UDC 621.91.01

APPROACH TO THE DEVELOPMENT AND TESTING OF POSTPROCESSOR THAT GENERATES WORK WITH MILLING SPINDLE OF MULTI-TASK MACHINE TOOLS

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Abstract. *We present and discuss the possibility to develop a postprocessor that generates NC programs with commands to work with rotated axis milling spindle (G68.1) for multi-task machines. Processing of the workpiece is modelled in the manufacturing module of the Pro/Engineer. The postprocessor is developed by a generalized postprocessor G-POST and specialized language to change the outcome of the postprocessor FIL (Factory Interface Language).*

Keywords: *multi-task machine tools, postprocessor, G-POST, FIL, Pro/Engineer, CAD/CAM, CNC.*

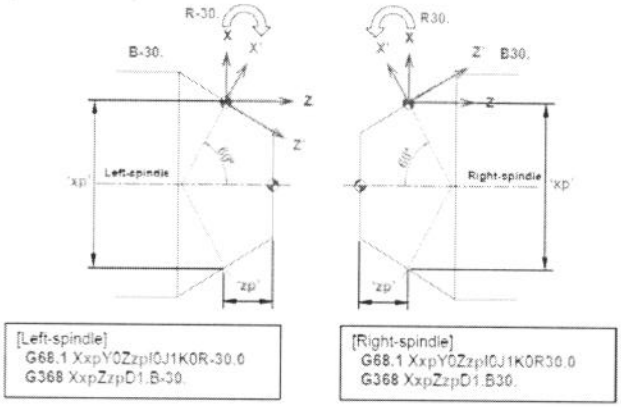


Fig. 1. Addresses meaning and setting of the command to rotate the coordinate system G68.1

The opportunity for the postprocessor to generate command G68.1 rotation of the workpiece coordinate system when working with CNC jig is explored. With the use of this command a local coordinate system rotated around the Y-axis is created. The format of the command is as follows [1]:

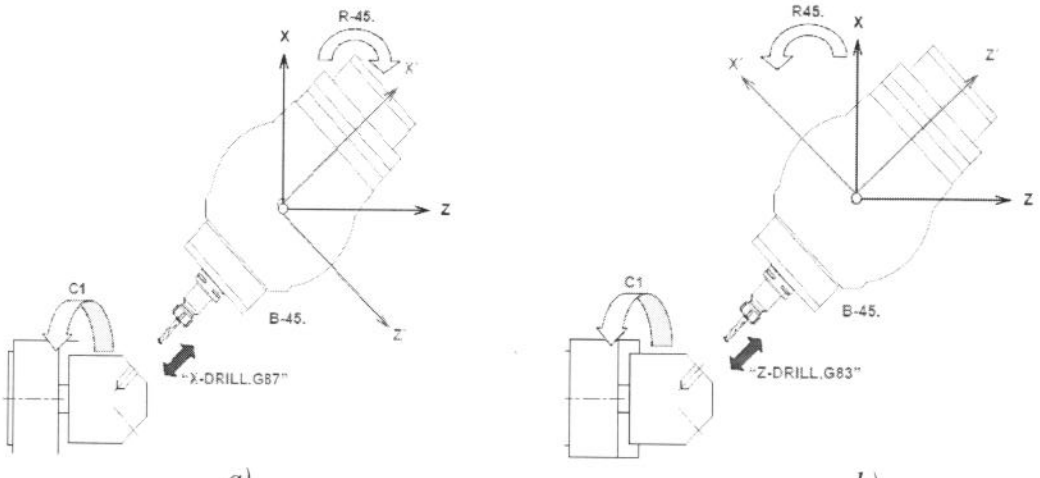
$$G68.1\ Xx_p\ Y0\ Zz_p\ I0J1\ K0\ R\_$$
$$G69.1,$$

where X_p, Y, Z_p – coordinates of the center of rotation; I, J, K – direction of the axis of rotation; R – angular displacement.

Due to the fact that the rotation of the milling spindle is directly linked to the rotation about B-axis, it is in the format of the command G68.1, J=1 address. Fig. 1 shows the significance of the addresses stored in the command G68.1.

The direction of rotation of the coordinate system determines the axis by which is organized the feeding of the tool towards the machined surface to obtain the precise dimensions and shape of the workpiece. By rotating the coordinate system in a clockwise direction (Fig. 2, a) the X-axis is determined as a tool axis and in a counter clockwise direction (Fig. 2, b) – the Z-axis is set as a tool axis.

