TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 57, Issue IV, November, 2014

DEVICE FOR HELICAL SURFACE GENERATION WITH TILTING SLIDER USED FOR SHARPENING MILLS WITH HELICAL PROFILE

Alexandru MICACIU, Ioan Gheorghe VUŞCAN, Radu Mircea MORARIU-GLIGOR

Abstract: *Helical surface generation can be performed by composing several motions. The machine tools that conduct the helical surface generation require the use of several axes, having as effect a high energy consumption and a complex construction. The current paper presents a device for helical surface generation with tilting slider used for sharpening mills, whose use allows helical surface processing on conventional machines, with low energy consumption.*
Key words: *device, helical motion, tilting slider, sharpening mills.*

1. INTRODUCTION

Sharpening mills consists in rectifying the tool face grinding, with the purpose of obtaining an appropriate geometry and smoothness of the surface.

The sharpening is performed on universal or special grinding machines or on grinders with the help of special devices.

Universal grinding machines perform the sharpening of a wide variety of cutting tools, such as: mills, drills, taps, reamers, knives. They are manufactured in many constructive versions, but all types have the same components.

Currently, universal grinding machines are used internally in industrial practice, machines that are manufactures at U.M. Cugir Mechanical Plant or at U.M. Plopeni.

The draft of a UAS 200 grinding machine made at Cugir Mechanical Plant is presented in Figure 1.

The universal grinding machine is composed of : 1 - frameworks; 2 – transversal frame; 3 – table support; 4 – machine table; 5 – tilting table; 6 – machine column; 7 – wheel head; 8 – main shaft; 9 - footstock; 10 –splitter; 11 - device for rectifying abrasive bodies [2].

Also, the current trend is to manufacture universal grinding machines with numerical control (CNC).

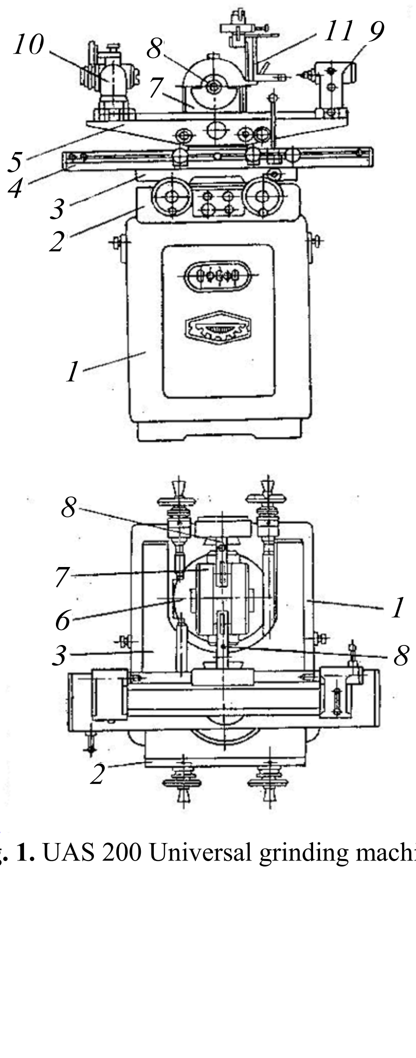

Fig. 1. UAS 200 Universal grinding machine

From the kinematic point of view, these machines are similar to universal grinding machines but with an improved and simplified construction by using the numerical control.

An example of grinding machine with numerical control is the one manufactured by the Klingelnberg company, CNC machine tool for sharpening worm cutter symbolized by SNC 31 (figure 2) having six CNC kinematic axes (figure 3).

