39-04 Solution

Comprehensive Subprogram 1

This project may take an extra time. The five tools used in the program will apply to the following operations :

- T01 - ∅3.0 Face Mill

The face mill will clean the top face to 0.45 part height. Two cuts are provided along the Y-axis.

- T02 - ∅1/2 Spot Drill

The spot drill will chamfer all 12 holes to Z-0.14 depth (∅0.25 hole + 2 × 0.015 chamfer at 45°)

- T03 - ∅1/4 Drill

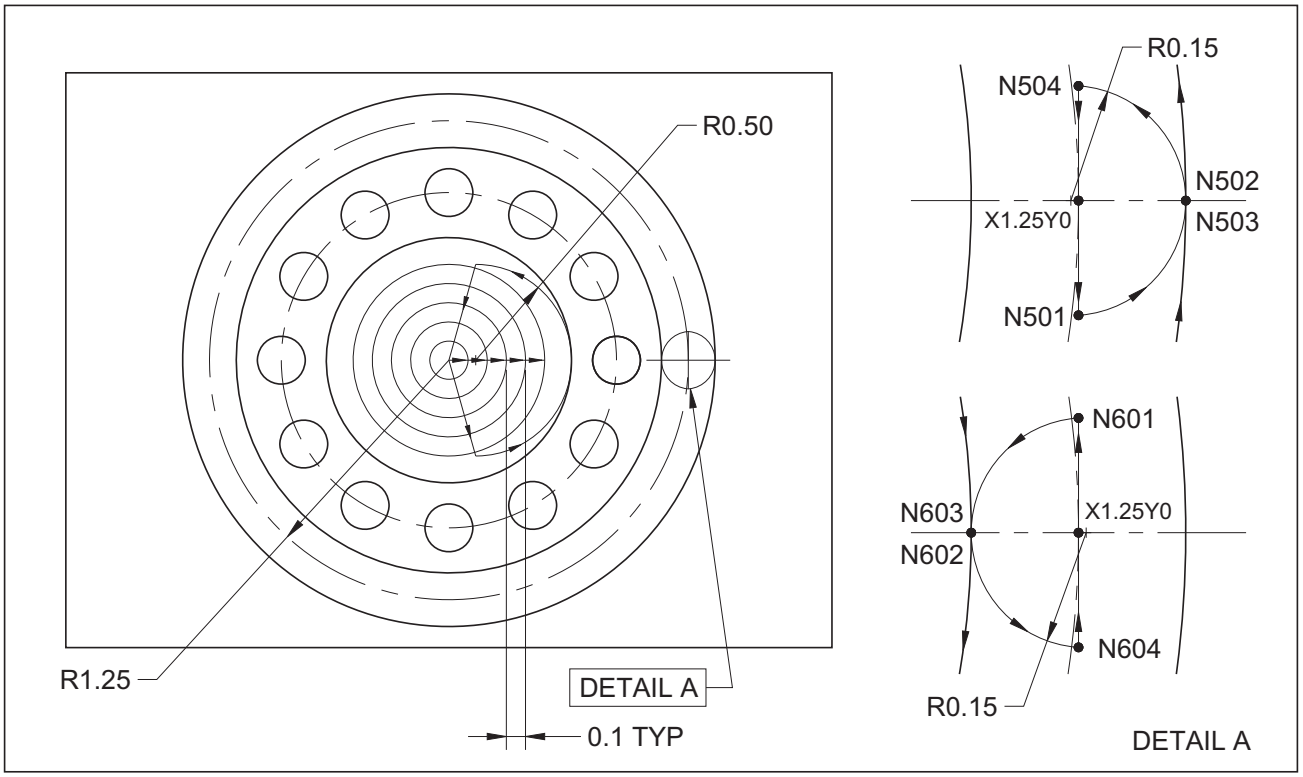
The drill will use the peck drilling method to drill all 12 holes through the material:
Z=0.45 plate thickness + 0.3 × ∅0.25 drill + 0.05 breakthrough clearance = Z-0.575

- T04 - ∅1/4 Center cutting end mill

The center cutting end mill (also called a *slot drill*) will rough out the ∅1.28 pocket in X-axis stepovers of 0.1 each, 0.05 depth at a time. Then, it will rough out the circular groove (slot). After roughing, the pocket is semifinished and finished, and the groove is finished by machining each circular wall individually.

- T05 - ∅3/8 Chamfering tool

The chamfering will break corners (sharp edges) on the 4×3 block, the circular pocket, and both walls of the circular slot. All important blocks are documented in the program in form of comments. The most important objective is to learn how a program can be written efficiently. Programming tools include not only subprograms but also multiple offsets (note the suggested values in the program).



Programs like this demand some very careful studying. Start evaluating one operation at a time. Study the given drawing, the supplied details and the program itself. It will take more than just one casual look to fully understand the subtleties of the program. Note the lead-in and lead-out motions in the detailed drawing. For an easier orientation, the block numbers shown in the detailed drawing, correspond to the block numbers in the subprogram.

The program is as short as possible to satisfy all the conditions established earlier..