Turning the milling spindle can be performed by command G368. It is similar to command G68.1. The format of the command is as follows:



a) *b)*

Fig. 2. Rotation of the coordinate system: a) clockwise b) counter clockwise

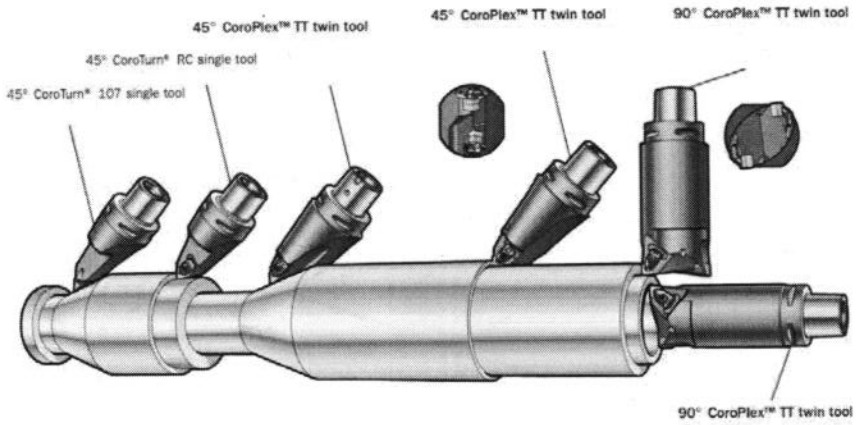


Fig. 3. Tools for multi-task machine tools offered by Sandvik [2]

G368 X... Z... D... B...
G369.

The significance of the addresses is as follows: *X* and *Z* – center of rotation; *D* – direction of feeding i.e. tool axis. This address can take the value 0 or 1. When *D*=0 – the feeding direction is along the *Z*-axis and *D*=1 – the feeding direction is along the *X*-axis; B – angle of rotation of the milling spindle.

This command is suitable to be applied in turning operations where the tools with one or more cutting edges (Fig. 3) are used [6]. The setting of the instruments in a position is related to the rotation of the milling spindle.

Treatment is preceded by a displacement along the *Y*-axis at a distance h_j [3] (Fig. 4)

To determine the rotation angle of the milling spindle, in Pro/MFG a local coordinate system on the surface is built, which requires treatment with a turned support. This coordinate system is related to the work coordinate system of the workpiece, which is desirable to match the design and technological bases. Fig. 5 shows a case in which the coordinate system is located on the axis of the opening.

The coordinates of the rotation center are relative to the workpiece coordinate system with a tool to analyze the size of the CAD model [4]. This tool allows measured values to be stored as objects in the tree model. By using commands from window "Distance" (Fig. 6)

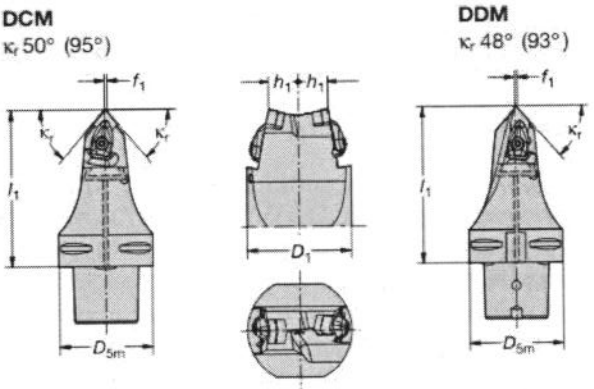


Fig. 4. Displacement of the tool along Y-axis with more than one cutting edge

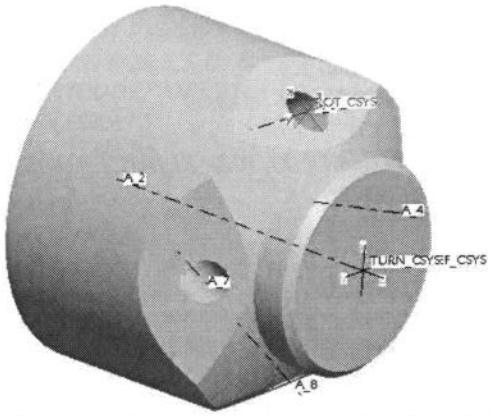


Fig. 5. Local coordinate system along which the rotation of the milling spindle is performed

