An approach to creation of a unified system of programming CNC machines in the dialog mode

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Abstract. The tendencies in the development of part programs for CNC machine tools are considered, the used programming methods are analysed, and the compatibility problem of interactive programming systems is proved. An approach is proposed with the use of canned cycles, which allows to unify the process of dialog programming for machines with CNC systems from different manufacturers. Practical aspects of creating part programs in dialog mode for machines equipped with CNC systems Siemens, Fanuc, Heidenhain, AxiOMA Control and Balt-Systems are presented.

1 Introduction

The choice of development method of the master part program - usage of the CAM-system, manual programming or CNC machine tools depend on exact conditions and situations, for example, type of production, the breadth of the details range, amount of the CNC systems participating in the manufacturing, qualification of the programmer-technologist [1]. CAM-systems allow program processing of any difficulty, involving usage of the detail models, eliminating the need for a programmer-technologist to carry out mathematical calculations manually. CAM-systems allow to create the part programs for various CNC-systems using one basic language, and with that CAM-systems provide programmer-technologist with typical functions that automate a particular machining process. In order to use CAM-systems programmer-technologist uses either PC or workstation. Expensiveness of both CAM-system and additional tools for it (postprocessors, 3D-models of the machines and tools, in case if they are not included in the standard set of the CAM-system) makes them available only for large enterprises with wide range of the frequently changing details. Often the CAM-system's users face the problem of converting the design model into CAM-system used by the programmer – some elements may not be found or to be displayed differently than intended in the design. Also, while using any special devices for fixing workpieces on the machine, it's necessary to have their 3D-models for the correct building of control trajectories, otherwise programmer would be forced to spend time on the design of those devices, which, as a result, increases the time of technological preparation of production.

Manual programming in cycles has a number of advantages before the CAM-system, for example, in case of making changes to the program. For example, while machining

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precise cylindrical surfaces with tight tolerances for some reason an error occurred in the form of a taper and did not meet the requirements for roughness. To compensate the error while programming manually, it would be enough to add to the existing pre-emphasis circuit in the form of a reverse taper to change the flow in the loop body. But while programming in the CAM-system it is necessary to rebuild the technological model and change machining parameters, since it proves quite difficult to find the necessary frame in a long code for its editing, as in manual programming. If in order to execute these, usually simple, corrections the programmer would be forced to use the CAM-system every time, that will drastically increase the time of technological preparation of production. In situations like these, manual programming is much easier to use.

Programming on the remote control CNC is becoming increasingly popular due to growing development of software and hardware for CNC systems [2, 3], improvement of their interface and expansion of performed tasks: the program is created and inputted directly on the CNC rack using the keyboard and display; constant cycles are selected and inserted into the part program by using special icons, verification of the part program can be executed in parallel with the operation of another part program. Dialog programming makes the process of creating the part program even easier, and with the growing development of mobile communications, it has special prospects, in particular - remote dialog programming.

2 The problem of compatibility of dialog programming systems

Systems of dialog programming are greatly varied. In most cases any of these systems is single-purpose system designed to automate the programming of machining on certain equipment.

Intuitive step-by-step dialog programming editor with user-friendly interface greatly shortens time for programming for individual and small-scale production in particular, but it's usage in medium- and large-scale production appears to be less effective, and usually proves ineffective, when programming the machining of the detail with complex configuration. CNC programming language based on high-level language's commands provides maximum flexibility and minimum development time up in dialogue mode, it combines the flexibility of the language of the CNC and the convenience of a simple parameterization of machining cycles that provides maximum productivity [4, 5]. For example, in CNC systems with built-in CAM-system Siemens ShopTurn and Fanuc ManualGuidei animation of machining process is applied, which provides visual support to operator, when programming the CNC system and when tracking the operation. Dialog programming on the rack is particularly useful in workshops and on site, producing the large variety of details.

Since manual programming and debugging of part programs in manual and in dialog mode takes less time than programming in CAM-systems for relatively simple parts, they can be replaced by an alternative - remote programming in dialog mode using a unified programming system, not tied to specific CNC systems [6, 7]. Similar systems exist to some extent, but they only complement the dialog programming on the rack, while using the CNC system emulator on a personal computer. Examples of such systems – Siemens Sinutrain, Fanuc NC Guide, Heidenhein Data Pilot 640, "AxiOMA Control" [8, 9, 10]. The part programs written through these systems can only work on them.

3 Approach to the universalization of the developed system

To maintain the concept of universality in the system of dialogue programming for each form uses a specific set of input data based on the standard cycles of each submitted CNC system.

The full range of turning and drilling cycles of the CNC systems under consideration is presented in Table 1.

Table 1. Turning and drilling cycles.

