The Efficiency Increasing of the Machining Stations by Using the Modern Machining Work-holders On The CNC Machines and the Flexible Machining System

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Abstract: In times of economic crisis, more and more emphasis is being put on the processes of searching for savings in the processes of realizing production in enterprises and their improvement, especially in significant processes such as assembly and machining. First of all, this applies to improvement of the flow of semi-finished products and production equipment between workstations and transport between workstations. Moreover, this regards to the organization of working space and movement of semi-finished and finished products on the production workstations and in their environment. Very important is the organization of working space in production workstations, including the machine tools and flexible machining systems. Particularly important is the proper selection and efficient operation of machine tools and workholders. Apart from tools and toolholders, they have a major impact on the quality of the final product. Considering the above, the author presented the growth trend of the construction of modern workholders, intended for CNC machine tools, machining centers and flexible machining systems. The article also inserts examples of design solutions of chosen flexible modular systems and combined workholders, quick-change workholder systems, and workholders integrated with flexible machining stations. It is a major problem which occurs during the process of forming the machine parts of the CNC machines and machining workstations. Proper selection and integration of workholders for machining stations can increase productivity of all the manufacturing process and thereby reduce production costs.

Keywords – The machining workholders for CNC machines, modular fixturing systems, machining center workholders

I. INTRODUCTION

The workholders like toolholders with tools directly react on the machined part in order to change its shape and dimensions. In most cases, they are used to fix and clamp the workpiece in a CNC machine. Sometimes, they also aim to give the machining object the different positions of the object unclamping during the machining operation. They have a great importance in the machining process because, by proper selecting of the workholder, we can reduce costs of production and increase the quality of manufactured parts. In particular, they have great importance in machining centers and Flexible Manufacturing Systems (FMS).

Speed of loading and unloading, fixing, and secure clamping/unclamping of the object are mainly important.

They take into account the workholder, environment in workspace of machine. A properly selected and configured the workholder and properly fixed and clamped on it in part, allow to obtain high quality of the workpiece, which depends just on the workholder.

As you can see this is an important problem, because in the article, we have been raised selected aspects concerning the workholders used in the manufacture of machine parts on CNC machines.

It presents among other things selected the lathe chucks, milling and grinding workholders (including electromagnetic or magnetic and acting on the vacuum), modular fixturing systems and workholders for the purpose of machining centers and FMS.

It has also been inserted many examples with photos and interesting information concerning the currently used the work-holders in industry.
II. WORKHOLDERS ON THE TURNING MACHINE STATIONS

On the CNC machines, on which occurs rotary semi-finished machining of axis-symmetrical and non-symmetrical used universal lathe chucks and sometimes special. Among are used universal lathe chucks the most often used are:

1. **Self-centering chucks of 2, 3, 4 or 6-jaws of lathe chucks with mechanical, hydraulic or pneumatic clamped.** Hydraulic and pneumatic chucks receive drive from pneumatic or hydraulic cylinder located on the back of the headstock of the lathe. In these chucks can be removed and clamped the object in jaws, when you press the foot pedal at the machine or press of suitable button in the control panel of CNC machine control. The standard applies to single and split jaws (soft or hard), made of steel, aluminium or plastic.

   Often, to increase the possibility of chucks clamping the special constructions of jaws are used adapted for clamping elements of different shapes. Some manufacturers also offers devices for the automatic change of jaws (Fig. 1e)).

2. **Combined lathe chucks (Fig. 1f))** - used to clamping symmetrical and non-symmetrical objects in individual and low-serial production. They are combination of self-centering chuck with independent, arbitrary set-up of every one of jaws.

3. **Mandrels (Fig. 1b))** - there are chucks which are used to turing and grinding finishing of externally cylindrical surfaces sleeves and discs. They can be stationary, expanded, cylindrical, mandrels with rollers and camping mass with disk springs or lameral inserts.

4. **Chucks with collets (Fig. 1c))** - the main element is a removable collet, which is used for camping of rods, short shafts, and automatic lathes.

5. **Rotary electromagnetic/magnetic chucks (Fig. 1d))** - used for end face machining of thin disks on the lathes and grinding machines.

6. **Rotate lathe chucks to clamping by vacuum** - are used to machining of non-magnetics materials.

