INVESTIGATION OF AUTOMATION OF THE CONTROL UNIT OF THE TURRET HEAD OF THE LATHE

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ABSTRACT

The article covers the tool change systems of the group of lathe machines, where equipment manufactured by Colombo, Baruffaldi, Duplomatic and Sauter have wide application in design of machines, as well as algorithm for changing the tool for revolver heads of lathe machines is given

Keywords: CNC system, revolver head, tool change algorithm, function block, core of CNC system, control signals, programming environment, EtherCAT high-speed protocol

INTRODUCTION

Transfer of implementation of control programs from the level of autonomous PLC to the level of CNC system allows abstracting from the type of used input/output modules for control signals. As a result, the binding of machine code is not carried out during compile time for specific platform, but by configuring hardware.

For example, for communication in frame of CNC system, EtherCAT high-speed protocol has wide application, which ensures the integration of dissimilar control elements (drive controllers and components of the electrical control system) into single information network. Regardless of hardware manufacturer that supports this international standard (Beckhoff, NCT, Yaskawa, etc.), the program code of function block remains unchanged, as well as the mathematical support of CNC system core. Only the range of shared memory is subject to change, which is projection of the state of physical inputs/outputs and serves as data exchange buffer between the program-implemented controller and the hardware control.

This approach ensures the independence of design of control system for electroautomatics of machine from the type of automation hardware used, which allows reusing previously developed functional blocks.

Let us consider the tool change systems of lathe machines group. Equipment manufactured by Colombo, Baruffaldi, Duplomatic and Sauter (Table 1) was widely used in the design of lathe machines.

Revolver heads are used as tool carriers in lathe, turning-milling, pipe processing and carousel machines [1]. Usually, the head has five to six tool sockets, rarely more than eight. The design of revolver heads is diverse, but two fundamentally different types are distinguished: for non-

rotating (cutters, boring plates, blocks, drills and other tools for processing bodies of rotation and holes) and rotating tools (Fig. 1).

Table 1. Comparison of technical characteristics of revolver heads from different manufacturers

	Revolver head / tool rotation motor	Quantity of tools	Clockwise / counterclockwise rotation	Orientation way	Motor / revolver head contact ratio	Control system (option)	Automatic operator
Duplomatic SM-B revolver head	Synchronous electric motor with permanent magnet excitation (siemens 1FT6, Fanuc a1)	12, 16	CLOCKWISE / COUNTERCLOCKWISE	External zero sensor + incremental motor position sensor	1:24 / 1:16	Autonomous control system DDC4	-
Duplomatic TMY-B revolver head		12			1:24		
Colombo CTM40	Three-phase asynchronous electric motor (MGM BA series)	12, 20, 30, 32		Key point (of the tool) position sensors	-	-	+
Baruffaldi TAN	Asynchronous electric motor	4, 6, 8	COUNTERCLOCKWISE			Electric module BA93/EL820	-
SAUTER	Asynchronous electric motor	4, 6, 8	COUNTERCLOCKWISE			Autonomous control system EK 501	-

Heads of the second type are used for installing drills and other tools when machining holes that do not coincide with the axis of rotation of the work piece (parallel, perpendicular, etc.), as well as for performing milling and other work and are equipped with mechanical parts to transfer rotation to the spindle and the tool (gears, bearings, couplings, etc.). The revolver head must have high rigidity to handle rough work while still providing high precision in finishing work [2].
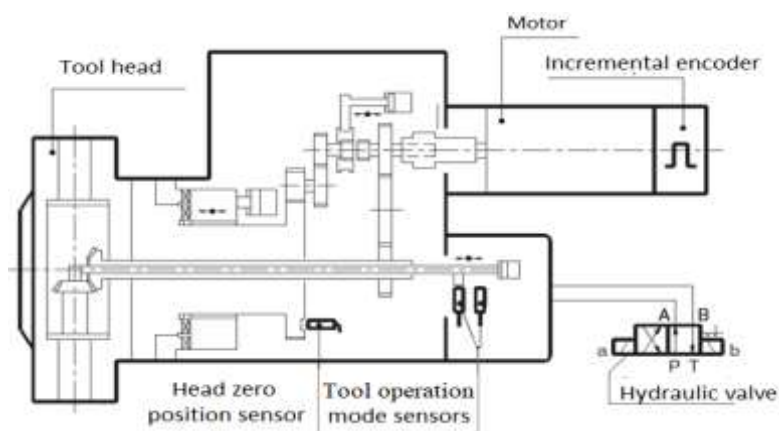

Fig. 1. Duplomatic SMB revolver head.

