

4 Metric Holes

➡ Answers to questions:

- ❑ 1 - There will be three tools used for this job
- ❑ 2 - The tools will be: Spot Drill Tap Drill, and Tap
- ❑ 3 - Yes, coolant will definitely benefit the machining - see comment below
- ❑ 4 - For M8x1.25 metric tap, the most common tap drill is $\varnothing 6.8$ mm
- ❑ 5 - This job has been successfully tapped at 600 r/min and 750.0 mm/min feedrate

This is a typical program for common holes that have to be spot drilled, drilled and tapped. Possibly the only comment relates to the use of coolant. Although hard nylon has an extremely good machinability, it also has the tendency to melt and clog the flutes of the cutting tool. Coolant will definitely help. Also, keep in mind that the answer #5 may be different and still correct - what is important is the synchronization of the selected spindle speed with the given feedrate. Here are some details relating to various calculations.

The complete project with the four metric holes has been designed to illustrate a complete development of a CNC program, from the time the drawing has been received, to the completed program, ready to be loaded into the CNC machine memory. The following settings are actual settings when the part was machined, and will vary for any next setup. The CNC machine was a medium size machining center, with Fanuc O-M control. Keep in mind that the actual numbers have no meaning off the machine, but they do serve the purpose of showing typical setting values. See the setup drawing for offset measurements.

➡ Work Offset:

The G54 work offset was set from the machine zero to the part zero as:

X-340.276 Y-137.919 Z0.000

➡ Tool Length Offset:

Each tool must have a tool length offset number *Hxx* – the offset number corresponds to the tool number:

Tool 1 (T01) H01: -331.417

Tool 2 (T02) H02: -288.335

Tool 3 (T03) H03: -266.543

Note that the smaller the tool length amount stored, the longer the actual length of the tool is.

➡ TOOL 1 CALCULATIONS

- ❑ Tool T01 – Spindle speed calculation:

Spindle speed was based on the surface speed of 45 m/min, therefore:

$$45 \times 1000 / (3.1416 \times 8.6) = 1665.57 = S1666$$

- ❑ Tool T01 – Spot drill depth calculation:

Spot drill has a 90° included angle at its tip. That means the spot drill depth must be equal to one half of the chamfer diameter. Chamfer size is selected by the programmer, in this case 0.3 mm. As the chamfer is around the circumference of the hole, it has to be added twice to the thread diameter:

```
Thread diameter = 8.0
Chamfer = 0.3 x 45
Chamfer diameter = 8.0 + 0.3 x 2 = 8.6
Z-depth = 8.6 / 2 = 4.3, programmed as Z-4.3
```

➡ TOOL 2 CALCULATIONS

- ❑ Tool T02 – Spindle speed calculation:

Spindle speed was based on the surface speed of 45 m/min, therefore:

$$45 \times 1000 / (3.1416 \times 6.8) = 2106.46 = S2106$$

- ❑ Tool T02 – Depth of drill calculation:

The tap drill ($\varnothing 6.8$ mm) breaks through the part, so the part thickness is important. An extra clearance below the part is also required, to guarantee a full diameter hole. In addition, the tool tip length must be considered, as the tool length has been measured to the tool tip.

```
Part thickness = 18 mm
Breakthrough clearance = 1.5 mm
Drill diameter = 6.8
Tool tip length = 6.8 x 0.3 = 2.04
Z-depth = 18 + 1.5 + 2.04 = 21.540, programmed as Z-21.54
```

Note: 0.3 is a standard constant to calculate tool point length P of a drill diameter D with 118° point angle:

$$P = D \times 0.3$$

➡ TOOL 3 CALCULATIONS

- ❑ Tool T03 – Spindle speed calculation:

Spindle speed was based on the surface speed of 15 m/min, therefore:

$$15 \times 1000 / (3.1416 \times 8) = 596.83 = S600$$

- ❑ Tool T03 – Feedrate calculation:

Feedrate in mm/min must match the thread pitch to the spindle speed in r/min, in order to synchronize the tap velocity, therefore:

```
Pitch = 1.125
Tapping federate (general) = r/min x Pitch
Tapping federate = 600 x 1.25 = 750 mm/min, programmed as F750.0
```

- ❑ Tool T03 – Depth of tap calculation:

To guarantee tapping through the hole, 2.5x pitch clearance has been used to breakthrough the part, and added to the part thickness:

```
Part thickness = 18 mm
Thread pitch = 1.25 mm
Breakthrough clearance = 2.5 x 1.25 = 3.125
Z-depth = 18 + 3.125 = 21.125, programmed as Z-21.125
```