    Universal lathe chucks are usually mounted in spindles of CNC machines as a single or they can operate as a fixed main spindle with the C1-rotation controlled axis and interception subspindle (C2 axis and movement of the linear-W).

    The advantage of this solution is making two set-ups without stopping the machine.

![Figure 1. Examples of the chucks: a) 3-jaws self-centering of pneumatic with thru hole [3], b) expanding mandrel [3], c) expanding collet [3], d) magnetic lathe chuck [4], e) self-centering with self-aligning jaws of multipoints [5], f) combined pneumatic chucks [6] ]
Figure 2. Examples of applications of various special lathe chucks: a) to gear clamping [3], b) mandrel to the clamping shaft with turbine [4], c) pneumatic chuck with automatic division [3], d) RWD chuck with jaws retractable with clamps [5], f) chuck to crankshaft machining [5], g) PLD pneumatic chuck to the gear finishing with 3-point support on the lateral side of gear tooth [5], h) chuck to clamping the forging with hole [7], i) turning mandrel to a few gears machining simultaneously [4]

The best-known producers of turning chucks includes: Schunk GmbH & Co KG (Germany), ATS Workholding (USA), GMT Ltd. (India), SMW Autoblock (Great Britain), TEC Workholding (USA), Hainbuch GmbH (Germany), Forkardt Deutschland GmbH (Germany), Roehm Spanntechnik (Switzerland), Karl Bruckner GmbH (Germany), Teikoku Chuck Co. Ltd. (Japan), Bison-Bial (Poland), Tanshing Accurate Industrial (Taiwan) etc.

Figure 3. An example additional elements to the supporting of rotate elements clamped: a) CNC steady rest [8], b) steady rest mounted in tools head [9], c) clamp support [10], d) pneumatic face driver in section and view [9], e) hydraulic tailstock [11]

III. ROTARY-INDEXING DEVICES ON THE MACHINING MILLING WORKSTATIONS

In the CNC milling machines and milling centers are widely used a indexing devices on which various workholders can be mounted. Thanks to CNC control of rotary tables and indexing devices the other controlled axes are made increase technological capabilities of machines that use such devices. These device can include:

1. **CNC rotary tables without no/with axial hole (Fig. 4 a, f)**– angular division around control axis- C or sometimes- B is realized. They can also be done with a few collets (Fig. 4d). They are used to circumferential milling, circumferential milling slots and continuous machining.
2. **Self-aligning tables (Fig. 4 i)**– mainly used in machining centers.
3. **Tilt-rotary tables**– angular division around of A- control axis (95° do -45°) and B-axis is realized. They can be lo-
cated on a one arm (Fig. 4 h)) or double arms (Fig. 4b)) and more than one rotary table (Fig. 4 e, g)). They are used in milling center.

4. Magnetic rotary-tilting tables (Fig. 4 c)).
5. Tilting tables.
6. Different configurations of workholders – on the Fig. 4c) shows indexing tables with two collets and two pneumatic CNC tailstock sets.

Vices are mounted individually or in teams on the tables of permanents, rotating, swiveling or rotating-swiveling, to the simultaneous machining of objects, as well as columns or boxes on the pallets.

In vices can also be used different kinds of shapes of the jaws with corresponding plates for supporting and positioning of objects in the jaw (Fig. 6 a-d)) and the different configuration of jaws (Fig. 5 b-d)).

In the jaws can also be placed the magnetic blocks for clamping of the magnetic objects.

There are also flexible clamping systems (e.g. Varioline Hilma’s) with a pneumatic drive, in which both jaws are pneumatically controlled and they move on special rails (Fig. 5f)).

On the CNC machines self-centering drill chucks of 2, 3, 4 or 6 jaws with a special bases and mechanical or pneumatic clamping are found and used.

The workholders bases are bolted to the table of CNC milling machine with T-slots.

IV. MACHINE VICE ON THE MILLING MACHINING STATIONS

The standard for CNC machines for milling is using pneumatic or hydraulic machine vices (Fig. 5 a-d)). They can be arranged in series or in parallel (Fig. 5 e-i)) or on the swivel table (Fig. 5g)).

