RESEARCH ON DIVIDING SCHEMES AND DEVICES WITH NUMERICAL CONTROL

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ABSTRACT: Dividing/ indexing represents a necessary process in certain technological operations/ systems of machining, control or assembly. In industrial or laboratory conditions, different variants of dividing/ indexing heads or tables/plateaus are used. In this paper, there is presented a series of elements of calculus, constructive-functional and simulation regarding dividing schemes and devices, with mechanical or computer numerical control. Specific elements refer to a dividing/ indexing table from the structure of a CNC machining center with 5 axes, of which 3 are numerically controlled and 2 - manually controlled.

KEYWORDS: dividing, indexing, dividing head, dividing table, CNC.

1. Introduction

The objective of this paper is to present general elements and applications on the development of functional schemes and dividing devices with mechanical control and computer numerical control, respectively.

The research-development methodology is structured in relation to the following reference elements: general framework; functional scheme; dividing calculations; constructive-functional development of dividing devices; simulation of dividing devices.

2. General considerations

The dividing/ indexing devices are type of: dividing/ indexing head, dividing/ indexing/ rotary table or plateau, etc.

The dividing head is used to divide the circumference of the workpiece into equally spaced divisions - on gears, helical gears, screws and for irregular profile workpieces. Indexing plates are used to ensure that the workpiece is positioned with accuracy. Most dividing heads have an indexing plate permanently attached to the spindle (Fig. 1) [1].

Fig. 1. Dividing head [4]

Rotary indexers use a scale and display the angle of rotation (0 - 360°) [4].
Dividing heads can be simple, universal (Fig. 2, 3), etc.

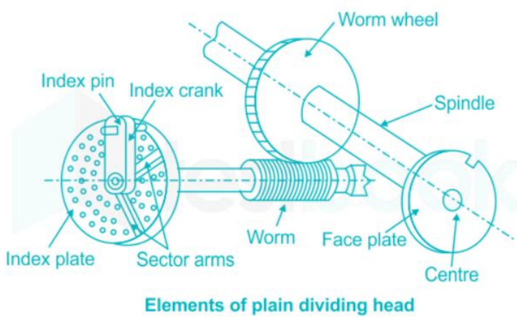

Fig. 2. Elements of a simple dividing head [5]

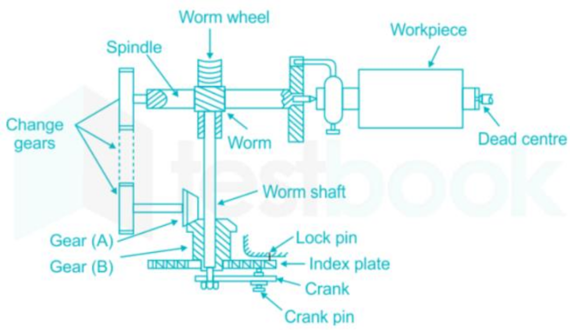

Fig. 3. Elements of a universal dividing head [5]

In a simple dividing head, an worm wheel is rigidly fixed to the spindle, while the index crank is rigidly mounted on the worm shaft, so that rotation of the index crank rotates the worm shaft (Fig. 2) [5].

The universal dividing head is used to set the horizontal, vertical or inclined working position in relation to the table of the machine - tool. Periodically, the working position is changed to a given angle for indexing the workpiece or to achieve a continuous rotary movement of the workpiece, e.g., for milling helical splines (Fig. 3) [5].

The optical dividing head is used for high-precision angular position indexing. The optical system is incorporated in the dividing head for angle reading (Fig. 4) [5].

Fig. 4. Optical divider head [5]

3. Numerical control indexing

A CNC indexing head is driven by a servo motor coupled to the drive shaft and electronically controlled. Control can be a keypad for operator or entirely type CNC (Fig. 5) [5].

A stepper motor is included in the structure of an indexing head. The stepper motor is a brushless DC motor in which the rotation is divided into a number of steps, which results from the motor construction. By default, a full 360° shaft rotation is divided into 200 steps, which means that the shaft takes a new step every 1.8°. Motors are also available in which the shaft pitch is 2; 2.5; 5, 15 or 30°. A complete rotation of the shaft is divided into several discrete segments; the stepper motor does not rotate continuously, but in steps, passing through intermediate states, which is why the operation of such a motor is accompanied by a characteristic sound or vibration (Fig. 6) [8].

Fig. 5. CNC indexing head [9]

Fig. 6. Stepper notor [10]

A closed-loop electronic indexing head uses servomotor and feedback measurements to ensure that the desired position is achieved. A common feedback sensor used in an electronic indexing head is the optical rotary encoder [2]. This consists of a light source, a photocell and a disc containing a series of slots through which the light source can shine to power the photocell. The disc is connected to the rotating shaft. The plate rotates, and the slots cause the light source to be seen by the photocell as a series of flashes, which are converted into an equivalent series of electrical pulses. By counting the pulses and calculating their frequency, the angle and rotational speed of the workpiece, determined in the basic optical encoder, can be calculated.

