waveform roughing

Maximum Material Removal

Waveform roughing strategy is a high speed machining technique that maintains a constant tool cutting load by ensuring the tool engagement into the material is consistent. The tool path moves in a smooth path to avoid sharp changes in direction which maintains the machine tool's velocity.

Benefits include :

Reduces cycle time

Tool life maximised

Full flute of tool utilised

Minimum tool vibration

Constant chip load

Intelligent toolpath linking

Cuts deeper and faster

Constant Engagement

Although the Concentric pattern looks much simpler at the first glance the problem is that the tool "digs" into each corner causing the tool to overload, leading to reduced tool life or tool breakage. In reality the machine tool operator may have to reduce the cycle feed rate to compensate and thus, increase manufacturing time.

As Waveform maintains a constant engagement with the material, the feed rate can remain at the optimal value throughout the cycle. This will improve the tool life and greatly reduce the risk of tool breakage - it is very simple to switch from traditional roughing to Waveform to see the toolpath pattern.

The Waveform Pattern

To maintain a constant chip load the cycle uses the philosophy that we machine from "Stock to part". This reduces the amount of intermittent cuts, particularly on external regions, which means the tool is engaged with the material for longer without lifting clear. Traditionally, cycles generally offset the component until they meet the stock. This can lead to the generation of sharp corners and discontinuous tool paths.

For pocket regions the tool will helical in to depth at the centre and open the pocket up so that it can create a continuous spiral cut until the edge of the pocket is reached. Any remaining corners are then removed. Waveform automatically detects open areas and uses them for tool entry, rather than cutting an open region like a closed region.

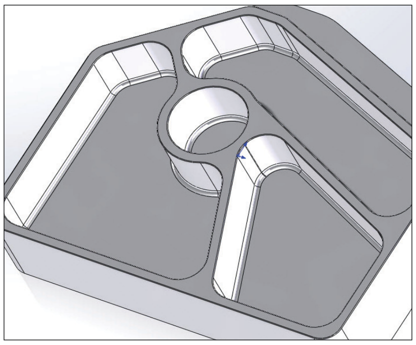
Adjusted Tool Engagement

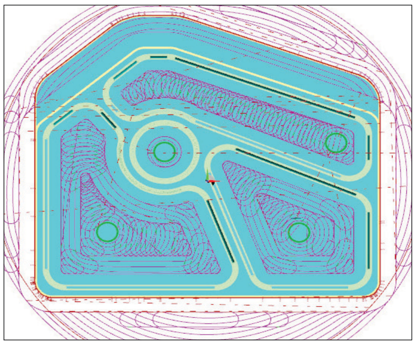
To maintain the tool engagement and the chip load the tool path is automatically adjusted to compensate. When cutting into a concave area tool engagement is increased. The cycle adjusts the step over between the passes to compensate and maintain the desired engagement.

When cutting a convex area the opposite affect occurs. As the material falls away the tool path step over is increased to maintain the desired engagement.

Intelligent Linking

To improve cycle efficiency, Waveform provides the ability to stay at depth whilst moving between milling areas or go up and over and stepping off the component.





waveform

Waveform Roughing greatly improves standard roughing cycles by removing a constant volume of material.

Cutting along as much of the flute length as possible distributes wear evenly along the entire flute length, rather than just the tip, massively reducing tool vibration. The radial cut depth is also reduced to ensure a consistent cutting force, allowing cut material to escape from the flutes. Tool life is further extended as most of the heat is removed in the chip.

CoroMill® Plura solid carbide square shoulder end mill

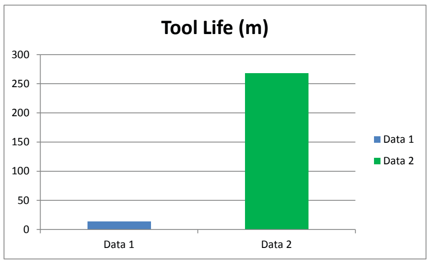
- Solid Carbide P1F7
- 50° Flute Helix Angle
- 4 flute - 90° Pitch
- PVD Coated

