Multiple clamping using reversible clamping devices

SINUMERIK 828D

Warranty and liability

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1 General

1.1 Definition of multiple clamping

Introduction

Multiple clamping means the possibility of clamping several different or identical parts or components in the machining space of a machine tool. Multiple clamping systems are primarily used for milling machines.

CNC workpiece programs are usually programmed in relation to the clamping of a workpiece. Single clamping of a workpiece may lead to the machining space not being used sufficiently, or the number of pieces to be produced requires the production of several workpieces simultaneously on one machine. The clamping of multiple workpieces uses the machining space of the machine better, but the advantage gained is quickly lost by the number of tool changes, caused by the individual programming of workpieces and the longer programming time. Using the "Multiple clamping" feature in SINUMERIK Operate (828D and 840D sl), the user has the option of optimizing the same or different workpiece programs for multiple clamping by just pressing a button. Figure 1-1 shows an example of three workpieces clamped onto a machine table. ShopMill was used to program each individual workpiece. Without the use of the multiple clamping feature, the control would machine these three workpiece programs sequentially, i.e. the same tools would be used and loaded several times, thus leading to a loss of time.

The multiple clamping feature automatically generates a new "Multiple clamping program" from multiple programs – this is only possible in ShopMill. In this program, the sequence of all tools used is rearranged for all workpieces, i.e. The number of tool changes will be reduced significantly, thus increasing the productivity. The workflow is repeated for all of the tools used for all of the workpieces.

Fig. 1-1 Possible multiple clamping arrangement

In practice, multiple clamping is used for medium-sized series production in the Job Shop domain. A significant increase in productivity by using multiple clamping systems starts from 100 workpieces and above.
1.2 Advantages and disadvantages of multiple clamping

Multiple clamping on a machine generally requires higher equipping time and costs, which only pays off for higher batch quantities. However, the high level of convenience offered by the SINUMERIK multiple clamping function significantly reduces programming costs. If you were to allocate the tools to several clamping operations manually, you would need a very experienced CNC programmer and the resulting workpiece would be rather confusing and diagnostics would not be user-friendly.

The advantages and disadvantages are compared in Table 1-1 below.

<table>
<thead>
<tr>
<th>No.</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Reduction of idle times (tool change, equipping time)</td>
<td>Higher one-off equipping costs</td>
</tr>
<tr>
<td>2.</td>
<td>Longer period of absence of the operator possible (parallel jobs)</td>
<td>Higher one-off setup costs</td>
</tr>
<tr>
<td>3.</td>
<td>Optimum utilization of the machining area</td>
<td>Increased one-off programming costs</td>
</tr>
<tr>
<td>4.</td>
<td>Shorter overall machining time</td>
<td>-</td>
</tr>
</tbody>
</table>

Requirements

When programming multiple clamping operations in ShopMill, the programs must meet the following requirements:

- It is only permissible to use machining step programs (no G code programming).
- The programs generated must be able to be executed.
- The program for the first clamping must be run-in.
- It is not permissible that jumps are used in the program (mark / repeat).
- It is not permissible that transformation operations (SCALE, RED, TRANS, etc.) are used.
- Contours must have unique names (contour names may not be used twice in the program).
- The start point parameter in the stock removal cycle (contour milling) may not be set to manual.
- Before generating multiple clamping programs, it is not permissible that different safety clearances are specified using settings.
- Settings that impact subsequent programs must be avoided.
- A maximum number of 50 contours per clamping or 99 clamping operations are permitted.
1.3 Multiple clamping types

The SINUMERIK multiple clamping function supports both simple linear clamping systems as well as those with clamping blocks, reversible clamping devices, clamping towers, etc. When using reversible clamping devices, clamping towers etc., the maximum number of clamping operations is limited to 99 (number of work offsets).

