

42 Hole Pattern

A standard CNC program can be developed using fixed cycles in incremental mode with the repetition count.

➔ Project 39-03A:

```

(39-03A - 42 HOLES - NO SUBPROGRAM)
(T01 - 0.5 DIA 90 DEGREE SPOT DRILL)
N1 G20
N2 G17 G40 G80 T01
N3 M06
N4 G90 G00 G54 X0.5 Y0.5 S850 M03 T02          (MOVE TO LOWER LEFT HOLE)
N5 G43 Z1.0 H01 M08
N6 G99 G82 R0.1 Z-0.14 P300 F4.0              (FIRST HOLE OF ROW 1)
N7 G91 X0.5 L6                                (ROW 1)
N8 Y0.4                                        (FIRST HOLE OF ROW 2)
N9 X-0.5 L6                                   (ROW 2)
N10 Y0.4                                       (FIRST HOLE OF ROW 3)
N11 X0.5 L6                                    (ROW 3)
N12 Y0.4                                       (FIRST HOLE OF ROW 4)
N13 X-0.5 L6                                   (ROW 4)
N14 Y0.4                                       (FIRST HOLE OF ROW 5)
N15 X0.5 L6                                    (ROW 5)
N16 Y0.4                                       (FIRST HOLE OF ROW 6)
N17 X-0.5 L6                                   (ROW 6)
N18 G90 G80 Z1.0 M09
N19 G28 Z1.0 M05
N20 M01

(T02 - NO 7 - 0.201 DIA TAP DRILL)
N21 T02
N22 M06
N23 G90 G00 G54 X0.5 Y2.5 S700 M03 T03        (MOVE TO UPPER LEFT HOLE)
N24 G43 Z1.0 H02 M08
N25 G99 G81 R0.1 Z-0.61 F7.0
N26 G91 X0.5 L6                                (FIRST HOLE OF ROW 6)
N27 Y-0.4                                       (ROW 6)
N28 X-0.5 L6                                   (FIRST HOLE OF ROW 5)
N29 Y-0.4                                       (ROW 5)
N30 X0.5 L6                                    (FIRST HOLE OF ROW 4)
N31 Y-0.4                                       (ROW 4)
N32 X-0.5 L6                                   (FIRST HOLE OF ROW 3)
N33 Y-0.4                                       (ROW 3)
N34 X0.5 L6                                    (FIRST HOLE OF ROW 2)
N35 Y-0.4                                       (ROW 2)
N36 X-0.5 L6                                   (FIRST HOLE OF ROW 1)
N37 G90 G80 Z1.0 M09
N38 G28 Z1.0 M05
N39 M01

(T03 - 1/4-20 PLUG TAP)
N40 T03
N41 M06
N42 G90 G00 G54 X0.5 Y0.5 S500 M03 T01        (MOVE TO LOWER LEFT HOLE)
N43 G43 Z1.0 H03 M08
N44 G99 G84 R0.25 Z-0.65 F25.0
N45 G91 X0.5 L6                                (FIRST HOLE OF ROW 1)
N46 Y0.4                                       (ROW 1)
N47 X-0.5 L6                                   (FIRST HOLE OF ROW 2)
N48 Y0.4                                       (ROW 2)
N49 X0.5 L6                                    (FIRST HOLE OF ROW 3)
N50 Y0.4                                       (ROW 3)

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N50 Y0.4 (FIRST HOLE OF ROW 4)
N51 X-0.5 L6 (ROW 4)
N52 Y0.4 (FIRST HOLE OF ROW 5)
N53 X0.5 L6 (ROW 5)
N54 Y0.4 (FIRST HOLE OF ROW 6)
N55 X-0.5 L6 (ROW 6)
N56 G90 G80 Z1.0 M09
N57 G28 Z1.0 M05
N58 X-2.0 Y7.0
N59 M30
%
```

The program above does not use any subprogramming shortcuts, but it does use the incremental mode and the repetitive count whenever possible. In the example the address *L* is used. Some controls require the *K* address.

➡ Project 39-03B:

The same program will be more efficient if the motions that are repeated for each tool can be stored once, and recalled many times, as needed. Which are these motions? Starting from the lower left hole of the bottom row, we make the first hole normally, after the initial approach:

```

G90 G54 G00 X0.5 Y0.5 S850 M03 T02 (LOWER LEFT HOLE)
G43 Z1.0 H01 M08
G99 G82 R0.1 Z-0.14 P300 F4.0
```

Once the cycle has been initiated, the holes in Row 1 are machined in X+ direction, then the tool moves along Y+ to the Row 2 and machines the holes in the X- direction. When the second row is done, the tool moves along Y+ to the Row 3, and the two-row pattern repeats. If the repeating pattern is isolated, the subprogram starts to develop:

```

G91 X0.5 L6 (ROW 1)
Y0.4 (FIRST HOLE OF ROW 2)
X-0.5 L6 (ROW 2)
Y0.4 (FIRST HOLE OF ROW 3)
```

If this pattern of holes is stored as a subprogram, a program number must be assigned (O5001 for the example), and the subprogram terminated with M99:

```

O5001 (SUBPROGRAM)
G91 X0.5 L6 (ROW 1 - ROW 3 - ROW 5)
Y0.4 (FIRST HOLE OF ROW 2 - ROW 4 - ROW 6)
X-0.5 L6 (ROW 2 - ROW 4 - ROW 6)
Y0.4 (FIRST HOLE OF ROW 3 - ROW 5)
M99
%
```

