5-axis Machining

VTXU

VMX42SR
5-axis Machining

- Benefits of 5 Axis / 5 Sided Machining
- Switching from 3 Axis to 5 Axis
- 3+2/5-axis Control Features
3-axis vs. 5-sided

- **3-axis machining**
  - Multiple setups for each side of the part
  - Increased setup time
  - Decreased part accuracy

- **5-sided machining**
  - Reduces setup times
  - Increases part accuracy
  - Increases shop capabilities

VM3  VMX42SR  VTXU
## Standard 3 Axis

<table>
<thead>
<tr>
<th>Operation</th>
<th>Setup Time</th>
<th>Load Time</th>
<th>Cycle Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 min</td>
<td>20 sec</td>
<td>3 min 58 sec</td>
<td>Drill top holes and C'bore</td>
</tr>
<tr>
<td>2</td>
<td>30 min</td>
<td>20 sec</td>
<td>0 min 42 sec</td>
<td>Facemill back side</td>
</tr>
<tr>
<td>3</td>
<td>30 min</td>
<td>20 sec</td>
<td>1 min 07 sec</td>
<td>Facemill front &amp; mill pockt</td>
</tr>
<tr>
<td>4</td>
<td>30 min</td>
<td>20 sec</td>
<td>2 min 29 sec</td>
<td>Mill, drill &amp; notch right side</td>
</tr>
<tr>
<td>5</td>
<td>30 min</td>
<td>20 sec</td>
<td>2 min 23 sec</td>
<td>Mill &amp; drill left side</td>
</tr>
<tr>
<td>6</td>
<td>1 hr 30 min</td>
<td>20 sec</td>
<td>5 min 05 sec</td>
<td>Mill front angle, drill &amp; C'bore - built fixture to cut angle</td>
</tr>
<tr>
<td>7</td>
<td>1 hr 30 min</td>
<td>20 sec</td>
<td>4 min 03 sec</td>
<td>Mill back angle - built fixture to cut angle</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5 hr 30 min</strong></td>
<td><strong>2 min 20 sec</strong></td>
<td><strong>19 min 47 sec</strong></td>
<td></td>
</tr>
</tbody>
</table>

## Hurco VM10U 5-axis

<table>
<thead>
<tr>
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<th>Setup Time</th>
<th>Load Time</th>
<th>Cycle Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 min</td>
<td>20 sec</td>
<td>1 min 20 sec</td>
<td>Drill, C'bore top side</td>
</tr>
<tr>
<td>2</td>
<td>1 hr</td>
<td>20 sec</td>
<td>11 min 44 sec</td>
<td>Complete the rest of the part</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1 hr 30 min</strong></td>
<td><strong>40 sec</strong></td>
<td><strong>13 min 04 sec</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Time Savings**

<table>
<thead>
<tr>
<th>Standard 3 Axis</th>
<th>Hurco VM10U 5-axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 hrs 1 min 40 sec</td>
<td>6 min 43 sec</td>
</tr>
</tbody>
</table>
3-axis

- Long tools are necessary if cuts are deep
- Problem for fine finishing operations – especially small diameter tools

5-axis

- Z depths are not an issue
- Shorter tools can be used
- Faster feed rates
- Heavier cuts
- Shorter total machining time
Switching from 3-axis to 5-sided

VTXU

VMX42SR

VM3
Switching from 3-axis to 5-sided

- Easy transition to 5-sided work

VTXU

VMX42SR

VM3
Switching from 3-axis to 5-sided

- Easy transition to 5-sided work
- Increases shop capability
Switching from 3-axis to 5-sided

- Easy transition to 5-sided work
- Increases shop capability
- Makes the jump to full 5-axis easier & less scary
5-sided vs. 5-axis

- **5-sided (3+2)**
  - Simple to program
  - Cuts faster
  - Fewer tool interference concerns
  - Excellent roughing strategy

- **5-axis**
  - Better surface finish
  - Longer tool life
  - Allows the tool to reach difficult places smoothly
  - Impressive but slow - avoid if possible
Machine Axis configuration

VTXU

VMX42SR
Why choose an SR over a trunion — and vice versa?
VTXU

• Trunion has better under-cut capability
VTXU

• Trunion has better under-cut capability

• Larger work volume
VTXU

- Trunion has better under-cut capability
- Larger work volume
- More torque at low rpm’s
Table has better weight capacity
VMX42SR

- More versatility by adding a vise

Table has better weight capacity
VMX42SR

• More versatility by adding a vise
• Fewer tool interference issues

Table has better weight capacity
VMX42SR

- More versatility by adding a vise
- Fewer tool interference issues
- Can be run horizontally for better chip control

Table has better weight capacity
Features to look for in 5 Axis Machines
Tool Centre Point Management

Simply program the part in your CAM software using the solid model zero location. No need to account for machine centerlines of rotation.