Each workpiece clamping must be assigned a work to offset. When using reversible clamping devices etc., the switch condition of the rotary axis must also be specified. This is realized in a pre-configured CUST_CLAMP cycle (see standard cycles in the system data area). In practice, the following multiple clamping systems are used:

Table 1-2 Overview of multiple clamping systems

<table>
<thead>
<tr>
<th>No.</th>
<th>Action</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Flat clamping systems, self-clamping systems or several machine vises</td>
<td><img src="image1.jpg" alt="Flat clamping systems" /></td>
</tr>
<tr>
<td>2.</td>
<td>Longitudinal multiple clamping systems</td>
<td><img src="image2.jpg" alt="Longitudinal multiple clamping systems" /></td>
</tr>
<tr>
<td>3.</td>
<td>Reversible clamping devices (Application: vertical milling machines, rotary axes required)</td>
<td><img src="image3.jpg" alt="Reversible clamping devices" /></td>
</tr>
<tr>
<td>4.</td>
<td>Plate tower (Application: horizontal milling machines, rotary axes required)</td>
<td><img src="image4.jpg" alt="Plate tower" /></td>
</tr>
</tbody>
</table>
1.4 SINUMERIK option required

The multiple clamping function only operates with ShopMill programs. For identical workpieces, the feature is part of the ShopMill (MLFB option ShopMill 6FC5800-0AP17-0YB0). In contrast, the multiple clamping feature is an option within ShopMill for different workpieces (MLFB option multiple clamping of different workpieces: 6FC5800-0AP14-0YB0).

Note

From software release 4.5, the multiple clamping feature for identical and different workpieces is part of SINUMERIK Operate in the ShopMill mode.
2 Task

Description of the application

In a milling machine with SINUMERIK 828D Basic and SINUMERIK Operate, the front and back of a workpiece should each be machined several times on a reverse clamping device in the fastest time. The reverse clamping device is fixed along the X-axis (MCS) with an additional rotating A-axis on the machine table.

There are two clamping operations per side, thus a maximum of eight parts can be simultaneously machined. Using the SINUMERIK input screen, multiple clamping can be easily programmed and the reverse clamping device can be electrically controlled by the SINUMERIK via a suitably configured interface. This application shows in detail how you can optimally utilize the multiple clamping function.

Overview of the automation task

The following diagram shows a mounted reverse clamping device with rotary axis, which is used to machine the workpieces a multiple number of times.

Fig. 2-1 Reverse clamping device with rotary axis
Necessary preconditions regarding the machine

- The machine must be equipped with an optional fourth axis or rotary axis. If necessary, this can be mounted on the machine bed (reverse clamping device with rotary axis).
- The inner machining area must have the necessary interfaces so that the drive power and the compressed air supply to the mounted motor are guaranteed.
- The necessary clamping jaws for fixing the front and rear sides of the workpiece must be available. In the example, there are 4 holders each on the front and rear sides.

Depending on the machine design, rotary axes can also be mounted on the machine table. If an additional rotary axis is to be installed in the machining area, the hardware and software requirements, as listed in the table, must be complied with. It may be necessary to consult the machine supplier.

Table 2-1 Installation steps

<table>
<thead>
<tr>
<th>No.</th>
<th>Action</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Make sure that the connection of the feed motor is guaranteed for the A-rotary axis via a drive and compressed air interface.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>The A-axis should operate without any problems after you have completed commissioning.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Ensure that the appropriate equipment is available for the drive modules in the control cabinet.</td>
<td></td>
</tr>
</tbody>
</table>
3 Solution

3.1 Adapting the CUST_CLAMP cycle

This chapter describes how an executable multiple clamping program using a rotary axis is generated from preconfigured rear and front side programs of a workpiece for complete machining. For linear multiple clamping systems on flat surfaces (i.e. in particular, for 3-axes milling machines), the CUST_CLAMP.SPF is predefined and can be immediately used for programming.

If, in our example, reverse clamping devices are used together with rotary axes, the switch condition of the rotary axis must be defined in relation to the zero points of the clamping operations. This is done once as background operation in CUST_CLAMP.

The CUST_CLAMP.SPF cycle is included as standard below the Startup menu item in the system data in the NC data/Cycles/Standard cycles folder.