Figure 4. Rotary tables and CNC devices: a) vertical rotary table with servo-drive [12], b) tilt-rotary table [13], c) tilt-rotary magnetic workholder [14], d) indexing device with two collets with servo-drive mounted on the plate with pneumatic tailstock [15], e) two-spindle tilt-rotary table [12], f) index table [7], g) tilt-rotary table with two spindles [15], h) tilt-rotary table with one support [16], i) horizontal self-aligning table [11]

Figure 5. Examples of machine vises configuration: a) single pneumatic vice [17], b-c) machine vise of various configurations the jaws [18], d) milling with using the three vise that are on the machine table [18], e) milling with a flexible clamping system of Varioline mounted on the machine table [18], f) 4 hydraulic vise mounted on a swivel table [18], g) pneumatic drill workholders of 2, 3, 4, 6-jaws [12]
These workholders are used to fixing and clamping the workpiece destined to the drilling.

![Figure 6](image)

**Figure 6. An example of additional plates for supporting and fixing of workpieces in the vise jaws: a) rectangular, b) angular, c) with vertical bumper, d) with a sinebar [18]**

V. THE WORKHOLDERS CLAMPED OF MAGNETIZING AND ELECTRO-MAGNETIZING FORCES AND WITH USING VACUUM

In case when it depends on are used a free access to the machining area, are used to tables with clamping of a magnetic force or with using a vacuum. These types of workholders are used during milling and grinding. This depends on workpieces material properties i.e. it is a magnetic or non-magnetic material [1]. Figure 7 describes the action of a magnetic holder.

![Figure 7](image)

**Figure 7. Diagram of a magnetic holder [19]**

In position- ON, the magnetic field lines come out the North pole- N, the segment of top plate, passes through on which the workpiece find and go to the south pole- S of a magnet. The objects is then drawn to the clamping surface.

In position- OFF the block magnets is displaced from the previous position, which causes a change in the shape on the magnetic circuit.

The magnetic fields lines leaving from the North pole- N to the South- S passing the workpiece clamped in workholder (not occur attraction on the top plate of workholder) [1, 9].

Figure 10 shows examples of configuration of the magnetic and electromagnetic workholders. For example in Fig. 10a) a typical diameter of the poles in the shape of circle is about 12mm, while the contact force is about 7 kN [20].

The Kenatec company has created a set of two magnetic support plate (Fig. 8), which clamp between each other the workpiece and are located on the magnetic/electromagnetic table.

In these plates are clamped parts of non-magnetics materials such as sintered carbide, aluminium, bronze, stainless steel and others, that cannot be directly located in a magnetic workholders.

![Figure 8](image)

**Figure 8. Schematic location of the supporting plates of non-magnetic elements on the magnetic table [14]**

Another type of workholders for milling and grinding are workholders operating on vacuum (Fig. 9).

They are used in the machining of non-magnetics materials such as plastics, non-ferrous metals and light alloys.

The main element is a plate in which there are holes and shaped recesses (holes, which are not used to for mounting are closed by means of special screws).

The object is pressed down to the steel surfaces plate, as the knob on the table and is turned in ON position.

Then the workholder is connected to a vacuum aggregate and a tank, in which is constant pressure below atmospheric.

After finishing of machining, the knob is twisting to the OFF position for at interior plates connects to the atmosphere, what allows for taking off object [14, 22].

Examples of magnetic workholders shows Fig. 10.
VI. MODULAR FIXTURING SYSTEM

Modular fixturing systems are workholders, that are mounted in a short time (several hours) from a set of the standardized components and assemblies applied to fixing and clamping of the workpiece and to ducting the tools.

Individual companies that produce of machining instrumentation, manufacture the systems consisting of elements tenses and is usually destine for specific classes of the parts [1].

With the Modular Fixturing Systems:
- Reduced the design and fixture manufacture costs.
- It is possible to apply them to the individual and small production, thanks to the availability of elements.
- Significantly reduced the storage spaces what occupied the fixtures.
- Obtained an easier and quicker replacement of workholders components in case of their failure.
- Obtained the flexibility of spacing the workholder elements on the base.
- Reduced the workholder manufacture costs.

