake face

- Select an Al203 coated grade
- Select a positive insert geometry
- Reduce the speed to obtain a lower temperature, and then reduce the feed

Plastic deformation

Plastic deformation of edge, depression or flank impression, leading to poor chip control, poor surface finish and insert breakage.

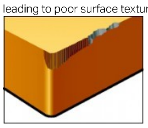


- Cutting temperature and pressure too high

- Select a more wear resistant (harder) grade
- Reduce cutting speed, v_c
- Reduce feed, f_z

Chipping

The part of the cutting edge not in cut is damaged by chip hammering. Both the top side and the support for the insert can be damaged, leading to poor surface texture and excessive flank wear.

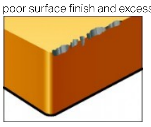


- The chips are deflected against the cutting edge

- Select a tougher grade
- Select an insert with a stronger cutting edge
- Increase cutting speed, v_c
- Select a positive geometry
- Reduce feed at the beginning of cut
- Improve stability

Chipping

Small cutting edge fractures (frittering) causing poor surface finish and excessive flank wear.

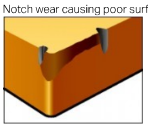


- Grade too brittle
- Insert geometry too weak
- Built-up edge

- Select a tougher grade
- Select an insert with a stronger geometry
- Increase cutting speed, v_c, or select a positive geometry
- Reduce feed at the beginning of cut

Notch wear

Notch wear causing poor surface finish and risk of edge breakage.

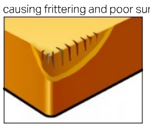


- Work hardening materials
- Skin and scale

- Reduce cutting speed, v_c
- Select a tougher grade
- Use a stronger geometry
- Use a cutting angle closer to 45 degrees
- Use round inserts for best result
- Use variable a_p technique to prolong the wear

Thermal cracks

Small cracks perpendicular to the cutting edge causing frittering and poor surface finish due to temperature variations.



- Intermittent machining
- Varying cutting fluid supply

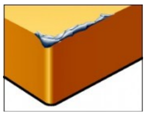
- Select a tougher grade with better resistance to thermal shocks
- Cutting fluid should be applied copiously or not at all

Built-up edge (BUE)

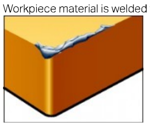
Built-up edge causing poor surface finish and cutting edge frittering when the BUE is torn away.

- Cutting zone temperature is too low
- Very sticky material, such as low-carbon steel, stainless steels, and aluminium

- Increase cutting speed, v_c
- Change to a more suitable insert geometry



Built-up edge (BUE)
Workpiece material is welded to the cutting edge.



- Low cutting speed, v_c
- Low feed, f_z
- Negative cutting geometry
- Poor surface finish

- Increase cutting speed, v_c
- Increase feed, f_z
- Select a positive geometry
- Use oil mist or cutting fluid

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