Fig. 2. Klingelnberg CNC machine tool for sharpening worm cutters, type SNC 31,[3]

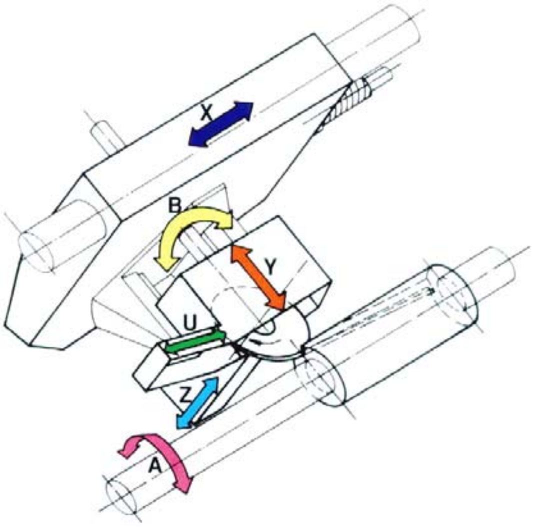

Fig. 3. CNC kinematic axes of the Klingelnberg machine tool for sharpening worm cutters, type SNC 31, [3]

In figure 3, the A – axis performs the rotation of the worm cutter; the X – axis performs the movement of the rectification saddle; the U and Z – axes perform the shaping of the abrasive body; the Y – axis performs the radial positioning of the abrasive disc; the Z – axis axially positions the abrasive disc; the B – axis makes the pivoting angle of the abrasive disc [3].

2. OPERATING PRINCIPLE

In figure 4, it is presented the operating principle of a helical surface grinding device with adjustable step, equipped with tilting slider which can be adjusted for face grinding machines. This constructive version has a high precision concentric chuck mounted on the main shaft.

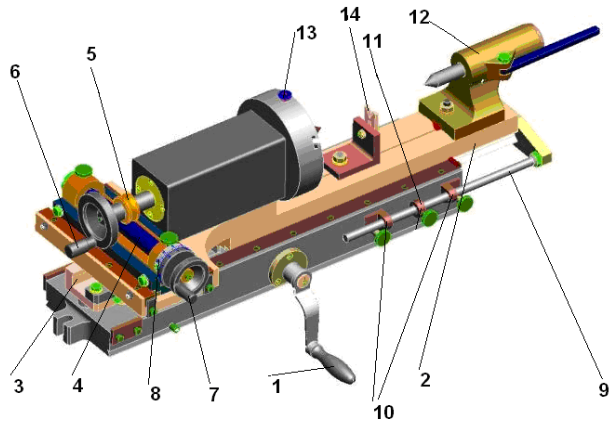

Fig. 4. The helical surface grinding device with adjustable step, equipped with tilting slider

Using the lever (1), the main carriage (2) is actuated in a translation motion, therefore assuring the axial displacement component of the helical motion.

During the motion of the main carriage, the tilting slider (1) guides the sliding block that engages the cross slide (3) supported on ball slide.

Also, during the sliding block displacement in the guideway of the tilting slider, the cross slide (3) is moved.

By moving the cross slide (3), the worm (4), which engages in a rotation motion the conjugated spiral wheel (5) mounted on the main shaft of the device ensuring the rotation component of the helical displacement.

In figure 4 it can be observed the rack (8) driven by the pinion (8) coaxial with (1) which engages the main carriage in a translation displacement ensuring the translation component of the helical motion.

The rod (9) is secured on the main carriage (2) (figure 4). A spring beam that dabs the limiting devices (10) is slidably mounted on it, limiting the longitudinal race of the slide at the desired value.

For a consecutive rectification of the tool helical teeth, after polishing the helical surface of a tooth an indexing operation will be performed when passing to the helical surface of the next tooth.

For this purpose the drop-in pin (1) will be pulled from the contact with the void between the index dial teeth (2), according to figure 5.