	Siemens	Fanuc i-T	Heidenhein	AxiOMA Ctrl	Balt-System
longitudal turning	CYCLE95	G90	G80	-	SPF(Z,…)
face turning	CYCLE95	G92	G80	-	SPF(X,…)
radial grooving	CYCLE93	G75	G870	G288	TGL(Z,X,…)
face grooving	CYCLE93	G74	G871	G289	TGL(X,Z,…)
radial undercut	CYCLE95	G71	G835	G281	SPF(Z,…)
face undercut	CYCLE95	G72	G835	G282	SPF(X,…)
threading	CYCLE97	G76	G352	G276	FIL
cutting	CYCLE93	G75	G859	G288	TGL(Z,X,…)
contour longitudal turning	CYCLE95	G71	G810	-	SPF(Z,…)
contour face turning	CYCLE95	G72	G820	-	SPF(X,…)
contour parallel turning	CYCLE95	G73	G830	-	SPP
centering	CYCLE81	G85	G71	G81	G81
drilling	CYCLE83	G83	G74	G83	G83
reaming	CYCLE82	G85	G72	G81	G82
tapping	CYCLE84	G84	G73	Tapping(“Z”,”C”,…)	G84

Work in the dialog mode editor (Fig. 1) is represented by the example of end groove machining programming with specified start and end points. Tool change is performed at the X200Z200 point in the machine coordinate system.

The size of the cross-cutting is defined as 0.8 of the width of the plate.

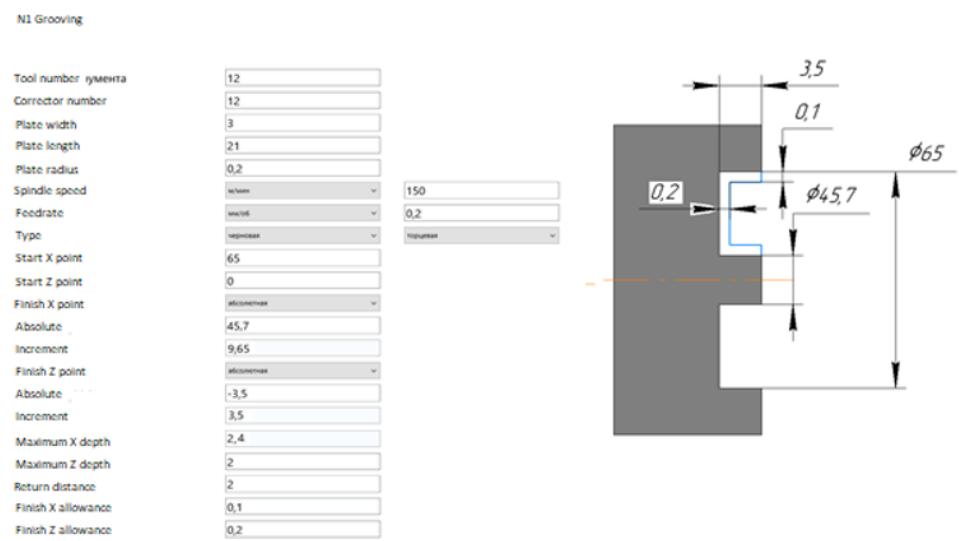

Fig. 1. Screen of editor in dialog mode.

The part program for each CNC system will look like this:

For Fanuc:

```
N10 (FACE GROOVING)
T1212
G99 G96 S150 M3
G0 X64.8 Z2
G74 R2
G74 X51.9 Z-3.3 Q2000 P2400 F0.2
G0 Z2 M5
G28 X200 Z200
```

For Siemens:

```
;N10 FACE GROOVING
T12 D1 M6
G96 S150 M3 G95 F0.2
CYCLE93 (65, 0, 9.65, 3.3, , , , , , , , 0.2, 0.1, 2, , 6)
G0 Z2
G153 T0 D0 X200 Z200
```

For Heidenhein:

```
N10 (AXIAL GROOVING)
T12
G96 S150 M3
G95 F0.2
G0 X65 Z2
CYCL DEF 871
Q215=+1 Q460=2 Q493=+45.7 Q494=-3.5 Q478=0.2 Q483=+0.1 Q494=+0.2
Q463=2
CYCL CALL
```

For AxiOMA Control:

```
N10 (FACE GROOVING)
T12 D1 M6
G95 G96 G64 BRISK
G0 X45.7 Z2 M3
G289 X45.9 Z0 Q3=150 Q5=-3.3 Q6=9.45 Q7=3 Q9=2.4
G0 Z2 M5
G28 H1 X200 Z200
```

For Balt-System NC:

```
;N10 FACE GROOVING
T12.12 M6
G96 S150 M3
G95 G1 F0.2
G X45.7 Z2
(TGL, Z-3.3, X64.8, K3);
G Z2 M5
G79 X200 Z200
```

5 Conclusions

Thus, the system of remote dialog programming is flexible, as it allows you to write part programs of small volume due to cycles and functions outside the machine and universal, as used one form of input processing information for all CNC systems.

This research was supported by the Ministry of Education and Science of the Russian Federation as a public program in the sphere of scientific activity (N 2.1237.2017/4.6).

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