- Program in work piece coordinate system
- Makes program and part setup independent
- Less complex post-processor
Tool Centre Point Management

- **M128 Code**
- **Simplifies Part Setup.**
- **Eliminates “Re-posting” the part program.**

Step 1. Fixture Part and Locate Part Zero.

Step 2. Enter Distance of Part Zero to Points of Rotation into CAM System and post program.

Step 3. Download G-code Program.

Step 4. Machine Part
Surface Normal

An axial vector that is perpendicular to a surface
Tool Vector

Tool tilt angle & direction away from surface contact point

- G01 X10. Y10. Z10. I0.5 J0.5 K0.707106
Tool Vector

Tool tilt angle & direction away from surface contact point

- G01 X10. Y10. Z10.  I0.5 J0.5 K0.707106
Tool Vector Retract

Tool retracts along the tool tilt angle

• Tool vector angle becomes “Z axis”
• Very important for swivel head machine
Tool Vector Input

Allows a program to run on any five axis machine - regardless of axis configuration.

Workpiece coordinates + tool vector

G01 X10. Y10. Z10. I0.5 J0.5 K0.707106
- the same as -

• Tool Vector input makes programs machine independent
• Control computes machine angles and positions

VIDEO EXAMPLE
Complaint: “...I machine with the tool off centerline to get better tool life and surface finish but I have to repost the program to adjust the tool diameter for wear”

Example

G41.2D_ R_
G00 X0.Y0.Z0. U0.V0.W1. I0.J0.K1.
G01 X10.Y10.Z10. U0.V0.W1. I0.5J0.5K0.707106
Shortest Angular Traverse

**With Shortest angular traverse:**

<table>
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<tr>
<th>Initial Position</th>
<th>Commanded Position</th>
<th>Angular distance traverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>350°</td>
<td>20°</td>
<td>+30°</td>
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**Without Shortest angular traverse:**

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<tr>
<td>350°</td>
<td>20°</td>
<td>-330°</td>
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Toolpath Linearization

Benefits of G43.4 Linearization:

- Eliminates gouging on the workpiece due to improper post-processor linearization methods and tolerances
- Tool tip “attaches” itself to the workpiece
- Doesn’t “blindly” follow rotations
- Smaller NC programs

VIDEO EXAMPLE
Benefits of Hurco conversational for 5-sided work
Benefits of Hurco conversational for 5-sided work

• Easy to set up
Benefits of Hurco conversational for 5-sided work

- Easy to set up
- **Program the part at the control**
Benefits of Hurco conversational for 5-sided work

• Easy to set up
• Program the part at the control
• **No need for CAD/CAM**
Benefits of Hurco conversational for 5-sided work

- Easy to set up
- Program the part at the control
- No need for CAD/CAM
- From print to part – easy!
Conversational Programming
Transform Plane

- Transform plane is defined with a Rotary Position block
- Tool axis always perpendicular to transform plane
- Programs like 2.5D feature
To jump to a block, enter its number.

**EMERGENCY STOP HAS BEEN DEPRESSED.**
| DATA BLOCKS                                      |              | SUB BLOCKS |              |              | MULTIPLE BLOCK FUNCTIONS |              |              |              |              | DELETE BLOCK                                      |              |              |              |              | PART PROGRAMMING                                  |              |              |              |              | PROGRAM PARAMETERS                                |              |              |              |              | PART SETUP                                        |              |              |              |              | PART PROGRAM TOOL REVIEW                          |              |              |              |              | INSERT BLOCK BEFORE                                |              |              |              |              | EXIT                                              |              |              |              |              | Training.HWM                                      |              |              |              |              |
TRANSFORMED PART ZERO - SIDE 2

ORIGINAL PART ZERO
HURCO

BLOCK  3

MILL CIRCLE

X CENTER  4.0000  Z START  0.0500
Y CENTER  4.0000  Z BOTTOM  -0.5000
RADIUS   3.0000

PREVIOUS BLOCK

NEXT BLOCK

DELETE BLOCK

PROGRAM

PARAMETERS

PART SETUP

TOOL SETUP

INSERT BLOCK

BEFORE

EXIT

ROUGHING  FINISHING  SFQ

TOOL  1 END MILL, dia. 0.5000
MILLING TYPE  POCKET BOUNDARY
POCKET TYPE  OUTWARD  POCKET OVERLAP (%)  50
MILL FEED  61.1  PECK DEPTH  0.1000
SPEED (RPM)  6111  PLUNGE FEED  20.0

To jump to a block, enter its number.

EMERGENCY STOP HAS BEEN DEPRESSED.

Training.HWM
To jump to a block, enter its number.

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Training.HWM
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EMERGENCY STOP HAS BEEN DEPRESSED.
Summary

• **Save Time and Reduce Setup Errors with 5 Axis**

• **Select 5 Axis Machine based on Torque, Work Volume and Versatility**

• **Choose a Machine/Control with high end 5 axis features:**
  • **Tool Center Point Management**
  • **Tool Vector Input**
  • **Smooth Tool Path Linearization**
  • **Conversational Programming**
Thank You!