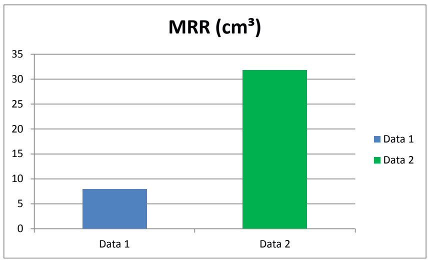
Objective	To Measure Tool Performance Utilising Edgecam Waveform	
Operation	Test 1 - Traditional	Test 2 - Waveform
Tool Details	R216.24-12050ECC26P 1620	
Machine	Mazak Integrex i200	
Coolant	Soluble 8- 10%	
Tool Holders	Hydraulic – Capto C6	
Material	TiAL6V4	
Speed (RPM)	1,326	6,631
Feed (mm/min)	265	3,183
Ap (mm)	6.3	20
Ae (mm)	4.8	0.5
Entry Strategy	Helical Ramp	
MRR (cm^3)	8.0	31.8
Cycle Time (mins)	85.75	20.93

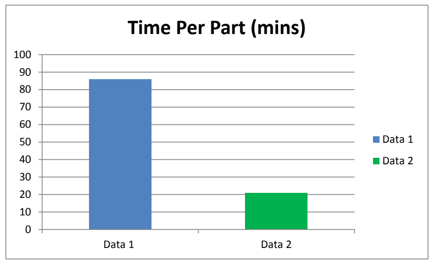
	Test Data 1	Test Data 2
Tool Life (mins)	85.75	84.0
Tool Life (metres)	13.5	267.4
MRR (cm^3)	8.0	31.83

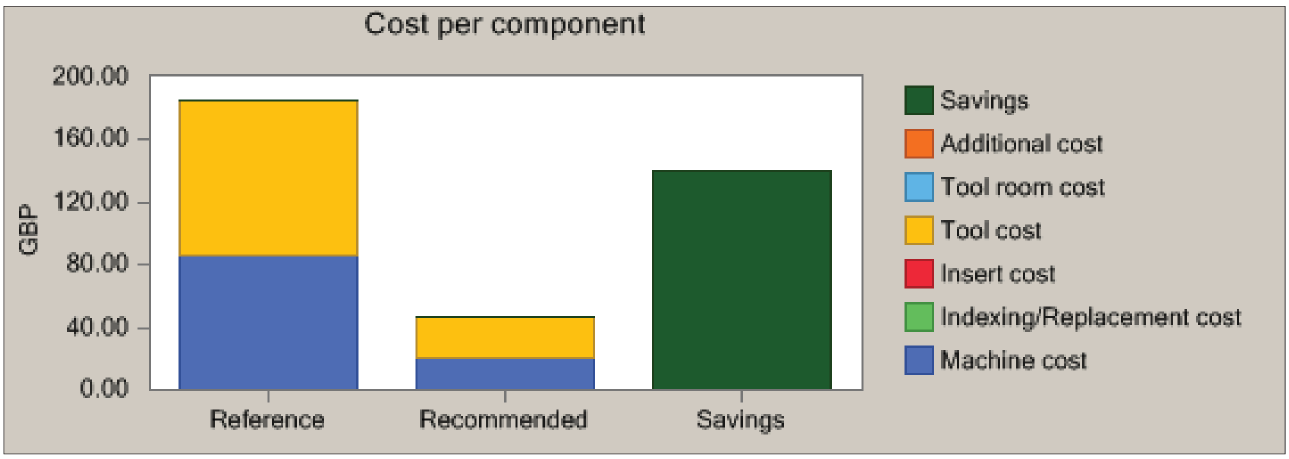
Traditional v's Waveform - Financial Savings (£)

	Test Data 1	Test Data 2
Component	Waveform Bracket	
Batch Size	500	
Machine	Mazak Integrex i200	
Machine Hourly Rate	£50.00	
No Of Components Per Tool	1	4
Tool Cost	£100.00	£25.00
Cycle Time / Component	85.75 mins	20.93 mins
Productivity Increase		308%
Batch Savings (hours)		540 Hours
Batch Savings (£)		£69,875









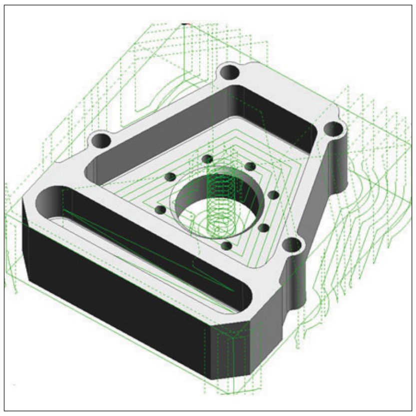
Courtesy of Sandvik Coromant UK

Note :

