Compilation technique of outside fillet macro program

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Abstract. With the popularization of software automatic programming, the application of macro program has become the greatest advantage of manual programming. In fact, macro programs have irreplaceable advantages in the processing of specific geometric shapes. Combining with the most common Siemens subsystem in the world, this paper expounds the programming skills of the outside fillet macro program. Three layers of nesting, i.e. main program nesting subroutine and re-nesting subroutine, are used to compile the outside fillet macro program. It has been widely applied in practical machining.

1. Introduction
With the vigorous development of modern manufacturing technology, the application of numerical control machine tools has been rapidly popularized, and the number of technical workers engaged in numerical control processing has been increasing. Enterprises attach great importance to numerical control technology. In NC milling, NC programming is becoming more and more important in the machinery manufacturing industry, and various NC programming software emerges in endlessly. Although automatic programming is convenient, it can not replace manual programming [1]. Manual programming is one of the skills that field operators must master. Manual programming can flexibly control the dimension accuracy of machining parts by changing the value of tool radius compensation and length compensation when milling simple graphics such as plane, pocket, outer-contour, inner-circle, outer-circle, keyway and so on. It has high processing efficiency.

In production and processing, we encounter some workpieces with small quantity, many varieties and similar shapes. In order to process such workpieces according to the conventional programming method, it is necessary to program each workpiece. Operators also need to adjust the procedures of each workpiece during processing, so the production and processing efficiency is low [2]. In the process of programming, we find their common points and use the macro program variable operation and program jump characteristics to write programs, commonly known as batch programming [3], which can shorten the overall programming time, reduce the adjusting time of operators to programs, and improve the efficiency of production and processing [4]. In this paper, three layers of nesting, i.e. main program nesting subroutine and re-nesting subroutine, are used to compile the outside fillet macro program.

2. Preparation for program implementation

2.1. Machining Center and System
Machining center: The main parameters of the machining center used in the experiment are: three-axis stroke (X*Y*Z) 1035*450*500mm, spindle speed range 120-8000r/min, cutting feed 1-50000mm/min. System: SIEMENS 840D, 840D digital NC system is used for all kinds of complex processing. It is...
suitable for all kinds of control technology through system setting on complex system platform. 840D, together with SINUMERIK 611 digital drive system and SIMATIC7 programmable controller, constitutes a full digital control system. It is suitable for the control of various complex processing tasks and has better dynamic quality and control accuracy than other systems. Its functions include general G and M codes, single cycle, single fixed cycle and compound cycle. At the same time, it has the function of parameter programming through variable assignment, that is, macro programming [5].

2.2. Idea of programming
The processing of the outside fillet is one of the common shapes in the processing of die parts. When the die cavity is assembled with the die base, the fillet part is the most interference part. In actual assembly, because parts are often superheated, fillets are often not processed to the size we require. It is very difficult to assemble the outside fillets of the assembly parts even if they are machined in right size, which requires a lot of later work of fitters. Usually in the process of processing, the outside fillet corners are required to be - 0.1mm. The aim is to ensure the accurate position of the cavity by the vertical coordination of the side wall in the assembly of the cavity. Macro Programming of outside fillet is a very practical method for die cavity processing. In programming, not all parts need to process four fillets. It must be considered that one or several fillets can be selected flexibly when programming outside fillet macro program. Programming logic schematic diagram as shown in Figure 1.

Figure 1. Programming logic diagram
3. Macro programming

In the program, the first-level main program is used as parameter setting. All machine parameters and model parameters are set in the first-level main program, and there is no need to enter the subroutine. The second layer is nested subroutines, which are mainly logical operations, and can freely set outside fillets to be processed. In the third layer, four parallel subroutines are nested, which correspond to the logical operation of four outside fillets.

