30-06 Solution

Cutter Radius Offset - Part 2

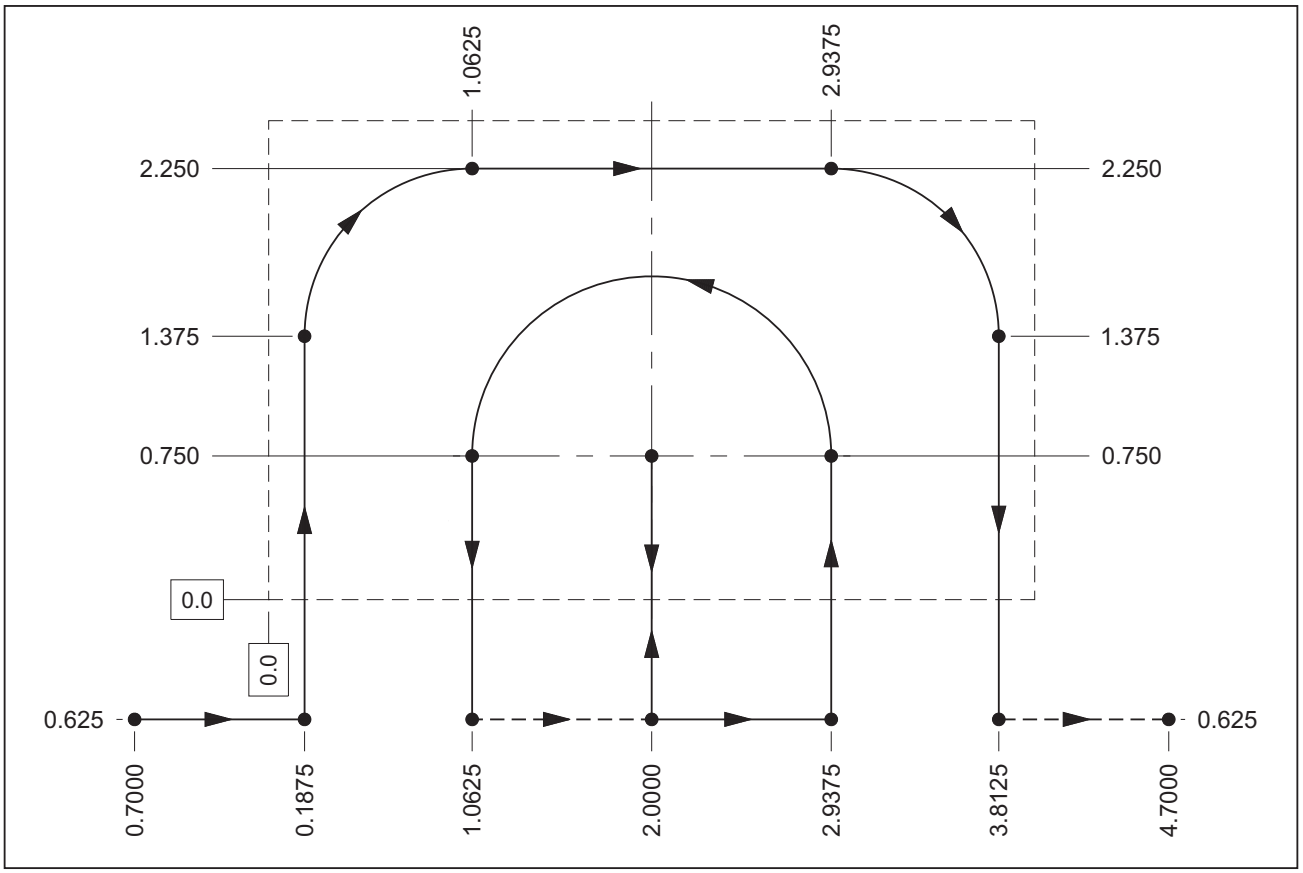
Drawing Evaluation

Just as in *Part 1* of this project, the most important drawing requirements are the tolerances on the outside contour and in the open slot. In this second part, the tolerances have changed - for the contour, thay have changed from ±0.001 to +0.002/+0.004, and for the slot, they have changed from ±0.001 to +0.003/+0.006. The program *30-05* has to be changed as well, although the cutting tools remain the same. The stock allowance requirement also remains the same - 0.015 on the walls and 0.01 on the bottom.

In the drawing, the tolerances are perhaps unreasonable from the engineering point of view, but they do represent a situation, where their range is the *same* for the outside contour *and* the inside contour (both into the plus direction, programmed with the *same* tool). The exaggeration here is intentional, to avoid a misunderstanding.

