Proceedings of the 15th International Conference on Manufacturing Systems – ICMaS
Published by Editura Academiei Române, ISSN 1842-3183

"Politehnica" University of Bucharest, Machine and Manufacturing Systems Department
Bucharest, Romania, 26–27 October, 2006

CUTTING UNITS FOR PRECISION TURNING OF INTERNAL AND EXTERNAL COMPLEX SURFACE WITH NUMERICAL CONTROL. APLICATION

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Abstract: *The paper spotlights two modes of manufacturing with lath tool of complex surface, respectively with turning units of axial or radial feed. In the case of turning units with radial feed, it analyzes shortly the classically controlled turning units and the numerically controlled turning units, showing the elements that make the deference. Finely, it shows applications of radial turning units and axial turning units that are able to solve problems in economy.*

Key words: *functional plays, pretension, precise positioning, radial feed module.*

1. INTRODUCTION

Usual the generating of complex surface by splintering with a cutter is done:

- on lathe, with rotating work piece – the main splintering action and the lathe tool with axial or radial feed referring with rotating axis of the work piece;
- with turning units, with standstill work piece and the cutting tool with both the movements: rotating – the main splintering action and axial or radial feed referring with rotating axis of the tool.

So, in the first case, the work piece makes the main cutting motion, the rotating motion, and the tool makes the feed motion. In the second case, the tool makes both main cutting rotating motion and feed motion.

The generating of complex surface by turning units, usual can be done with:

- turning units with radial feed and classical control;
- turning units with radial feed and numerical control.

Further will be analyzed the turning units with radial feed with these two kind of controls.

2. CUTTING UNITS FOR TURNING WITH RADIAL FEED, CLASICAL CONSTRUCTION

Cutting units for turning of internal and external surface classical construction, has a structure made up of a feed unit working along tool rotating axis, and a main spindle equipped with a radial feed module working perpendicular on tool rotating axis.

In classical construction, the cutting unit is made up of a feed slide with feed mechanism with trapeze – threaded screw, with drive mechanism, made up of feed planetary gear box, driven by two electric motors, one for feed and another for rapid traversing, an main spindle fastened on slide plate equipped with hydraulic driven faceplate.

On faceplate body is fixed a reamer bar that can ream internal and external surface, on the same measure, on line with main spindle axis, and on faceplate slider can be fixed tool holder that can allow ream front faces, countersunks or groove, through radial motion of the faceplate slider.

The feed motion for slide way is obtained usually with a hydraulic cylinder for radial feed that work between two initials adjusted buffer brake.

Cutting units for turning internal and external surface, classical construction has some disadvantages:

- electromechanical feed slide and feed mechanism of faceplate has functional plays and this diminish the precision of positioning;
- duty cycle for feed slide and for faceplate slider is relatively rigid;
- can not be done complex cycles (for ex. repeated cycles);
- output usefully effect for mechanism based on sliding motion (plate travel on slide guide way, screw and nut with trapeze thread) are low.

3. CUTTING UNITS FOR TURNING WITH RADIAL FEED AND NUMERICAL CONTROL

For precise turning of interior and exterior surface are engaged cutting units for turning with radial feed and numerical control.

Cutting units for turning with radial feed and numerical control has a structure made up from a feed unit with numerical control for Z axis, and a main spindle equipped with a radial feed module (faceplate) with numerical control for the motion on U axis (perpendicular on main spindle axes).

Feed unit for Z-axis is a feed and positioning slide with numerical control.

Further, we give an example of working unit for turning with radial feed with numerical control (Fig. 1).

It is composed by: 1 – slide of feed and positioning with numerical control (it assures the feed after Z axe); 2 – spindle for turning; 3 – radial feed module (chuck plate); 4 – driving mechanism for radial feed module, with numerical control (it assures U axe).