The angle between the disk slots, ∝, in ^{0}/slot, is:

$$\alpha = \frac{360}{n_s} \tag{1}$$

where n_s is the number of slots from the disk, in slot/rev, and the angle of 360 is in ^{0}/rev.

For a given angular rotation of the workpiece, A_g, the encoder generates a number of pulses n_p:

$$n_p = \frac{360 n_s}{A_g} \tag{2}$$

The frequency of the pulses, f_p,'in Hz (pulse/sec), is:

$$f_p = \frac{f_r n_s}{60p} \tag{3}$$

where: n_s - the number of slots in the encoder disk, in pulses/rev; f_r – the feed rate in mm/min (known); p – the pitch, in mm/rev (known); 60 - converts seconds to minutes (Fig. 7) [2].

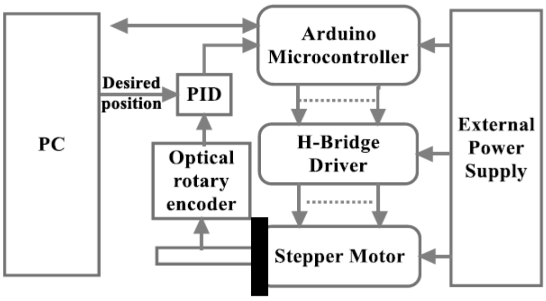

Fig. 7. Schematic diagram of an electronic indexing head [2]


Fig. 8. Indexing table [11]

The indexing table (Fig. 8) [11] is used to transport components of the production line from one point to another, stabilizing a component to perform a production task, a certain quality control or marking - through the side devices of the table. The side devices can be placed around the table and near to special stations to perform the specific operation [3].

4. Constructive-functional analysis and simulation of the dividing table from the structure of a CNC machining centre

Within Dr. Köcher SRL, an analysis has been performed in order to highlight the functionality of the dividing/ indexing table from the dtructure of a DMU 50 CNC Centre (Fig. 9). The core business of the company is the production of die-casting and injection moulds for plastic mass, the manufacturing of die-cast parts and other products [7].

The DMU 50 CNC Center presents a robust construction, with a simple installation concept, low space requirements, high rigidity, precision and long service life.

Fig. 9. DMU 50 CNC

The specifications of the DMU 50 CNC Centre are as follows:

- Traverse range: X = 500 mm, Y = 450 mm, Z = 400 mm;
- Rotational speed: 20 - 8 000 rpm;
- Drive capacity: 13 kW (40% DC), 9 kW (100% DC);
- Permissible tool diameter: 130 mm;
- Permissible tool height: 290 mm;
- Permissible tool mass: 6 kg;
- 3 automatic axes / X, Y, Z
- 2 angular axes, manual/ B, C;
- The B-axis is specific to the linear Y-axis and the C-axis is specific to the linear Z-axis.

In order to machine an electrode, EL1F/ Cu, on the DMU 50 CNC Center, with the semi-automatic activation of the indexing table from the structure, a series of associated elements are presented in Fig. 10 – 13.

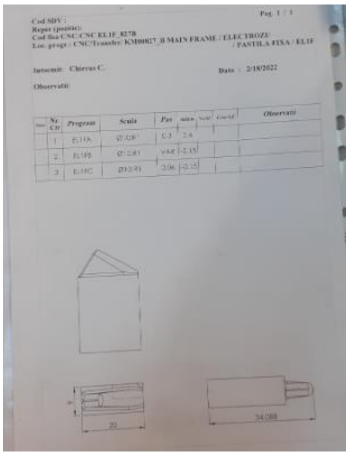

Fig. 10.The design drawing of EL1F/Cu part

Fig. 11. The semi-finished product for EL1F/Cu part

Fig. 12. Entering parameters in the machine program

Fig.13. Sequence from the macining operation of EL1PF part

Constructive-functional elements of the dividing table of the DMU 50 CNC center structure are presnted in Fig. 14, 15, 16. The main components of the dividing table are: the gear worm shaft - worm wheel, the worm gear subassembly, the hydraulic cylinder and the springs for axial locking of the dividing table. By pressing the start button, the hydraulic cylinder is actuated and, respectively, the dividing table is unlocked, etc. [7].