(26-02 - 4 HOLES-METRIC)

(HARD NYLON - 75 X 50 X 18 MM BLOCK)
(X0Y0 - LOWER LEFT CORNER - Z0 TOP OF PART)

(T01 - 90 DEGREE SPOT DRILL - 12 MM DIA)
(T02 - 6.8 MM DIA TAP DRILL)
(T03 - M8X1.25 PLUG TAP)

(T01 - 90 DEGREE SPOT DRILL - 12 MM DIA)
N1 G21
N2 G17 G40 G80 T01
N3 M06
N4 G90 G54 G00 X14.0 Y15.5 S1666 M03 T02
N5 G43 Z25.0 H01 M08
N6 G99 G82 R2.0 Z-4.3 P200 F100.0
N7 X20.5 Y36.0
N8 X45.0
N9 X60.0 Y23.0
N10 G80 G00 Z25.0 M09
N11 G28 Z25.0 M05
N12 M01

(T02 - 6.8 MM DIA TAP DRILL)
N13 T02
N14 M06
N15 G90 G54 G00 X60.0 Y23.0 S2106 M03 T03
N16 G43 Z25.0 H02 M08
N17 G99 G81 R2.0 Z-21.54 F250.0
N18 X45.0 Y36.0
N19 X20.5
N20 X14.0 Y15.5
N21 G80 G00 Z25.0 M09
N22 G28 Z25.0 M05
N23 M01

(T03 - M8X1.25 PLUG TAP)
N24 T03
N25 M06
N26 G90 G54 G00 X14.0 Y15.5 S600 M03 T01
N27 G43 Z25.0 H03 M08
N28 G99 G84 R5.0 Z-21.125 F750.0
N29 X20.5 Y36.0
N30 X45.0
N31 X60.0 Y23.0
N32 G80 G00 Z25.0 M09
N33 G28 Z25.0 M05
N34 G28 X60.0 Y23.0
N35 M30
%

(METRIC UNITS SETTING)
(CANCEL AT STARTUP - SEARCH FOR T01)
(ATC - T01 INTO SPINDLE - T01 ACTIVE)
(ABS-WORK OFFSET-RPD-SPINDLE-SEARCH T02)
(LG OFFSET H01-MOVE TO CLEAR-COOLANT ON)
(SPOT DRILLING CYCLE - HOLE NO. 1 OF 4)
(SPOT DRILLING CYCLE - HOLE NO. 2 OF 4)
(SPOT DRILLING CYCLE - HOLE NO. 3 OF 4)
(SPOT DRILLING CYCLE - HOLE NO. 4 OF 4)
(CYCLE CANCEL-CLEAR RETRACT-COOLANT OFF)
(HOME IN Z-AXIS - SPINDLE STOP)
(OPTIONAL STOP)

(SEARCH FOR T02)
(ATC - T02 INTO SPINDLE - T02 ACTIVE)
(ABS-WORK OFFSET-RPD-SPINDLE-SEARCH T03)
(LG OFFSET H02-MOVE TO CLEAR-COOLANT ON)
(DRILL CYCLE - THROUGH - HOLE NO. 4 OF 4)
(DRILL CYCLE - THROUGH - HOLE NO. 3 OF 4)
(DRILL CYCLE - THROUGH - HOLE NO. 2 OF 4)
(DRILL CYCLE - THROUGH - HOLE NO. 1 OF 4)
(CYCLE CANCEL-CLEAR RETRACT-COOLANT OFF)
(HOME IN Z-AXIS - SPINDLE STOP)
(OPTIONAL STOP)

(SEARCH FOR T03)
(ATC - T03 INTO SPINDLE - T03 ACTIVE)
(ABS-WORK OFFSET-RPD-SPINDLE-SEARCH T01)
(LG OFFSET H03-MOVE TO CLEAR-COOLANT ON)
(TAPPING CYCLE - HOLE NO. 1 OF 4)
(TAPPING CYCLE - HOLE NO. 2 OF 4)
(TAPPING CYCLE - HOLE NO. 3 OF 4)
(TAPPING CYCLE - HOLE NO. 4 OF 4)
(CYCLE CANCEL-CLEAR RETRACT-COOLANT OFF)
(HOME IN Z-AXIS - SPINDLE STOP)
(HOME IN XY-AXES - SPINDLE STOP)
(END OF PROGRAM - RETURN TO TOP)
(FILE END MARKER FOR COMMUNICATIONS)