For the second type of revolver heads, only the tool that is currently in the working position (opposite the work piece) receives forced rotation - from a special electric motor. In total, two or three revolver heads can be installed on lathe machines, often in combination with tool chain magazine. For machining body workpieces, driven revolver heads are used only in combination with magazines. In this case, two positions of the head are distinguished: the working one, which serves to rotate the working tool and the diametrically opposite one, to change the used one. The transfer of tools (fixed in standard mandrels) from the magazine to the socket of the head and vice versa is carried out by the auto-operator during the operation of the machine. In this case, the stop of the spindle is needed only during the rotation of the turret by 90.

Fig.2 shows algorithm for changing tools for revolver heads of lathe machines.

The wide range of products of each manufacturer is due to the design features important for different types of machines: the number of tools, the arrangement of tools (axial / radial), the method of fastening the tool, etc [3]. Based on the criteria highlighted in Table 2, most equipment can be divided into subgroups to implement unified control routines (functional blocks). Moreover, each of the criteria is a parameter that does not affect the control algorithm as a whole, but determines only the quantitative characteristics of the technological equipment. According to the algorithm, the following sequence of actions must be performed:

1) unlock the mechanical brake of motor of revolver head;
2) implement the turn of the revolver head clockwise / counterclockwise (turn in a given direction according to the algorithm for finding the shortest path)
3) turn the engine by the specified number of discrete (control is carried out by the feedback sensor - DOS or position sensor);
4) turn on the mechanical brake of motor of revolver head;
5) turn the hand of auto-operator to carry out the automatic tool change operation (if necessary).
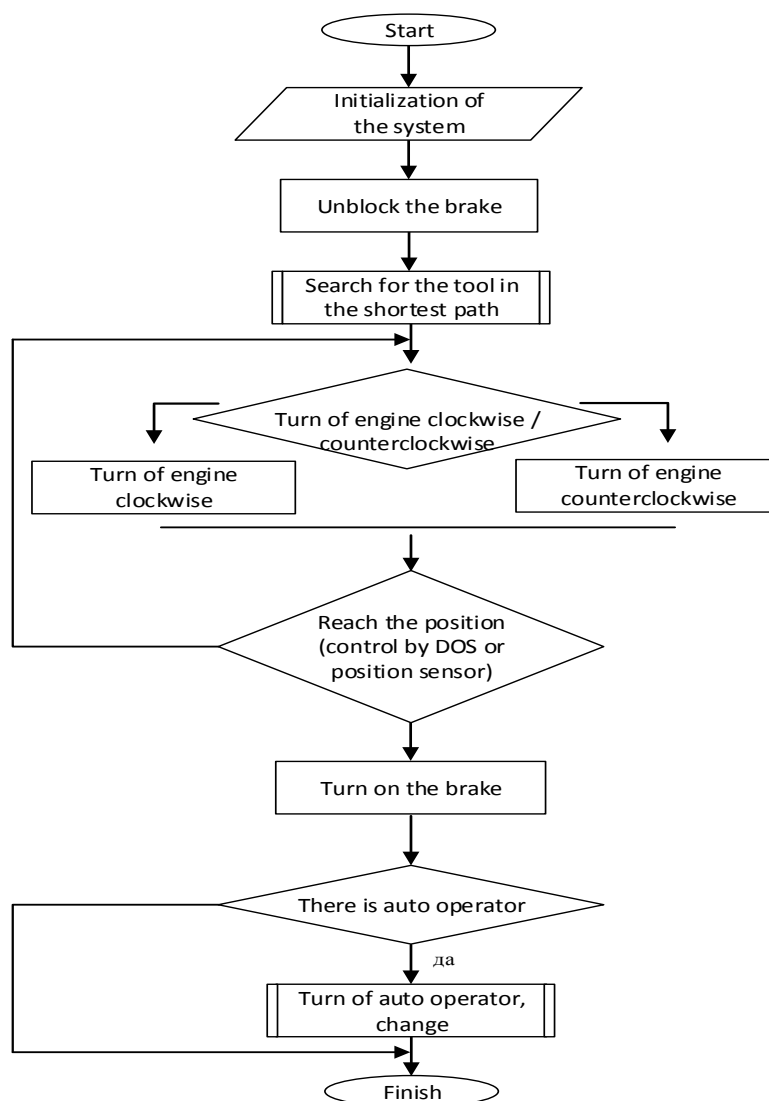

Fig.2. Algorithm for changing tools for revolver heads.