Main program:

```
%_N_4R_MPF

R71 = -30.  Y coordinate of lower right corner
R72 = -69.  X coordinate of lower left corner
R73 = 69.   X coordinate of lower right corner
R74 = 60.   Y-Direction length
R75 = 10.   Radius of outside fillets
R80 = 30.   Radius of feed arc
R111 = 0.5  The first layer depth
R112 = 1.   Depth of each layer
R113 = 15.5 The final layer depth
R91 = 1     Tool number
R92 = 1800  Spindle speed
R93 = 800   Cutting Feed rate
G90 G54 G64 Designated coordinate system G54
T = R91 M6  Designated tool
S = R92 M3  Set Spindle speed
G90 G0 X0 Y0. Arrive at the origin
G0 Z100.   Quickly move to safe height
L105       Call L105 subroutine
G90 G0 Z100. Return to Safety Height
M30         Program end
%
```

```
Layer 2 subroutine:

%_N_L105_SPF

R130 = R75 + R72  R131 = R73 - R75
R132 = R71 + R75  R133 = R71 + R74 - R75
R134 = R71 + R74  R135 = R71 - R80
R136 = R80 * 0.707 R147 = R73 + R136
R148 = R71 + R80  R149 = R132 + R136
R150 = R131 - R136 R151 = R71 - R136
R152 = R133 - R136 R153 = R134 + R80
R154 = R134 + R136 R155 = R130 + R136
R156 = R72 - R136 R157 = R72 - R80
R119 = R111
L111
L112
L113
L114
G90 G0 Z100.
M17
%
```

```
Layer 3 subroutine:

%_N_L105_SPF

R130 = R75 + R72  R131 = R73 - R75
R132 = R71 + R75  R133 = R71 + R74 - R75
R134 = R71 + R74  R135 = R71 - R80
R136 = R80 * 0.707 R147 = R73 + R136
R148 = R71 + R80  R149 = R132 + R136
R150 = R131 - R136 R151 = R71 - R136
R152 = R133 - R136 R153 = R134 + R80
R154 = R134 + R136 R155 = R130 + R136
R156 = R72 - R136 R157 = R72 - R80
R119 = R111
L111
L112
L113
L114
G90 G0 Z100.
M17
%
```

Initial depth conversion
```
Lower left fillet
Upper left fillet
Upper right fillet
Lower right fillet
%_N_L111_SPF                           Lower left fillet
R111=R119                               Read start depth
MARK1: G90G0X=R148Y=R132               Quickly reach the cutting position
Z=10.-R111 D1                           Fast moving to 10 mm cutting height
G1Z=-R111F200                           Reach the first cutting depth
G1G41G1X=R147Y=R149F=R93*2.             Radius Compensation Assignment
G3X=R73Y=R132CR=R80F=R93                Arc cut in
G2X=R131Y=R71CR=R75                   Fillet cutting
G3X=R150Y=R151CR=R80                  Arc cut out
G40G1X=R131Y=R135F=R93*2              Cancellation of Tool Radius Compensation
G90G0Z100.                               Return to Safety Height
R111= R111+R112                          Deep accumulation
IF R111<= R113 GOTOB MARK1             Depth judgement
G90G0Z100.                               Return to Safety Height
M17                                      Return to the upper program
%

Subroutine L112, L113 and L114 are written in the same way as L111.

It can be seen from the program that machine tool parameters and model parameters of machined
parts need to be set in the main program of outside fillet. Four outside fillets to be machined are set in
subprogram L105. L111, L112, L113 and L114 are the four outside fillets that need to be machined.
When four outside fillets need to be processed, four subroutines are retained at the same time. When
we only need to process some of the four outside fillets, or only a few outside fillets in the parts, we
just need to keep the corresponding position of the subroutine. Such macro programming method of
nested subroutines of main program and re-nested subroutines greatly improves the flexibility of
macro program application.

![Figure 2. The parameter of milling outside fillet micro program](image)

4. Appendices

Through the application of the outside fillet macro program in the actual processing, it is found that
the outside fillet macro program can enhance the flexibility of NC machine tools in parts processing,
avoid the drawback of the lengthy program generated by CAD/CAM, greatly simplify the
programming workload of programmers and improve the efficiency and thinking ability of
programming. The outside fillet macro program has been put into use after being verified by field
practice. It can be used as a good example for CNC machine tool operators to apply and learn.
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