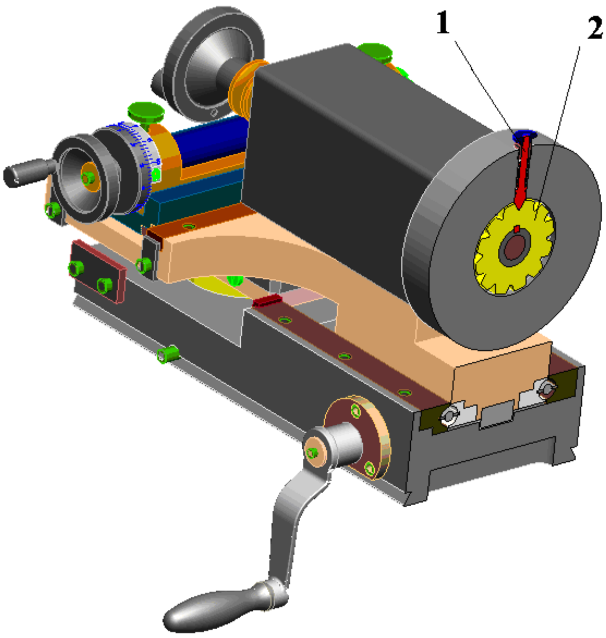

Fig. 5. Device with adjustable step for helical surface generation (with guide): (1) drop-in pin of the index mechanism, (2) index dial.

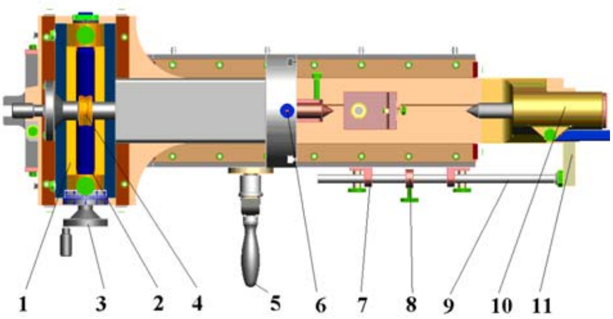

Fig. 6. Device with adjustable step for helical surface generation (with shoe), top view.

In figure 6, the device view from the top is presented with the components: (1) the cross slide; (2) the transversal worm; (3) the hand wheel for driving the worm; (4) the worm wheel conjugated to the transversal worm; (5) the lever driving the main carriage; (6) the index mechanism; (7) the limiting devices of the longitudinal race (8); the sliding limiting device for adjusting the length of the longitudinal slide race; (9) the support rod for the mobile limiting devices that adjusts the longitudinal race and which is joint with main carriage; (10) the device footstock; (11) the support for securing the rod on the longitudinal slide of the rod for the race of the limiting devices.

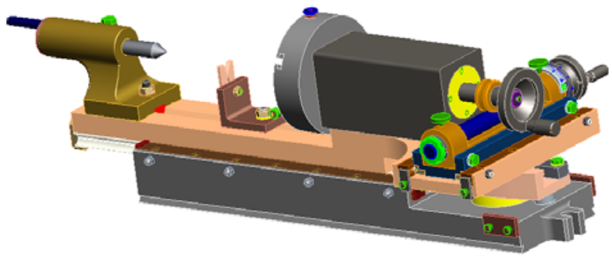

Fig. 7. Device with adjustable step for helical surface generation (with guide), view from behind.

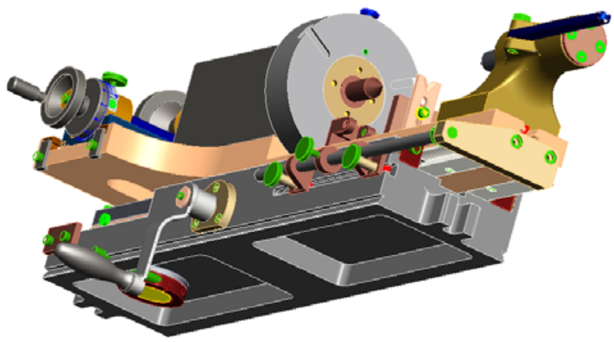

Fig. 8. Device with adjustable step for helical surface generation (with guide), view from underneath.

In figures 7 and 8 the device is shown in a view from behind and a view from underneath, respectively.