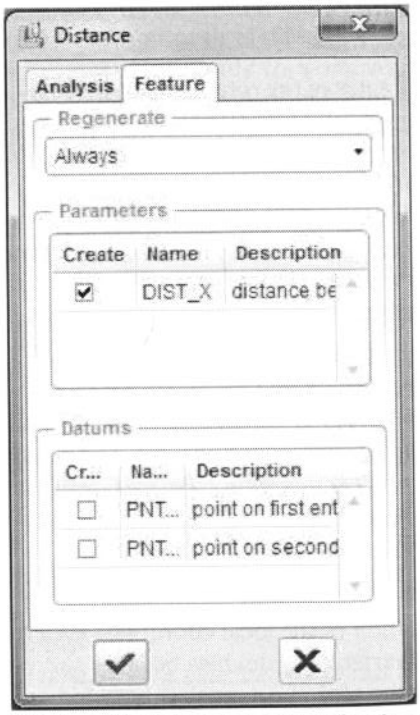


Fig. 6. "Distance" window to analyze the size of CAD models and set the parameter name

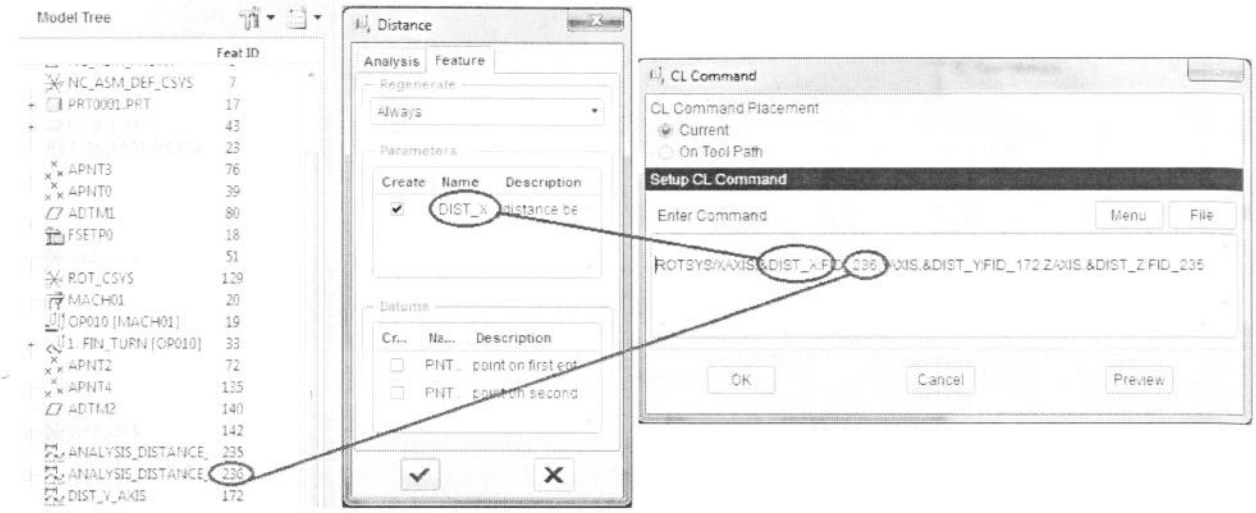


Fig. 7. Introducing a CL command to set the rotation center defined by the instrument to measure Distance

the name of the parameter that saves the measured value can be set.

This allows the measurement values to be used at any time when necessary. This approach for size analysis, followed by recording the values as a parameter, is convenient to be applied when establishing a post-processor that generates control programs in the form of a dialog cycles for process components (cylindrical, rectangular, square pockets) and for the system HEIDENHAIN. To generate a command for the rotation of the milling jig it is necessary in the CL Data file to establish the coordinates of the rotation center recorded as parameters and stored by window Distance. Their introduction is performed by a CL command with the following format:

ROTSYS/XAXIS, &DIST_X:FID_236, YAXIS,
&DIST_Y:FID_172, ZAXIS, &DIST_Z:FID_235.

Coordinates of the rotation center of axis *X*, *Y* and *Z* are read by parameters *DIST_X*, *DIST_Y* and *DIST_Z*, from the tree model with an identification number (Feat ID) 236, 172 and 235 (Fig. 7).