Modular fixturing systems are composed with the following elements [2, 23-26]:

1. **Base** – made with alloy steel such as: chrome-nickel steel with hardness 64HRC with holes (threaded or not) or T-slots spaced of the workholder abutting base surface of crossed can take the form:
   - Plates of rectangular, square and round shape (Fig. 11a)- this plates apart from the holes used for fixing and clamping of workholder elements keep also the holes to the fixing the base of the machine table. To the holes can also be supplied an oil by connecting holes special system located in the base.

Figure 9. Examples of workholders to the clamped of workpieces on the vacuum: a) view of the workholder [14], b) the objects machining of clamped in vacuum workholder and a general view of the hole system [20, 22]

Figure 10. Examples of magnetic/electromagnetic workholders: a) magnetic table for surface of AMR [20], b) bipolar electromagnetic table to clamped of rotate workpieces [20], c) electromagnetic table with T-slots and use magnetic blocks [19], d) electromagnetic workholder to surface grinding [21], e) electromagnetic workholder with slit support block [6], f) clamped system of A-POD using magnetic blocks located in T-slots of the column [20], g) around magnetic block system of the A-POD on the machine table [20], h) with using magnetic V-blocks of B-Polar [14, 20], i) with clamping surface in shape of square field [18], f) electromagnetic workholder with slit support blocks [6]
• Boxes or columns (fig. 11b and c)) – on which can be fixed and clamped workpieces in horizontally or vertically position. Holes (threaded or not) are located on two or on all four surfaces of the box. On the holes can be build a variety of workholder. They are used in horizontal milling machines, drilling milling machines and machining centers.

• Basics of angle bracket shape (Fig. 11d)).

2. Fixing elements- these includes: pins and fixed screw stands, self-aligning stands, adjustable pins, pivots, support plate, the plates with accurately made socket, angles to the support object, V-block, fixing elements with sloped surfaces, plain pins etc.

3. Clamping elements- gripper clamp of stationary and rotary, lever sets clamping, collets, adjustable tailstocks, hook clamps, eccentric lever, adjustable handles, handwheels and others etc.

4. Fasteners in the form of clamping bolts with nuts and other.

5. Subassemblies.

There are many manufacturers of modular fixtures among other things belong to them: Heinrich KIPP Werk KG (Germany), Stevens Engineering Inc. (USA), Ferra Tools (Germany), Gerardi S.p. A. (Italy), ADVANCED Machine & Engineers Co.(USA) Halder Norm+Technik (USA/Germany), Hohenstein GmbH (Germany), Imao Corporation (Japan) etc.

Figure 12 shows examples of applications of the modular fixtures:

VII. WORKHOLDERS USED IN MACHINING CENTERS

In the CNC machining centers (milling, turning, milling-turning, etc.) where are made the several machining treatments simultaneously, such as: milling, drilling, boring, turning and others, using special workholders locate on pallets (Fig. 13), in which are mainly manufactured body, flat or rotary parts. They are used to making higher speed the delivery of workpieces to the work area of machining center and fast changes of pallet configurations. The workpiece is fixed and clamped on the table of machining center and is performed usually prepared. On the pallets there are generally located bases and others: the special workholder elements in the form of a special (Fig. 14): full column or boxes in the shape of rectangular prism, octahe-
Pallets of table during manufacturing also rotate, so they can work the objects manufactured located on the four sides of the column.

Pallets with columns after fixing and clamping of workpieces can be found on the appropriate table with ways after which the workpieces of machining area the machining center.

After working the pallets with machined good parts goes from with machining center and with using of pallet changer is changed the move direction of the range 90° is changed and directed onto the track with guides on which will move to a loading workstation, where the object will be unclamped and clamping a new one.

While the pallets with machined parts moves to the delivery workstation, the second pallet with semi-finished to machining moves to the pallet changer and the change in direction of 90° is changed and driving to the machining center is manufacturing these parts.
changeover time and expands the configuration possibility. They are mainly used for milling and turning centers, to rotary tables and for machining and grinding gears.

IX. CONCLUSIONS

In conclusion, it was found that the workholders are evolved over the years.

It shows clear, that appeared a tendency to make the workholders, which are characterized easy operation, design flexibility, speed action, easy of modification of its components, and increase their productivity.

The aim is also to the fact that they are more used standard elements.

This is due to the rapid development CNC machines, among other things: machining centers and flexible machining workstations, as well as equipment applied for them.

X. REFERENCES

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