### Note
- The cycles follow a defined prioritization principle
  - Priority 1: User
  - Priority 2: Manufacturer
  - 3rd priority: Standard
- If the CUST_CLAMP.SPF is in the standard cycles, and e.g. in the user cycles, then the NC accesses the file in the user cycles.
3 Solution

3.1 Adapting the CUST_CLAMP cycle

To obtain a better overview, the parameters of the CUST_CLAMP.SPF cycle are explained in the following table:

**Table 3-1 Explanation of the parameters**

<table>
<thead>
<tr>
<th>No.</th>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>_NPF</td>
<td>Number of the first work offset (0=G500, 1=G54, etc.)</td>
</tr>
<tr>
<td>2</td>
<td>_PREV</td>
<td>Number of the preceding clamping position (-1 = none)</td>
</tr>
<tr>
<td>3</td>
<td>_ACT</td>
<td>Number of the current clamping position (1,...)</td>
</tr>
<tr>
<td>4</td>
<td>_NEXT</td>
<td>Number of the next clamping position (-1 = none)</td>
</tr>
<tr>
<td>5</td>
<td>_NV=_NPF+_ACT</td>
<td>Calculation of the actual work offset</td>
</tr>
<tr>
<td>6</td>
<td>PROC</td>
<td>First operation in a program</td>
</tr>
<tr>
<td>7</td>
<td>INT</td>
<td>File type (signed integer value)</td>
</tr>
<tr>
<td>8</td>
<td>SBLOF</td>
<td>Single block suppression</td>
</tr>
<tr>
<td>9</td>
<td>DISPLOF</td>
<td>Command for suppressing the actual block</td>
</tr>
<tr>
<td>10</td>
<td>DEF</td>
<td>Definition</td>
</tr>
</tbody>
</table>
For reverse clamping devices, the rotation through 90° must be ensured within CUST_CLAMP.SPF. The respective zero point for the workpieces must be taken in accordance with what is provided in the drawing and entered in the correct work offsets. In the example, eight zero points are used; two of these are used for each plane of rotation.

The CUST_CLAMP.SPF cycle must first be selected and copied into the directory of the system data "NC data/Cycles/User cycles". The subprogram is then changed in the following way.

```plaintext
PROC CUST_CLAMP (INT _NPV, INT _PREV, INT _ACT, INT _NEXT) SBLOF DISPLOF
   DEF INT _NV
   _NV=_NPV+_ACT
   G[8]=_NV

Rotation of the reverse clamping device (A-axis) when reaching the appropriate work offset
   IF _ACT==1
      G0 A=DC(0)
   ENDIF

   IF _ACT==2
      G0 A=DC(0)
   ENDIF

   IF _ACT==3
      G0 A=DC(90)
   ENDIF

   IF _ACT==4
      G0 A=DC(90)
   ENDIF

   IF _ACT==5
      G0 A=DC(180)
   ENDIF

   IF _ACT==6
      G0 A=DC(180)
   ENDIF
```

Multiple clamping
Entry ID: 78454115,  V1.0,  09/2013
### 3.1 Adapting the CUST_CLAMP cycle

```plaintext
IF _ACT==7
G0 A=DC(270)
ENDIF

IF _ACT==8
G0 A=DC(270)
ENDIF

RET
```

#### Table 3-2 Explanation of the parameters of the modified subprogram

<table>
<thead>
<tr>
<th>No.</th>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>_NPF</td>
<td>Number of the first work offset (0=G500, 1=G54, etc.)</td>
</tr>
<tr>
<td>2</td>
<td>_PREV</td>
<td>Number of the preceding clamping position (-1 = none)</td>
</tr>
<tr>
<td>3</td>
<td>_ACT</td>
<td>Number of the current clamping position (1,...)</td>
</tr>
<tr>
<td>4</td>
<td>_NEXT</td>
<td>Number of the next clamping position (-1 = none)</td>
</tr>
<tr>
<td>5</td>
<td>_NV=_NPF+_ACT</td>
<td>Calculation of the actual work offset</td>
</tr>
<tr>
<td>6</td>
<td>PROC</td>
<td>First operation in a program</td>
</tr>
<tr>
<td>7</td>
<td>INT</td>
<td>File type (signed integer value)</td>
</tr>
<tr>
<td>8</td>
<td>SBLOF</td>
<td>Single block suppression</td>
</tr>
<tr>
<td>9</td>
<td>DISPLOF</td>
<td>Command for suppressing the actual block</td>
</tr>
<tr>
<td>10</td>
<td>DEF</td>
<td>Definition</td>
</tr>
<tr>
<td>11</td>
<td>IF_ACT==(1, 2, 3,...) GO A=DC (0°, 90°, etc.)</td>
<td>After each second action, the rotary axis rotates through 90°</td>
</tr>
</tbody>
</table>
3.2 Generating the multiple clamping program

Once the CUST_CLAMP has been generated, the multiple clamping function can be called via the CNC programming. For the part to be generated, a sequential program is required for the front and rear sides. The maximum degree of automation is achieved in the current example, if four clamping operations are used for the front and rear sides. The objective of the multiple clamping program is that four finished parts are removed, four semi-finished ones are reclamped and four new blanks are inserted.