Coordinates of the rotation center are assigned by the CL Data file using the language FIL to capture all ROTSYS records. This is achieved with a record of the following type:

```
CIMFIL/ON, ROTSYS
XI=POSTF(7,5)*2
YI=POSTF(7,7)
ZI=POSTF(7,9)
XX=POSTF(26,5,5,1)
XX=POSTF(13)
CIMFIL/OFF.
```

Variables *XI*, *YI* and *ZI* are assigned values of the rotation center of the local coordinate system. The value of the variable *XI* doubles because the value determined by the tool "Distance" is reported and recorded radial and in the form of command G68.1 the same value is set diametrically (Fig. 2). Coordinates of the rotation center along the *Y*-axis must be zero for the proper display of command G68.1. If *Y*#0, then the local coordinates system axes are not parallel to the machine coordinate system. After assigning values to variables with command *XX=POSTF (26,5,5,1)* goes directly to the recording motion *GOTO*. This command works similar to operators *IF-THEN-ELSE* or *CASE-WHEN* to find a specific subtype [5]. In recording motion *GOTO* it is recorded the output format command to work with turned support G68.1. Recording motion has the following structure:

```
CIMFIL/ON,GOTO
XX=POSTF(13)
XX=POSTF(20)
IVAL=POSTF(7,9)
JVAL=POSTF(7,10)
XX=POSTF(21)
XX=POSTF(13)
IF(FIXT.EQ.(ICODEF(68)))THEN
IF(IVAL.EQ.0)THEN
ROTV=ACOSF(ABSF(JVAL))
DOT=TEXT/'.'
INSERT/'G68.1X',XI,'Y0Z-',ZI,DOT,'I0J1K0R',ROTV,'$'
XX=POSTF(26,5,5,0)
ENDIF
IF(IVAL.NE.0)THEN
XX=POSTF(20)
ROTV=ACOSF(ABSF(IVAL))
DOT=TEXT/'.'
INSERT/'G68.1X',XI,'Y0Z-',ZI,DOT,'I0J1K0R',ROTV,'$'
XX=POSTF(21)
XX=POSTF(13)
XX=POSTF(26,5,5,0)
XX=POSTF(13)
ENDIF
XX=POSTF(13)
CIMFIL/OFF
```

Variables IVAL and JVAL are assigned the values that define the tool axis vector. When JVAL = 0, then

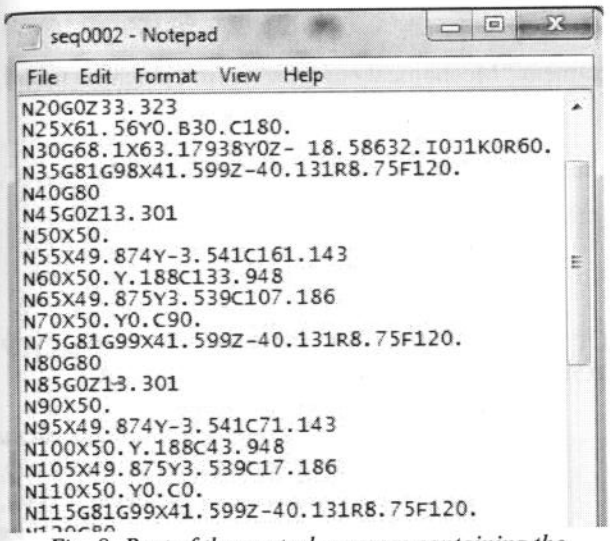


Fig. 8. Part of the control program containing the command to rotate the workpiece coordinate system command G68.1