THE RANGE OF TOLERANCES IS FOR TRAINING PURPOSES ONLY

The following illustration is exactly the same as for *30-05* - it shows all cutting motions and the coordinates of each contour point. All dimensions are based on the part drawing:



Programming Cutter Radius

As in the *Part 1*, the cutter radius offset will be used for both roughing and finishing operations, with the exception of the slot startup, where no radius offset will be used. In all cases, climb milling mode will be also be used. For the purposes of this project, the nominal cutter diameter will be assumed for setting the offset values. In actual machining, the situation may be slightly different but based on the same principles.

The key to understanding radius offsets is to understand what makes a size within tolerances. Both the contour *and* the slot must be oversize - tolerances are on the plus side for both profiles - using the same tool! Oversize on the outside contour means to leave *more* stock, oversize on the inside slot means to leave *less* stock. The solution?

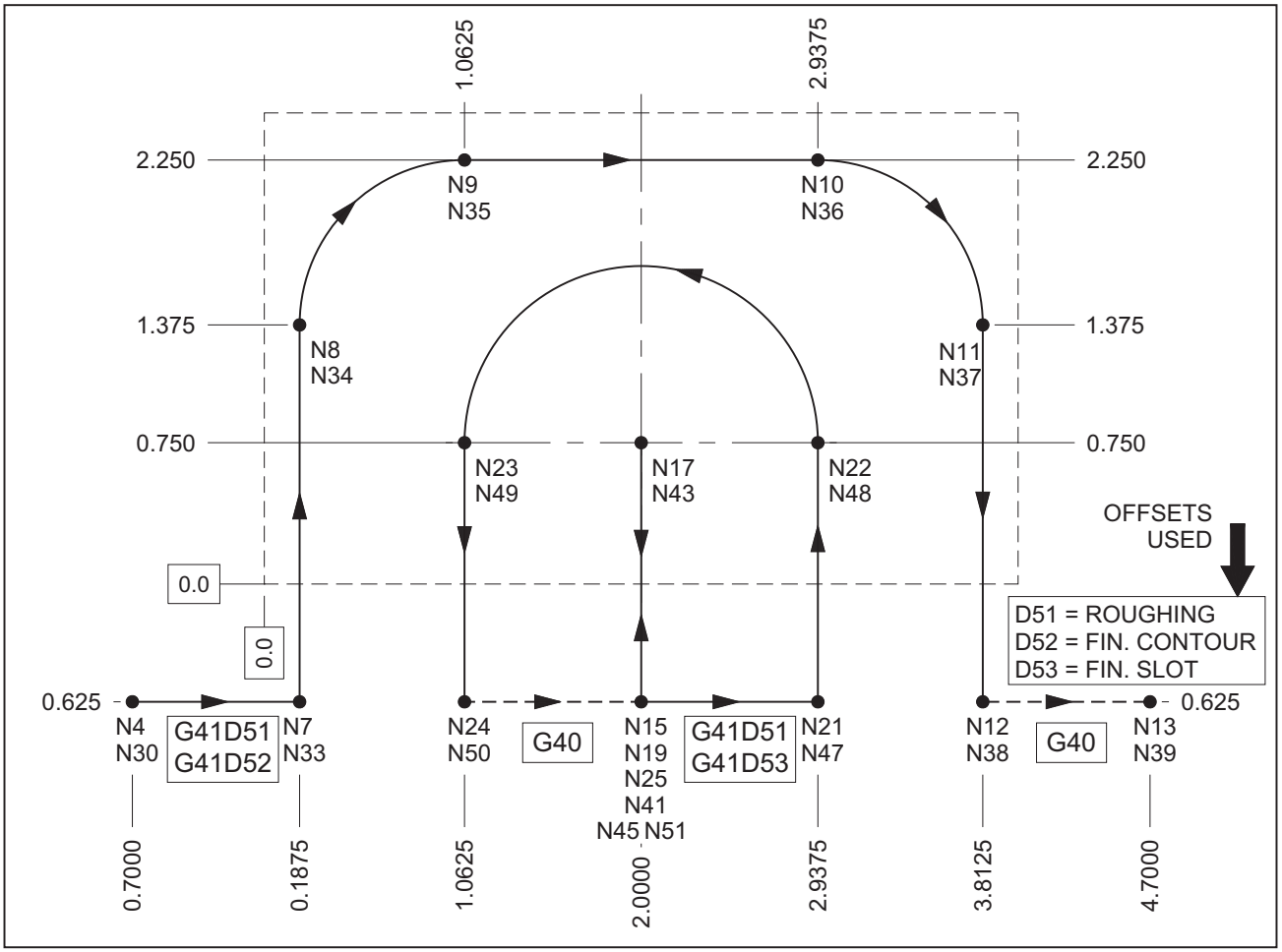
This type of dimensioning tolerances must use *two offsets*, usually for the finishing path only. Use one offset for the outside contour - it will be *larger* than the nominal cutter radius. Use another offset for the inside slot - it will be *smaller* than the nominal radius. In this example, the mid-size tolerance will be used for both finishing offsets. Note - either offset has to be adjusted per side of the contour, not per width.

