Development of standardized tools for shopfloor programming of turning and turn-milling machines

Liliya I Martinova*, Roman L Pushkov and Nikolay N Fokin
FSBEI HPE MSTU “STANKIN”, Moscow, Russia

*lili@ncsystems.ru

Abstract. The problems of using CAM-applications for shop floor programming are studited. The reasons of problems of transfer of the created control programs from one CNC systems to another are revealed. A solution for unifying the format of recording of machine cycles is proposed and its applying for different CNC systems is demonstrated.

1. Modern tools for preparation of control programs

The manufacturers of CNC systems and software offer various solutions for creation of control programs for CNC machines [1-3]. Currently, full-fledged systems of automated development of control programs such as NX CAM (Siemens), CAMWorks (SolidWorks) or PTC Creo are widely distributed. Such application as ShopMill, ShopTurn (Siemens), Dialog (Heidenhain) and ManualGuide (Fanuc) they are popular programming systems, allowing programming using G-code and canned cycles. In addition, the developers of CNC systems provide users the possibility of advanced programming with using the high-level programming languages of the 3rd generation such as C, PASCAL, BASIC [4].

The applicability of certain solutions in enterprises is determined by the tasks and capabilities of users [5-7]. Thus, CAD/CAM-systems, in addition to being expensive, they must have additional postprocessors for each CNC system on which the control program will be run; and when debugging control programs, as a rule, one needs multiple iterations in the CAM-system. But for complex parts CAM-systems are often no alternative solution. Interactive programming systems, when the operator creates a control program directly on the CNC, using the operator's screen with a system of menu, graphic icons and keyboard [8], are widely used in machine-building enterprises not only in the limited production, but also in the average production.

However, the shop floor programming applications support a limited set of functionality developed by the manufacturer. Embedding your own cycles and developments in them is quite a challenge [9, 10]. Programming tools in the high-level languages, despite the difficulties, associated with the using of algorithmic structures, allows you to create flexible parametric control programs, to work with variables during program execution, to organize libraries of subroutines and canned cycles for multiple using.

Currently, users of CNC systems are interested in the issue of distribution of shop CAM-systems on tablets and smartphones [11,12].

2. The complexity of transfer of control programs from one CNC to others

Shop floor programming systems allow you to create control programs for processing up to 70-90% of standard simple parts. Dialog programming of CNC systems is carried out by sequential selection and
introduction of parameters of cycles of typical cutting pass [13]. The control programs generated in this way are stored in the libraries and can be used as needed. In the real production conditions, it is often necessary to process the workpiece on a machine equipped a CNC system another than the one for which the program was created. Moreover, there are often faced with the problem of portation of the control programs created in such CAM-systems, in a particular CNC system, since these control programs are unable to consider the specifics of control systems and a program code of different manufacturers and only work on "their" CNC systems [14, 15]. This is because each CNC system uses its own logic of organization of movements and the format of specifying of the geometric and technological parameters for each type of processing; in addition, the cycle patterns for processing of the same geometric forms vary with different CNC systems manufacturers [16]. For example, ShopTurn (Siemens) and ManualGuide (Fanuc) applications have significant differences in the form of data entry. In programs from ShopTurn auxiliary M -commands are incorporated in the original processing templates and are automatically connected when the program is generated, and in programs from ManualGuide only geometric parameters are laid in the templates, and auxiliary commands (tool change, spindle on/off, etc.) are entered manually.

Such circumstances makes it impossible to use control program, written ShopTurn, on machine tools with Fanuc CNC systems and Vice versa. Users need the tool that allows the control program written in it to be used in different CNC systems.

3. Approach to unification of the form of cycle recording for different CNC systems

When transferring control programs from one CNC system to another, there are practically no problems with fragments written in G-code. Difficulties are associated with the interpretation and execution of canned cycles [9].

The analysis shows that the unified cycle form should take into consideration:
- the geometry of structural elements,
- processing modes (speed, flow, value of insertion),
- the sequence of the working and auxiliary movements of the tool.

The developed unified format of cycle recording is a certain software tool that takes into consideration the specifics of high-level languages of the most common in Russian CNC systems: Siemens, Fanuc, AxiOMA Control [17,18], but it can be applied to other systems, taking in consideration its syntax.

The rules for writing subroutines to the memory of various CNC systems are also saved. The control program is a sequence of calls of macroprograms or subroutines with a preliminary set of values for the variables responsible for the main and auxiliary movements of the tool and the spindle.

4. An example of developing a control program for various CNC systems using the unified Toolkit

On the example of a part, processing of which is performed in cycles, an example of using a control program created with the help of the developed unified tools in different CNC systems is demonstrated. It is necessary to make a radial groove and the end groove of the part (Figure 1). For turning is used the groove cutter with the width of plate 2 mm and a nose radius 0.1 mm. Undercut protectives cutter with angle 72.5 deg., the angle at the top of 35 deg. and the radius at the top 0.4 mm.
Figure 1. Geometrical parameters of the manufactured part

The process operation is programmed in ISO-7bit. The control program for the CNC Siemens system is shown in Figure 2.

Figure 2. Control program for CNC system Siemens

Technological transitions are implemented in the control program in the form of canned cycles: OO9133 – cycle of radial groove turning, OO9149 – cycle of the front groove turning. Figure 3 shows the result of running the control program on a Siemens CNC lathe.