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(39-04.NC - MATERIAL - 4 X 3 X 1/2 ALUMINUM PLATE - HORIZONTAL ORIENTATION)
(X0 Y0 IS CENTER OF 2.78 DIA - Z0 IS FINISHED TOP OF PLATE)

(T01 - 3.0 DIA FACE MILL - CLEAN UP TOP FACE)
(T02 - 1/2 DIA SPOT DRILL - 90 DEGREES)
(T03 - 1/4 DIA DRILL)
(T04 - 1/4 DIA SLOT DRILL - DEPTH OF CUT 0.05 MAX)
(T05 - 3/8 DIA CHAMFERING TOOL - 45 DEGREES)
(D51 - OFFSET FOR SEMI-FINISHING WITH T04 - NOMINAL 0.1300)
(D52 - OFFSET FOR FINISHING WITH T04      - NOMINAL 0.1250)
(D53 - OFFSET FOR CHAMFERING WITH T05     - NOMINAL 0.1100)

(T01 - 3.0 DIA FACE MILL - CLEAN UP TOP FACE)
N1 G20
N2 G17 G40 G80 T01
N3 M06
N4 G90 G54 G00 X-1.375 Y-3.25 S3500 M03 T02
N5 G43 Z1.0 H01 M08
N6 G01 Z0 F30.0
N7 Y3.125 F15.0
N8 G00 X1.375
N9 G01 Y-3.25
N10 G00 Z1.0 M09
N11 G28 Z1.0 M05
N12 X-2.0 Y8.0
N13 M01

(T02 - 1/2 DIA SPOT DRILL - 90 DEGREES)
N14 T02
N15 M06
N16 G90 G54 G00 X0 Y0 S3800 M03 T03
N17 G43 Z1.0 H02 M08
N18 G99 G82 R0.05 Z-0.14 P200 F5.0 L0
N19 M98 P2001
N20 G80 Z1.0 M09
N21 G28 Z1.0 M05
N22 X-2.0 Y8.0
N23 M01

(T03 - 1/4 DIA DRILL)
N24 T03
N25 M06
N26 G90 G54 G00 X0 Y0 S2000 M03 T04
N27 G43 Z1.0 H03 M08
N28 G99 G73 R0.05 Z-0.575 Q0.2 F6.0 L0
N29 M98 P2001
N30 G80 Z1.0 M09
N31 G28 Z1.0 M05
N32 X-2.0 Y8.0
N33 M01

(T04 - 1/4 DIA SLOT DRILL)
N34 T04
N35 M06
N36 G90 G54 G00 X0 Y0 S3500 M03 T05
N37 G43 Z1.0 H04 M08
N38 G01 Z0.1 F50.0
N39 Z0 F6.0
N40 M98 P2002 L4                          (ROUGH POCKET - 4 CUTS)
N41 G00 Z0.1
N42 X1.25 Y0                              (START OF SLOT)
N43 G01 Z0.005 F10.0                      (LEAVE 0.005 FOR FINISHING)
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N44 M98 P2003 L5                              (ROUGH SLOT AT CENTER)
N45 G00 Z0.1
N46 X0 Y0
N47 G01 Z-0.2 F5.0
N48 M98 P2004 D51 F6.0                        (SEMI-FINISH CIRCULAR POCKET)
N49 M98 P2004 D52 F6.0                        (FINISH CIRCULAR POCKET)
N50 G00 Z0.1
N51 X1.25 Y0
N52 Z-0.25 F3.0                               (SLOT FULL DEPTH)
N53 M98 P2005 D52 F6.0                        (FINISH 2.78 DIA OF SLOT)
N54 M98 P2006 D52 F6.0                        (FINISH 2.22 DIA OF SLOT)
N55 G00 Z1.0 M09
N56 G28 Z1.0 M05
N57 X-2.0 Y8.0
N58 M01

(T05 - 3/8 DIA CHAMFERING TOOL - 45 DEGREES)
N59 T05
N60 M06
N61 G90 G54 G00 X-2.5 Y-2.0 S4000 M03 T01
N62 G43 Z1.0 H05 M08
N63 G01 Z-0.075 F50.0
N64 G41 X-2.0 D53                             (CHAMFER 4 X 3 BLOCK)
N65 Y1.5 F12.0
N66 X2.0
N67 Y-1.5
N68 X-2.5
N69 G00 G40 Y-2.0
N70 Z0.1
N71 X0 Y0
N72 G01 Z-0.075
N73 M98 P2004 D53 F12.0                       (CHAMFER CIRCULAR POCKET)
N74 G00 Z0.1
N75 X1.25 Y0
N76 G01 Z-0.075
N77 M98 P2005 D53 F12.0                       (CHAMFER 2.78 SLOT DIA)
N78 M98 P2006 D53 F12.0                       (CHAMFER 2.22 SLOT DIA)
N79 G00 Z0.1 M09
N80 G28 Z0.1 M05
N81 X-2.0 Y8.0
N82 M30
%