To find the new offset values, find the *difference per side* for each toolpath:

☞ For the contour, the width has increased by (0.002+0.004)/2=0.003, which is 0.0015 per side. The new offset will be ***larger***, as more stock will be ***added*** to the contour - from the original 0.375 to the modified 0.3765.

☞ For the slot, the width has increased by (0.003+0.006)/2=0.0045, which is 0.0023 per side. The new offset will be ***smaller***, as more stock will be ***removed*** from the slot - from the original 0.375 to the modified 0.3728.

In the program listing, the initial comments suggest the offset values. Note the blocks that initiate and cancel each offset. The following program shows the cutter radius offset for each tool, matching the earlier illustrations:



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(30-06 - CUTTER RADIUS OFFSET - MULTI OFFSET FOR THE FINISHING TOOL)
(D51 FOR ROUGHING  = 0.5150 - CONTROLS OFFSET FOR A SINGLE TOOL)
(D52 FOR FINISHING = 0.3765 - CONTROLS THE WIDTH OF THE CONTOUR)
(D53 FOR FINISHING = 0.3728 - CONTROLS THE WIDTH OF THE SLOT)
(*** THERE WAS NO CHANGE IN BLOCKS N1 TO N27 ***)

N1 G20                                          (T01 - 1.0 DIA END MILL - ROUGHING)
N2 G17 G40 G80 T01
N3 M06
N4 G90 G54 G00 X-0.7 Y-0.625 S3000 M03 T02
N5 G43 Z0.1 H01 M08
N6 Z-0.29                                       (0.01 STOCK ON CONTOUR DEPTH)
N7 G01 G41 D51 X0.1875 F12.0                    (START OF CONTOUR - G41 D51 APPLIED)
N8 Y1.375 F10.0
N9 G02 X1.0625 Y2.25 R0.875
N10 G01 X2.9375
N11 G02 X3.8125 Y1.375 R0.875
N12 G01 Y-0.625
N13 G00 G40 X4.7                                (END OF CONTOUR - G40)
N14 Z0.1
N15 X2.0
N16 Z-0.24                                      (0.01 STOCK ON SLOT DEPTH)
N17 G01 Y0.75                                   (ROUGH OUT SLOT CENTER)
N18 G00 Z0.1
N19 Y-0.625
N20 Z-0.24                                      (0.01 STOCK ON SLOT DEPTH)
N21 G01 G41 D51 X2.9375                         (START OF SLOT - G41 D51 APPLIED)
N22 Y0.75
N23 G03 X1.0625 R0.9375
N24 G01 Y-0.625
N25 G00 G40 X2.0 M09                            (END OF SLOT - G40)
N26 G28 Z1.0 M05
N27 M01

N28 T02                                         (T02 - 0.75 DIA END MILL - FINISHING)
N29 M06
N30 G90 G54 G00 X-0.7 Y-0.625 S3250 M03 T01
N31 G43 Z0.1 H02 M08
N32 Z-0.3                                       (CONTOUR FULL DEPTH)
N33 G01 G41 D52 X0.1875 F12.0                   (START OF CONTOUR - G41 D52 APPLIED)
N34 Y1.375 F8.0
N35 G02 X1.0625 Y2.25 R0.875
N36 G01 X2.9375
N37 G02 X3.8125 T1.375 R0.875
N38 G01 Y-0.625
N39 G00 G40 X4.7                                (END OF CONTOUR - G40)
N40 Z0.1
N41 X2.0
N42 Z-0.25                                      (SLOT CENTER CLEANUP)
N43 G01 Y0.75
N44 G00 Z0.1
N45 Y-0.625
N46 Z-0.25                                      (SLOT FULL DEPTH)
N47 G01 G41 D53 X2.9375                         (START OF SLOT - G41 D53 APPLIED)
N48 Y0.75
N49 G03 X1.0625 R0.9375
N50 G01 Y-0.625
N51 G00 G40 X2.0 M09                            (END OF SLOT - G40)
N52 G28 Z1.0 M05
N53 X-1.5 Y10.0
N54 M30
%
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Both parts of this project use only a single roughing offset for both contours. Because of the tolerance requirements, this choice will result in a slightly different amount of stock left for finishing each contour. In most cases, the amount is negligible and poses no problem. If the stock needs to be the same for both contour and the slot, program two offsets for the roughing cuts as well, which will guarantee the same stock allowance for both toolpaths.