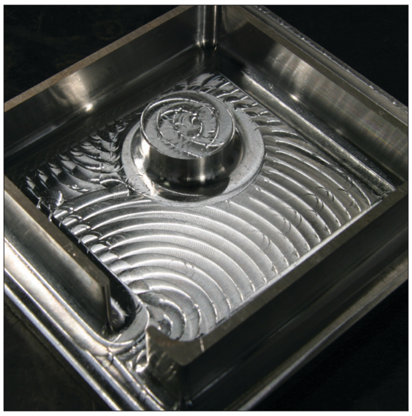
To achieve above 8000 mm/min G05 must be used. When using RPM Speed Reduction for helical approach G05 P2 must be disabled prior to S Block then reinstated at depth as per sample code as follows :

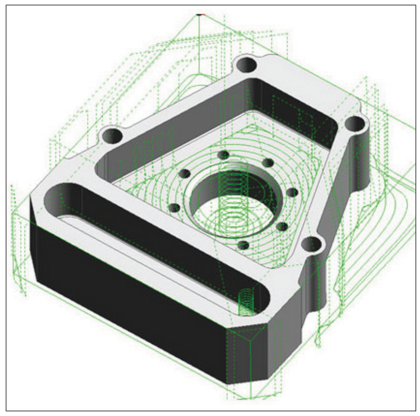
```
G3 X31.321 Y-13.628 I3.6J10
G05 PO.
S12000
G05P2 (HIGH SPEED)
G1 X31.055 Y-14.389 F8000
```

See a movie on your smart device by scanning HERE



Traditional Toolpath





Waveform Toolpath

Starting with tooling, using an odd number of flutes helps with rigidity. Recommendations are to use 5 to 7 flute cutters on Steel and 3 to 5 flute cutters on Aluminium. Using hydraulic, shrink fit or collet chucks are highly recommended. Weldon chucks are not recommended because they don't encompass the full diameter of the cutter, throwing the cutter out of balance.

Place the designated material in your machine's fixture leaving a machinable amount of stock above the work fixture. Assigning the work offset at the lower right corner will simplify the NC code. Looking into the machine, we will test cut the front of the stock from right to left creating a straight line climb cut. A large lead-in will ensure machine acceleration to proper feed rate before entering the cut. Starting with a depth of cut (DoC) of 1 to 1.5 X diameter, calculate speeds and feeds based on suppliers recommendations.

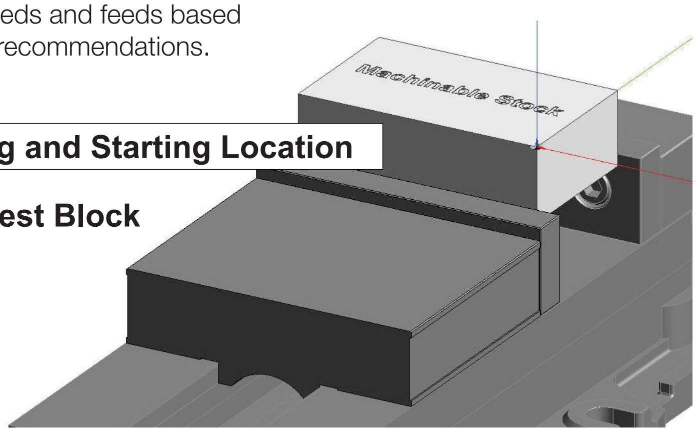
Sample Straight Line Test Code

```
%O1000
N1 G90 G20 G00 G40
N2 T1 M6
N3 S[RPM] M3
N4 M8
N5 X3. Y[%Stepover X Tool Dia]
N6 G43 Z0.25 H01
N7 Z[Depth of Cut]
N8 G1 X-10 F[Feedrate]
N9 G0 Z0.25
N10 G28 Z0
N11 G28 X0
N12 M30
```

Key factors to consider for straight-line test cuts are chip colour, chip edges, load meter, and sound.

Fixturing and Starting Location

Test Block



Proper chips should have a smooth edge from start to end (see photos). In Steel, heat from machining will be removed with the chips, leaving them a bluish brown colour.

Based on your tool type and material, adjusting one parameter at a time, depth of cut or width of cut, will optimise feeds and speeds.

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