Slide of feed has the following significantly constructive elements:

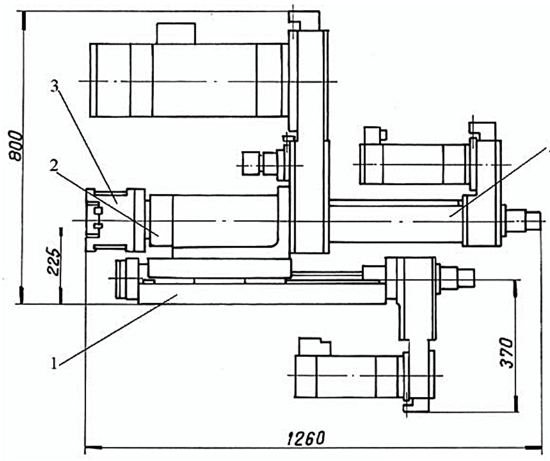

Fig. 1. Working unit for radial feed turning, with numerical control.

- guide way with rolling elements;
- feeding mechanism with rolling elements;
- servo driving mechanism with numerical control.

Radial feed module (chuck plate) has the following significantly constructive elements:

- guide way with rolling elements;
- feeding mechanism with rolling elements;
- servo driving mechanism with numerical control.

Adapting the methodology used in value analyzes for determination of technical-economical level of a cutting unit type feed slide, we can write:

$$\mathrm{NTE} = \frac{\mathrm{NT}}{\mathrm{EF}} \tag{1}$$

where: NTE – produce tehnic-economic level, NT – produce technic level, EF – financiar effort for obtaining technic level of product.

As we know, designing new products is an applied research activity, where the researcher – designer, using personal practical experience, contrives constructive solutions solving the client request.

Starting with the functional designing of an unite type feed slide with numerical control and taking into account the technical dimensions of the significant functions of the product, in the classical constructive situation, respectively in the numerical control situation, the author of this paper established by computing, the fact that the technical level of a feed slide with numerical control (constructively optimized) is in average three times higher than the one of a feed slide of classical construction.

The mechanical optimized construction, with guide way with rolling elements, feeding mechanism with rolling elements, usual pre stressed, servo driving mechanism with numerical control, radial feed module with slider on rolling pre stressed guide ways, slider feed mechanism with pre stressed rolling elements, servo driving mechanism with numerical control for slider, gives to the cutting unit for tuning with radial feed a high technical level, characterized by:

- motions for *Z* and *U* axes numerically controlled;
- pre stress existence in feed systems for *Z* and *U* axes;
- simplified mechanical structure of driving by mechanism (feed servo drive and gear box with tooth belt, usually with 1:2 ratio);
- high output usefully effect for travel on guide way with rolling elements and for feeding mechanism equipped with screw-nut with rolling elements;
- complex duty cycle for cutting units;
- precision positioning as ± 0.025 mm.

Radial feed module (chuck plate), together with feeding mechanism and driving mechanism are constructive elements mentioned as *U* axis module without to be indicated the constructive details, in technical literature.

In promoted constructive solutions by the author, the transfer function of radial feed module can be written through following relation:

$$y_r = k \cdot y_a, \tag{2}$$

where: y_r – moving after radial direction, y_a – moving after axial direction, k – the constructive constant of radial feed module.

As employee in the research and technological engineering institute, the author has promoted two constructive variants of radial feed module with the afferent feed and drive system. This is exposed by means of presenting two applications that was executed for the Romanian market.

4. EXAMPLES OF APPLICATINS OF CUTTING UNITS FOR PRECISE TURNING FOR INTERIOR AND EXTERIOR SURFACES, WITH NUMERICAL CONTROL

For the applications that will be presented as follow, the significant constructive difference can emphasized on the *U* axis nodule, as namely:

- for a application the feed module (faceplate) is a complete pre stressed system, and the feed mechanism is a screw nut mechanism with rolling elements, with rotary screw and axial movable nut;
- at the second application, regarding feed module, a component of feed module (chuck plate) has a functional loose of 2…4 μm, taken through a spring system, and the feed mechanism is a screw nut mechanism with rolling elements, with rotary nut and axial movable screw.

The constructive constant of feed module in first application has the value $k = 1$, and in the second application has the value $k = 0.325$.

4.1. The aggregate machine tool MRAM 8, modernized and equipped for body valve machining

The aggregate machine tool MRAM 8, modernized and equipped for body valve machining (Fig. 2) realizes operation of plane turning, drilling, conical turning, external conical threading with cutting tool in repeated cycle, enlarge and threading with tape.