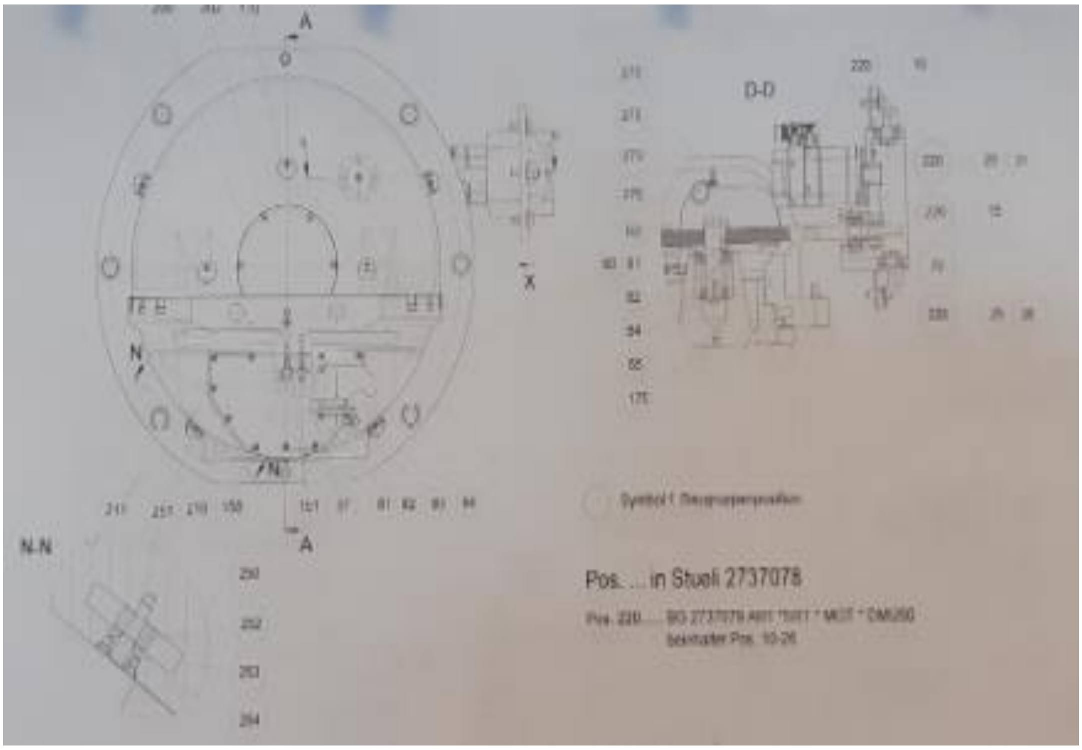

Fig. 14. Design drawing of dividing table - front projection

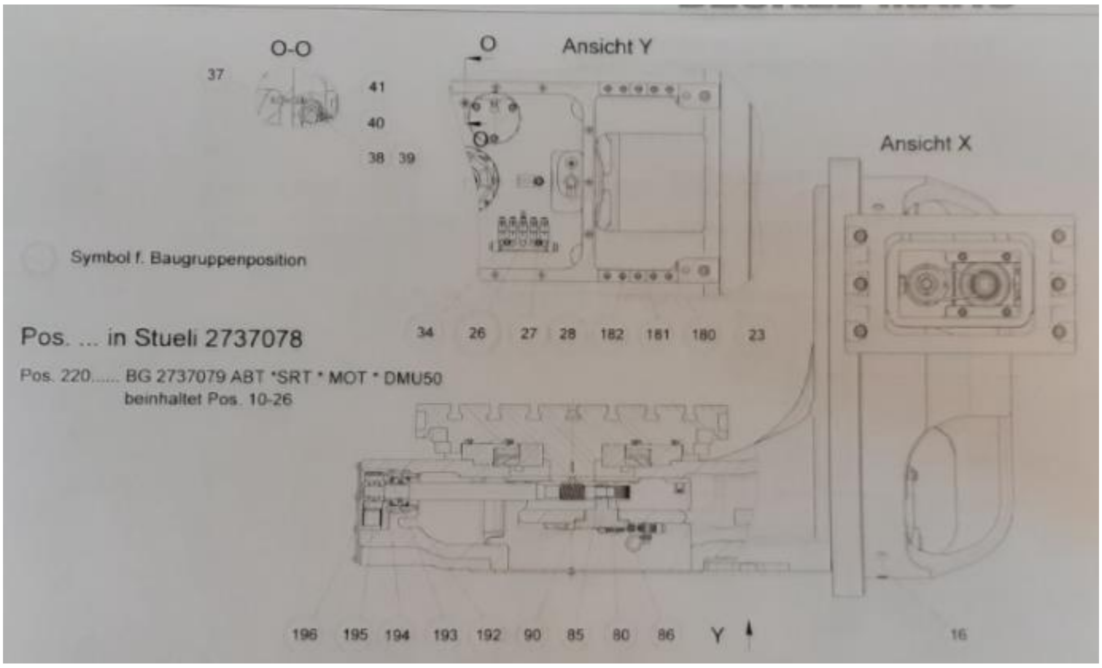

Fig. 15. Design drawing of dividing table - side projection

a.

b.

Fig. 16. Elements of the operation of a dividing table:
a - rotation C relative to the Z-axis; b - rotation B relative to the Y-axis.

5. Conclusions

From the analysis of mechanical, semi-automatic and automatic dividing schemes and devices, the superiority of the automatic dividing process is shown by a number of advantages.

By digitization, all data are kept intact for future reference. In case of emergency, data can be easily retrieved. It is faster, more reliable and more cost-effective. The processing quality is stable, the processing accuracy and repeat accuracy are at a high level, so that, the processing requirements are satisfied.

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