Sequence when generating the program

A multiple clamping program is generated as follows:

1. In the Program Manager menu item, the extension of the vertical softkey bar must be selected first followed by the multiple clamping function (Figure 3-3).

2. A window opens where you are asked to enter the number of clamping operations. In the selected example, “8” clamping operations should be used. Furthermore, a drop-down box for setting the work offset is located in this query mask (Fig. 3-4).

   All additional work offsets are incremented by one with respect to the first offset. If G54 would be the first work offset, the other seven offsets in the example chosen are G55, G56, G57, G500, G501, G502 and G503.

3. You can select any name for the multiple clamping program. After generating the program, an .MPF file (Fig. 3-5) is created in the respective preselected folder for the actual sequential program – and an .INI file, which contains the necessary information for the multiple clamping program.

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Multiple clamping
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3.2 Generating the multiple clamping program

4. The required program is selected for the particular clamping. There is also the possibility of allocating identical workpieces to the "On all clamping operations" function, thus time is saved when compared to selecting all of the individual programs. The following should show what the result of the compilation looks like on the basis of a multiple clamping program for identical workpieces in two clamping operations.

Fig. 3-5 Illustration of the generated .MPF file

<table>
<thead>
<tr>
<th>No.</th>
<th>WO</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G54</td>
<td>RUECKSEITE_PPU_MCP.MPF</td>
</tr>
<tr>
<td>2</td>
<td>G55</td>
<td>RUECKSEITE_PPU_MCP.MPF</td>
</tr>
</tbody>
</table>

5. The example shows that the workpiece is first face milled in clamping operation G54 and then the same operation is selected for G55. The "rectangular spigot" operation is started in the next step. This approach optimizes the tool change times.
Self-written cycle

Below are the individual steps for programming the multiple clamping program in detail.

Fig. 3-6 Overview of the complete clamping program

In the actual example, the MHOME_WENDESPANNER function is a self-written cycle in the user area (Fig. 3-6). Here, the machine table, and thus the reverse clamping device are moved to a safe position (corner position) to avoid collisions when tools are changed or the reverse clamping device is rotated. Figure 3-7 Shows the self-written cycle in detail.
3.2 Generating the multiple clamping program

Fig. 3-7 Overview of the MHOME_WENDESPANNER cycle

```plaintext
USB/MHOME_WENDESPANNER.SPE

N10 PROC MHOME_WENDESPANNER (STRING[1] _AXIS_1, STRING[1] _AXIS_2) &
AVE 1
DEF REAL _D_NUM
N20 MSG("home position Z hoch, Y UND X FRONT") &
_D_NUM=SP_TOOL
STOPREM
N30 SUPA G00 G40 G0 D0 Z=0 M98
N40 SUPA G00 G40 G0 D=0_NUM Y=0 X=-700 T
G0 A81
N50 D=_D_NUM
1
N130 IF _AXIS_2="C" &
N150 :G150 G0 C05
N150 ENDIF
1
N160 _END_A_C: 1
1
N170 MSG -
```

Copy
Paste
Cut
Build group
Search
Mark

Multiple clamping
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4 Notes regarding multiple clamping

3.2 Generating the multiple clamping program

Using ShopMill

The multiple clamping function only works with pure ShopMill programs. When G code lines are written in the ShopMill program, it is possible that they are not compiled correctly later in the multiple clamping program. The compilation is solely for ShopMill cycles.

How are clamping operations simulated?

The simulation does not show different clamping operations. They must be tested in the original programs.

Note

It is not permissible that programming commands ROT, AROT, SCALE, ASCALE, TRANS, ATRANS, MIRROR, AMIRROR are used in ShopMill programs that are used for multiple clamping.
5 Contact person

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6 History

Table 6-1

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1.0</td>
<td>09/2013</td>
<td>First Edition</td>
</tr>
</tbody>
</table>