The altered aggregate machine-tool MRAM 8 is composed of a central bed, a rotary table with 12 indexing positions, 7 working units and a loading/unloading unit.

The feed motion at working units 2H, 3H, 5H, 7H is obtained centralized from rotary table through camshaft, cams, counter-cams, and arms and feed rods.

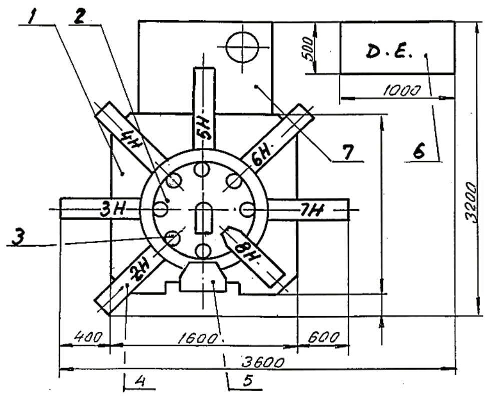

Fig. 2. The aggregate machine tool MRAM 8 for body valve machining.

The machine is composed of:
1 – central bed,
2 – indexing rotary table,
3 – piece clamping device,
4 – working units,
5 – manual loading-unloading unit,
6 – electric box,
7 – tank for cooling liquid.

In 4H unit (external conical turning) and 6H (external conical threading with cutting tool, with repet cycle) is a working unit each for turning with radial feed, with numerical control, at witch radial feed module (chuck plate, Fig. 3) was made by the author with elements in relative motion, pretentionate, for eliminating looses in system.

On this aggergate machine tool 4 typo dimensions of pieces type body valve are machining (Fig. 4).

4H unit (external conical turning) and 6H (external conical threading with cutting-tool, with repeted cycle) numerical controled, have following components:

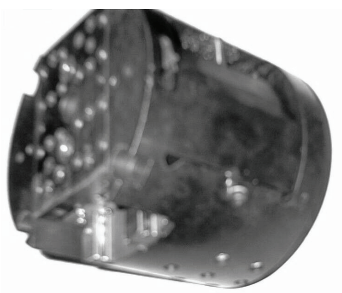

Fig. 3. Radial feed module (chuck plate).

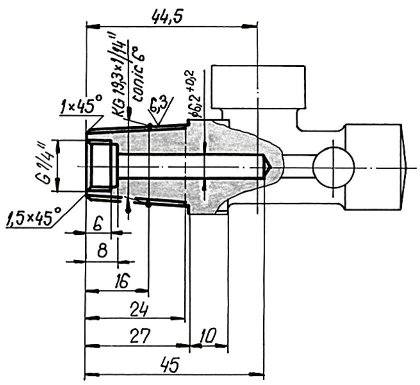

Fig. 4. The piece type body valve which is machining on aggregate machine-tool MRAM 8.

- positioning and feed slide;
- turning spindle;
- radial feed module (including driving elements);
- gearbox with gear belt.

These elements realize a working unit with CNC, with two axes (*Z* and *U*), witch can perform cycles for realizing complete surfaces through turning with radial feed and/or axial feed.

4.2. Special machine-tool for boring assembled rod

Special machine-tool for boring assembled rod assure the machining head and foot bore of rod for auto industry, through boring-roughing operations with cutting-tool, chamfering and boring-finishing with cutting-tool, for four rods simultaneous.

Near the bores machining, the machine assures the control for boring operation machining with cutting-tool and the compensation of wearing tool, and for keeping the data in prescript tolerance field.

The machine is aggregate machine-tool type (Fig. 5) with three units.

The components of this machine is following: 1 – layout plane, 2 – protector, 3 – lubrication installation, 4 – blowing system and chips evacuation, 5 – elements on machine, 6 – centering and clamping rod device, 7 – manual loading-unloading unit, 8 – horizontal working unit for boring and chamfering, 9 – horizontal unit for dimensional control, 10 – circular transfer mechanism, 11 – hydro-pneumatic installation, 12 – electrical installation, CP – control panel.