(****** SUBPROGRAMS ******)
O2001 (12 HOLES)
N101 X0.875 Y0                                (HOLE 1)
N102 X0.7578 Y0.4375                          (HOLE 2)
N103 X0.4375 Y0.7578                          (HOLE 3)
N104 X0 Y0.875                                (HOLE 4)
N105 X-0.4375 Y0.7578                         (HOLE 5)
N106 X-0.7578 Y0.4375                         (HOLE 6)
N107 X-0.875 Y0                               (HOLE 7)
N108 X-0.7578 Y-0.4375                        (HOLE 8)
N109 X-0.4375 Y-0.7578                        (HOLE 9)
N110 X0 Y-0.875                               (HOLE 10)
N111 X0.4375 Y-0.7578                         (HOLE 11)
N112 X0.7578 Y-0.4375                         (HOLE 12)
N113 M99                                      (END OF SUBPROGRAM O2001)
%

O2002 (ROUGH 1.28 DIA CIRCULAR POCKET)
N201 G91 Z-0.05 F2.0                          (0.05 DEPTH OF CUT)
N202 G90 G01 X0.1 F6.0                        (0.1 STEP FOR ROUGH CUT 1 OF 5)
N203 G03 I-0.1                                (ROUGH CUT 1 - FULL CIRCLE)
N204 G01 X0.2                                 (0.1 STEP FOR ROUGH CUT 2 OF 5)
N205 G03 I-0.2                                (ROUGH CUT 2 - FULL CIRCLE)
N206 G01 X0.3                                 (0.1 STEP FOR ROUGH CUT 3 OF 5)
N207 G03 I-0.3                                (ROUGH CUT 3 - FULL CIRCLE)
N208 G01 X0.4                                 (0.1 STEP FOR ROUGH CUT 4 OF 5)
N209 G03 I-0.4                                (ROUGH CUT 4 - FULL CIRCLE)
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N210 G01 X0.5                              (0.1 STEP FOR ROUGH CUT 5 OF 5)
N211 G03 I-0.5                             (ROUGH CUT 5 - FULL CIRCLE)
N212 G01 X0 F15.0                          (MOVE TOOL TO CENTER)
N213 M99                                   (END OF SUBPROGRAM O2002)
%

O2003 (ROUGH SLOT AT CENTER - START AT X1.25 Y0)
(ROUGH AT 2.50 DIA - CENTER OF SLOT)
N301 G91 G01 Z-0.05 F2.0
N302 G90 G03 I-1.25 F10.0                  (FULL CIRCLE FOR ROUGH GROOVE)
N303 M99                                   (END OF SUBPROGRAM O2003)
%

O2004 (CIRCULAR POCKET - WALL FINISH - START AT X0 Y0)
(CIRCULAR POCKET - SEMI-FINISHING WITH OFFSET D51)
(CIRCULAR POCKET - FINISHING WITH OFFSET D52)
(CHAMFER POCKET - WITH D53)
N401 G41 X0.14 Y-0.5                       (LINEAR MOTION TO LEAD-IN ARC)
N402 G03 X0.64 Y0 R0.5                     (LEAD-IN ARC TO FULL CIRCLE)
N403 I-0.64                                (FULL CIRCLE 1.28 DIA)
N404 X0.14 Y0.5 R0.5                       (LEAD-OUT ARC FROM FULL CIRCLE)
N405 G40 G01 X0 Y0                         (LINEAR MOTION TO CENTER)
N406 M99                                   (END OF SUBPROGRAM O2004)
%

O2005 (2.78 DIA SLOT FINISH - START AT X1.25 Y0)
(FINISH 2.78 SLOT DIA - OFFSET D52)
(CHAMFER 2.78 SLOT DIA - OFFSET D53)
N501 G01 G41 Y-0.15                        (LINEAR MOTION TO LEAD-IN ARC)
N502 G03 X1.39 Y0 R0.15                    (LEAD-IN ARC TO FULL CIRCLE)
N503 I-1.39                                (FULL CIRCLE OF 2.78 DIA)
N504 X1.25 Y0.15 R0.15                     (LEAD-OUT ARC FROM FULL CIRCLE)
N505 G01 G40 Y0                            (LINEAR MOTION TO START POINT)
N506 M99                                   (END OF SUBPROGRAM O2005)
%

O2006 (2.22 DIA SLOT FINISH - START AT X1.25 Y0)
(FINISH 2.22 SLOT DIA - OFFSET D52)
(CHAMFER 2.22 SLOT DIA - OFFSET D53)
N601 G01 G41 Y0.15                         (LINEAR MOTION TO LEAD-IN ARC)
N602 G03 X1.11 Y0 R0.15                    (LEAD-IN ARC TO FULL CIRCLE)
N603 G02 I-1.11                            (FULL CIRCLE OF 2.22 DIA)
N604 G03 X1.25 Y-0.15 R0.15                (LEAD-OUT ARC FROM FULL CIRCLE)
N605 G01 G40 Y0                            (LINEAR MOTION TO START POINT)
N606 M99                                   (END OF SUBPROGRAM O2006)
%
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