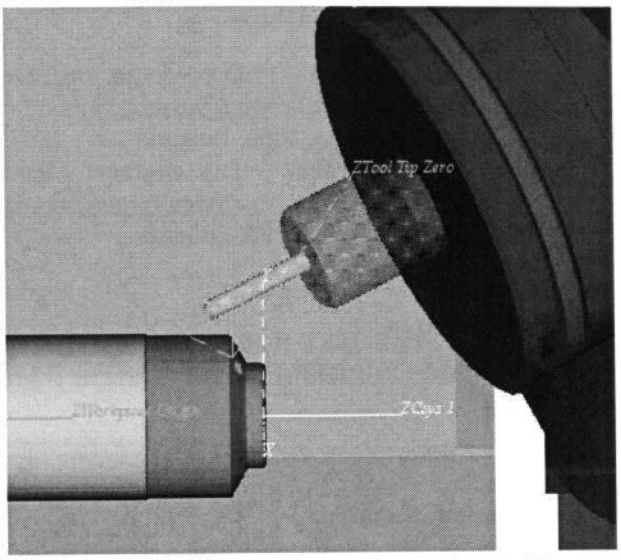


Fig. 9. G68.1 command verification by VeriCut

the rotation of the coordinate system happens around Y-axis i.e. the rotation of the coordinate system is in clockwise and is determined by relationship (1). Thus, the processing of the surface will be performed by feeding the tool along X-axis.

$$A=\begin{pmatrix}\cos\psi & 0 & \sin\psi & 0\\ 0 & 1 & 0 & 0\\ -\sin\psi & 0 & \cos\psi & 0\\ 0 & 0 & 0 & 1\end{pmatrix}. \qquad (1)$$

In this case, the rotation angle is calculated as *ROTV=ACOSF(ABSF (JVAL))*. In the case when the *Z*-axis is the axis of the instrument (the coordinate system is rotated in the counter clockwise direction) rotation angle is calculated as *ROTV=ACOSF(ABSF (IVAL))*.

FIXT variable is determined by the recording that captures all records related to the coordinate system. It has the following structure:

```
CIMFIL/ON,SET
FIXT=POSTF(7,5)
CASE/FIXT
WHEN/(ICODEF(68))
DMY=POSTF(26,5,5,1)
WHEN/(ICODEF(OFF))
INSERT/'G69.1 $'
WHEN/OTHERS
CONTIN
ENDCAS
XX=POSTF(13)
CIMFIL/OFF
```

At Fig. 8 it can be noticed a part of a program which contains a command to rotate the milling spindle command G68.1. This approach can be applied successfully in developing a postprocessor for machining centres with 5-axes simultaneously controlled to generate the command to rotate the workpiece coordinate system G68.2 (in systems FANUC).

Fig. 9 shows the window VeriCut, which is used to examine the generated NC program for turning the workpiece coordinate system command G68.1. Coordinate system Z Toll Tip Zero is a local coordinate system created after loading automatically command G68.1.

Conclusions:

1. A postprocessor to generate NC program in an environment of Pro/Engineer for DOOSAN machine with CNC FANUC 18i is developed;

2. The developed postprocessor is verified by the product VeriCut.

3. The proposed approach to develop a postprocessor that generates commands to work with turned spindle (G68.1) can be applied in machining centers with 5-controlled axes where the command G68.2. is generated.

References

1. DOOSAN PROGRAMMING MANUAL PUMA series, MX2000, MX2000L/T/LT/S/LS/LST, MX2000L/T/LT/S/LS/LST, MX3000, MX3000S.

2. www.sandvik.coromant.com

3. Хаджийски П. Програмиране на CNC машини. ТУ-София, 2010.

4. CAD/CAM Pro/ENGINEER. PTC Global Services, 2007. Part Modeling. User Guide, Pro/MANUFACTURING and Pro/NC-CHECK User's Guide. Parametric Technology Corporation.

5. FIL Manual V63.

6. Николчева Г. Режещи инструменти. София, 2008.

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ПОДХОД К РАЗРАБОТКЕ И ИССЛЕДОВАНИЮ ПОСТПРОЦЕССОРА, ГЕНЕРИРУЮЩЕГО РАБОТУ С ФРЕЗЕРНЫМ ШПИНДЕЛЕМ У МНОГОЦЕЛЕВЫХ ТОКАРНЫХ СТАНКОВ

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В настоящей работе представлена возможность разработки постпроцессора, который генерирует ЧПУ программы с помощью команд для работы с повернутой осью фрезерного шпинделя (G68.1) для токарных станков высокой производительности. Обработка деталей моделируется в производственном модуле Pro/Engineer. Для создания постпроцессора использован обобщенный постпроцессор G-POST и специализированный язык FIL (Factory Interface Language), который позволяет изменять выход постпроцессора.

Ключевые слова: *многоцелевые станки, постпроцессор, G-POST, FIL, Pro/Engineer, CAD/CAM, CNC.*

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