The tolerance field of working piece dimension (Fig. 6) is 15 μm at small bore, and at big bore the tolerance field is 32 μm.

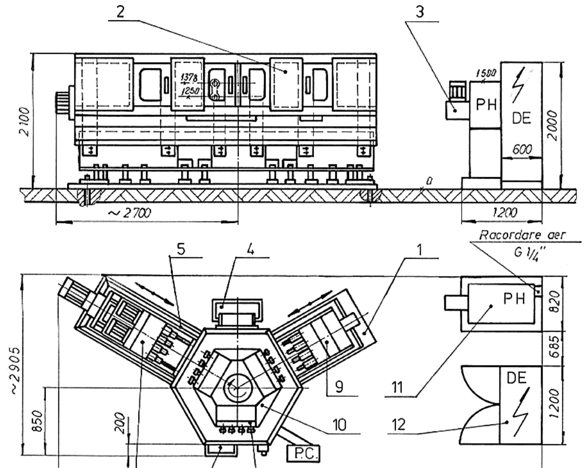

Fig. 5. Special machine-tool for boring assembled rod.

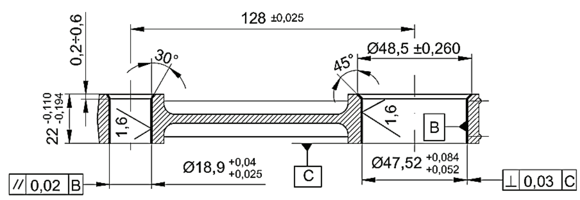

Fig. 6. The machining piece (assembled rod).

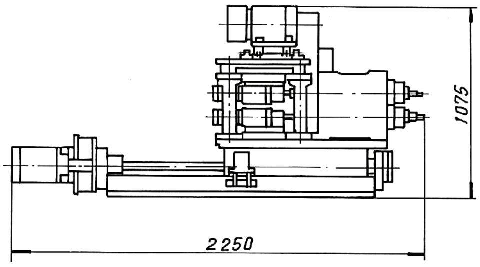

Fig. 7. Horizontal working unit for boring and chamfering with cutting tool.

The endorsed building solution for the machine allows the maintenance tolerance field in the space 2 till 4 µm, in prescript tolerance field.

The horizontal unit for boring and chamfering (Fig. 7), made by the author, performs operations of boring-rough with cutting-tool, chamfering and boring-finishing with cutting-tool, with wearing tool compensation.

Each spindle is for seen with one turning module with radial feed (chuck plate) with screw-nut feed mechanism type with rotary elements, pretension and driving mechanism with feed motor and position transducer. The feed mechanism is rotary nut type and axial movable screw.

After machining, the piece is measured in control unit and function of measured value, the command of compensation of wearing tool is giving for keeping the data in prescript tolerance field.

5. CONCLUSIONS

The working units for turning external and internal complex surfaces of precision, with numerical control are relative plane structures, made of performance components (turning elements for guide way system, feed mechanism with turning elements, pretension, driving mechanism with feed motor and gearbox with gear belt, with 1:2 rate, radial feed module), most furnished by special producers at suitable quality level, what give to that produces a high technical level.

This working units type allow the different demanding of customers regarding (Fig. 8):

- complex profiles turning (internal and external);

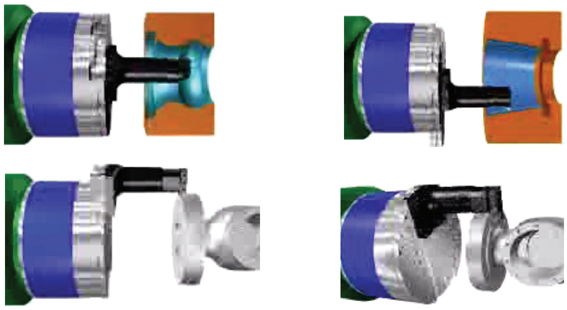

Fig. 8. Few exemples of machined surfaces.

- turning and threading conical surfaces (internal and external);
- turning frontal faces, grooves (internal and external);
- machining through turning with tool wearing compensation.

The working unit for precise turning internal and external complex surfaces, with numerical control is a special field for national design-developing-research activity.

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