The subprogram can be called by the main program, three times for each tool. Only the first tool is shown:

```


(T01 - 0.5 DIA 90 DEGREE SPOT DRILL)
N1 G20
N2 G17 G40 G80 T01 M06
N3 G90 G54 G00 X0.5 Y0.5 S850 M03 T02 (MOVE TO LOWER LEFT HOLE)
N4 G43 Z1.0 H01 M08
N5 G99 G82 R0.1 Z-0.14 P300 F4.0 (FIRST HOLE OF ROW 1)
N6 M98 P5001 L3 (REMAINING HOLES)
N7 G90 G80 Z1.0 M09
N8 G28 Z1.0 M05
N9 M01
...
```


There is a major problem with this design. When the subprogram is executed for the *last* time, it will drill an extra hole in the wrong place! The structure of the subprogram needs to be changed. The last motion cannot be eliminated from the subprogram, because it serves as a link between the two-row patterns. To solve the problem, is to change the current order of X+, Y+, X-, Y+ to the order of Y+, X+, Y+, X-:

```

O5001 (SUBPROGRAM)
N1 G91 Y0.4 (FIRST HOLE OF ROW 1 - ROW 3 - ROW 5)
N2 X0.5 L6 (ROW 1 - ROW 3 - ROW 5)
N3 Y0.4 (FIRST HOLE OF ROW 2 - ROW 4 - ROW 6)
N4 X-0.5 L6 (ROW 2 - ROW 4 - ROW 6)
N5 M99 (END OF SUBPROGRAM)
%
```

It appears that the problem has only been shifted from the end of the subprogram to its beginning and remains unsolved. Right now, there is a wrong hole in another location. So far, that is true - *unless there is also a change in the main program*:

 **Task 1** - The Y-start position must be changed by the Y-increment from Y0.5 to Y0.1 (by the 0.4 hole spacing in the Y direction)

 **Task 2** - The execution of the cycle at the 'dummy' location must be prevented !

The first task is done in the block where the tool approaches the first hole. Block N3 in the main program has to be changed:

```
N3 G90 G54 G00 X0.5 Y0.5 S850 M03 T02 (MOVE TO LOWER LEFT HOLE)
```

to:

```
N3 G90 G54 G00 X0.5 Y0.1 S850 M03 T02 (MOVE TO DUMMY HOLE)
```

For the second task, a simple call of L0/K0 has to be added to the cycle call. Block N5 will be changed:

```
N5 G99 G82 R0.1 Z-0.14 P300 F4.0 (FIRST HOLE OF ROW 1)
```

to:

```
N5 G99 G82 R0.1 Z-0.14 P300 F4.0 L0 (DUMMY HOLE - NOT MACHINED)
```

The complete listing of the subprogram and the main program is listed next:

```

O5001 (SUBPROGRAM)
N1 G91 Y0.4 (DUMMY HOLE - FIRST HOLE ROW 3 - ROW 5)
N2 X0.5 L6 (ROW 1 - ROW 3 - ROW 5)
N3 Y0.4 (FIRST HOLE OF ROW 2 - ROW 4 - ROW 6)
N4 X-0.5 L6 (ROW 2 - ROW 4 - ROW 6)
N5 M99
%

(SUBPROGRAMS - 42 HOLES)
(T01 - 0.5 DIA 90 DEGREE SPOT DRILL)
N1 G20
N2 G17 G40 G80 T01 M06
N3 G90 G54 G00 X0.5 Y0.1 S850 M03 T02 (MOVE TO DUMMY HOLE)
N4 G43 Z1.0 H01 M08
N5 G99 G82 R0.1 Z-0.14 P300 F4.0 L0 (DUMMY HOLE - NOT MACHINED)
N6 M98 P5001 L3 (42 HOLES - 3 REPEATS OF 2 ROWS)
N7 G90 G80 Z1.0 M09
N8 G28 Z1.0 M05
N9 M01

(T02 - NO 7 - 0.201 DIA TAP DRILL)
N10 T02 M06
N11 G90 G54 G00 X0.5 Y0.1 S700 M03 T03 (MOVE TO DUMMY HOLE)
N12 G43 Z1.0 H02 M08
N13 G99 G81 R0.1 Z-0.61 F7.0 L0 (DUMMY HOLE - NOT MACHINED)
N14 M98 P5001 L3 (42 HOLES - 3 REPEATS OF 2 ROWS)
N15 G90 G80 Z1.0 M09
N16 G28 Z1.0 M05
N17 M01
```

```

(T03 - 1/4-20 PLUG TAP)
N18 T03 M06
N19 G90 G54 G00 X0.5 Y0.1 S500 M03 T01      (MOVE TO DUMMY HOLE)
N20 G43 Z1.0 H03 M08
N21 G99 G84 R0.25 Z-0.65 F25.0 L0           (DUMMY HOLE - NOT MACHINED)
N22 M98 P5001 L3                           (42 HOLES - 3 REPEATS OF 2 ROWS)
N23 G90 G80 Z1.0 M09
N24 G28 Z1.0 M05
N25 X-2.0 Y7.0
N26 M30
%
```

Nothing is perfect - there is a small disadvantage in this subprogram format. The order of machining for all three tools is the same, starting at the dummy hole and continuing to the hole number 42. In a program that does not use a subprogram, the order could be *Hole 1..42* for T01 and T03, and the order of *Hole 42..1* for T02. However, the extra rapid motion presents a negligible time loss.

Keep in mind that this is not the only method to use a subprogram to machine a pattern of row and column holes shown in this project. However, it is a good illustration of one particular method.