Figure 3. The result of the control program execution on a lathe with CNC system Siemens

Figure 4 and figure 5 represent, respectively, the control program and the result of its implementation in the CNC AxiOMA Control.
Figure 4. The control program for the CNC system AxiOMA Control

As you can see, the specifics of quite different CNC systems did not affect the correct interpretation and execution of the control program.

Conclusions
The use of shopfloor programming for the manufacture of relatively simple parts, the transfer of shop CAM-systems on tablets and smartphones is of increasing interest to specialists in the automation of production. However, in practice there are problems associated with the transfer of developed programs from one CNC system to another. The reason is that each CNC system uses its own logic of organization of movements and its own form of setting technological parameters, which prevents the unambiguous interpretation of control programs and the execution of canned cycles. The developed unified tools for shopfloor programming of lathes and turning-milling machines allows to bypass these problems and to create control programs unambiguously interpreted by different CNC systems.
Acknowledgments
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) and was carried out using equipment provided by the Center of Collective Use of MSUT "STANKIN".

References
[1] Martinova L.I., Martinov, G.M. (2018). Automation of Machine-Building Production According to Industry 4.0. In: 3rd Russian-Pacific Conference on Computer Technology and Applications. Vladivostok, pp.1 - 4.
[2] Martinov, G.M., Martinova, L.I. Trends in the numerical control of machine-tool systems. Russian Engineering Research, 30(10), (2010). Pp.1041-1045.
[3] Martinov G.M. CNC System "AxiOMA Control": prospects of development in the field of world trends // Bulletin of MSTU "Stankin", №1. (2018). P. 106-110.
[4] Pushkov R.L., Salamatin E., Evstafieva S.V.. Method of developing parametric machine cycles for modern CNC systems using high-level language. In: MATEC Web Conf. Volume 224. International Conference on Modern Trends in Manufacturing Technologies and Equipment. Sevastopol, Russia, (September 2018). Pp.1-7.
[5] Martinov G.M., Nikishechkin P.A., Grigoriev A.S. and Chervonnova N. Organizing Interaction of Basic Components in the CNC System AxiOMA Control for Integrating New Technologies and Solutions // Automation and Remote Control, (2019), Vol. 80, No. 3, pp. 584–591.
[6] Grigoriev S.N., Martinov G.M., Chadeev V.M., Aristova N.I. Digital engineering: trends and prospects // Automation in industry, №5. (2017). Pp. 3-4
[7] Martinov G.M., Kozak N.V., Nezhmetdinov R.A., Grigoriev A.S., Obukhov A.I., Martinova L.I. Method of decomposition and synthesis of the custom CNC systems // Automation and Remote Control. (March 2017), Vol. 78, Is. 3, pp 525–536.
[8] Grigoriev S.N., Martinov, G.M. An ARM-based Multi-channel CNC Solution for Multi-tasking Turning and Milling Machines. Procedia CIRP, 46,( 2016). Pp.525-528.
[9] Martinova L.I., Fokin N.N.. An approach to creation of a unified system of programming CNC machines in the dialog mode. In: MATEC Web Conf. Volume 224, 2018. International Conference on Modern Trends in Manufacturing Technologies and Equipment. Sevastopol, Russia, September 10-14, (2018). Pp.1-5.
[10] Martinova L. I., Fokin N. N. Research and development of a unified tool for generating control programs. In SB.: Systems of design, technological preparation of production and management of stages of life cycle of industrial product (CAD/CAM/PDM) Proceedings of XVII international conference of IPU RAS. 2017. P. 361-363.
[11] Nikichechkin P., Cervonnova N., Nikich A. An approach to building specialized portable terminal for monitoring and control of technological equipment // Automation in industry, No. 6. (2018). 3, 63-67.
[12] Grigoriev, S.N. and Martinov, G.M. The Control Platform for Decomposition and Synthesis of Specialized CNC Systems. Procedia CIRP, 41, pp.858-863. (2016). https://doi.org/10.1016/j.procir.2015.08.031.
[13] Pushkov, R., Martinova, L. and Evstafieva, S. Extending Functionality of Control System by Adding Engraving Capabilities. In: (2018) International Russian Automation Conference (RusAutoCon). Sochi: IEEE. https://doi.org/10.1109/RUSAUTOCON.2018.8501673
[14] Martinova L.I., Kozak N.V., Nezhmetdinov R.A., Pushkov R.L., Obukhov A.I. The russian multi-functional CNC system AxiOMA control: practical aspects of application// Automation and Remote Control. (2015). T. 76, № 1. С. 179-186.
[15] Grigoriev, S. and Martinov, G. An Approach to Creation of Terminal Clients in CNC System. In: 3rd Russian-Pacific Conference on Computer Technology and Applications. Vladivostok, pp.1-4. (2018). https://doi.org/10.1109/RPC.2018.8482153.
Grigoriev S.N., Martinov G.M. The Control Platform for Decomposition and Synthesis of Specialized CNC Systems // Procedia CIRP, Volume 41, (2016), Pages 858-863

Martinov G.M., Kozak N.V., Nezhmetdinov R.A., Grigoriev S.N., Obukhov A.I. and Martinova L.I. Method of decomposition and synthesis of the custom CNC systems.// Automation and Remote Control, 78(3), pp.525-536. (2017). https://doi.org/10.1134/S0005117917030122.

Martinova L.I., Kozak N.V., Nezhmetdinov R.A., Pushkov R.L. and Obukhov A.I.. The Russian multi-functional CNC system AxiOMA control: Practical aspects of application. Automation and Remote Control, 76(1), pp.179-186. (2015). https://doi.org/10.1134/S000511791501018X.