Analysis of the tool change algorithm allows determining the distinctive features of various types of equipment, which were further identified as a parameter of functional block:

- Type of tool search sensor used. Determines the search mechanism for the required position: by the sensor installed on each cell of the tool magazine (revolver head) or by the angle sensor on the rotation motor of the tool magazine (revolver head). This parameter is key and to the greatest extent determines the algorithm of the entire block (parameter No. 1).
- The presence of mechanical brake on the revolver head rotation motor (determines the necessity of performing steps No.1 and 4 - parameter No. 2).
- Possibility of rotating the revolver head clockwise/counterclockwise/in both directions (determines the possibility of using the algorithm for finding the shortest path - parameter No. 3).

The use of the shortest path search algorithm can significantly reduce the auxiliary time of the tool change operation. Let us take as parameters: A - the number of the active tool, T - the number of the required tool, N - the total number of tools. If one of the inequalities is true:

$$0 < T - A \leq \frac{N}{2} \quad \text{or} \quad (1 - N) \leq T - A \leq -\frac{N}{2}, \qquad (1)$$

it is necessary to rotate the drive towards increasing the serial number of the tool. If one of the inequalities is true:

$$\frac{N}{2} < T - A \leq N - 1 \quad \text{или} \quad -\frac{N}{2} \leq T - A \leq 0, \qquad (2)$$

then it is necessary to rotate the drive towards decreasing the tool serial number. The presented inequalities (1) and (2) show that the determination of the direction of rotation of the motor depends on the total number of tools N (parameter No. 4).

The number of tools in the revolver head (N) in conjunction with the motor encoder resolution (Δ) and the motor/revolver head contact ratio (n) determine the number of feedback encoder signals received during one position rotation. When turning from the position of the active tool (A) to the position of the required tool (T), the motor must rotate in the selected direction, while receiving from the feedback sensor the number of signals (Cnt) equal to:

$$Cnt = (T - A) \frac{n * \Delta}{N}. \qquad (3)$$

Formula (3) determines that the value of Cnt is directly proportional to the product of the values of n and Δ (parameters No. 5 and 6, respectively).

The presence of hand of auto-operator determines the need to perform the fifth step of the tool change algorithm (parameter No. 7).

In the programming environment of the Soft PLC of controller, a function block (FB) for automatic tool change was implemented. The selected parameters constituted a set of FB inputs, the values of which determine the sequence of actions during the tool change operation (**Error! Reference source not found.**).
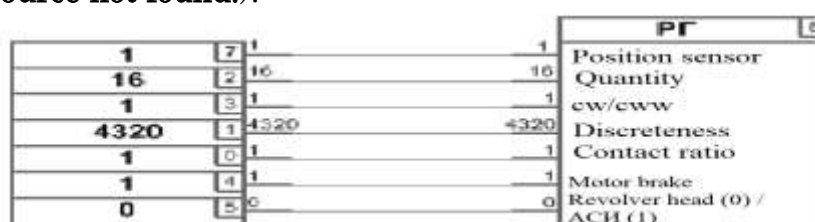

Fig. 3. Appearance of parameterized functin block

Internal implementation of functional block (**Error! Reference source not found.**4) is a programmatic description of the steps of algorithm in the language of functional blocks, which is part of the MEC 61131 standard (FB - functional blocks). The program contains standard functional blocks (implement logical, mathematical and comparison functions) and specialized user blocks (implementation of mechanism for finding the shortest path and controlling the auto-operator). Because of the operation of the tool change functional unit, control actions are formed on the executive bodies of the revolver head, which in turn leads to the selection and installation of the required tool.

REFERENCES

1. Nezhmetdinov R.A., Martinov G.M., Kuliev A.U. Approach to implementation of hardware-independent control of electroautomatics of lathing and turning-milling machines with CNC // Proceedings of higher educational institutions. Aviation technology. 2016. No. 2. p. 128-131
2. Nezhmetdinov R.A., Pushkov R.L., Evstafieva S.V., Martinova L.I. Construction of specialized NC system for multi-axis turning-milling machining centers // Automation in industry. 2014. No.6. P. 25-28.
3. Martinov G.M., Nezhmetdinov R.A., Kuliev A.U. Approach to the implementation of hardwareindependent control of electrics of turning and turningmilling machines with NC // Bulletin of higher educational institutions. Aviation technology. 2016. No.2. P. 128-131.