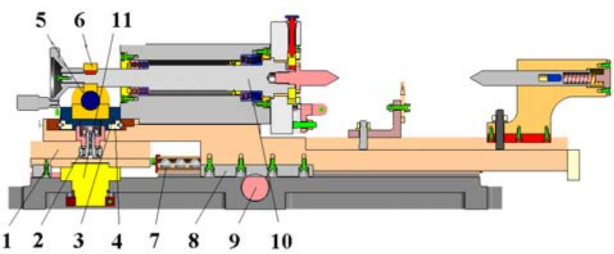

Fig. 9. Device with adjustable step for helical surface generation (with guide), cross section.

A longitudinal section through the device is shown in figure 9. It can be observed the bearings of the main shaft (10), respectively the shaft (11) around which the tilting slider (1) swivels.

Also, the pinion (9) can be observed, which is coaxial with the lever driving the main carriage and in gear with the rack (8), secured by screws on the main carriage.

The device was also designed by three-dimensional modeling in another constructive version without a concentric chuck.

The second version of the three-dimensional model of the device is presented in figure 10.

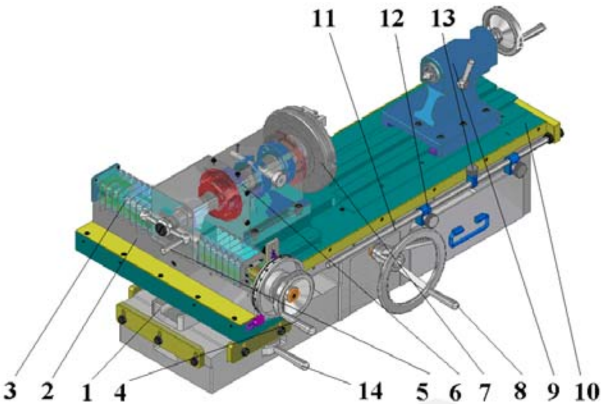

Fig. 10. The three-dimensional model of the device for helical surface generation with tilting slider

The components of the device from figure 10 are: (1) the tilting slider of the device; (2) the transversal slide/saddle; (3) transversal worm; (4) the hand wheel for driving the worm; (5) the hand wheel for the snail conjugated to the transversal worm; (6) the main shaft of the device; (7) the gripping faceplate of the part that needs to be grinded; (8) the hand wheel for driving the main carriage; (9) the footstock; (10) the main carriage; (11) the support rod for the limiting devices of the longitudinal race ; (12) the limiting devices of the longitudinal race; (13) the sliding limiting devices of the longitudinal race; (14) the lock of the tilting slider in the adjusted position.

The second version of the device was manufactured at U.M. Cugir (figure 11).

3. MATHEMATICAL MODEL

The way to obtain the helical motion has been described in the previous section, a great importance having the gauge block from the device structure.

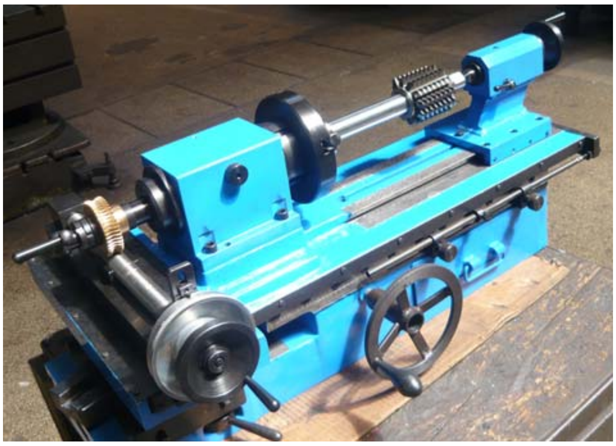

Fig. 11. Grinding device manufactured at Cugir M.P.

Thereby, cylindrical helix step is obtained using the gauge block dimension, the calculation of the dimension being presented further on.

The draft of the second constructive version of the device for helical surface grinding with tilting slider is presented in figure 12.

The manual moment, developed by the operator for the device actuation, is given by:

$$M = F_m \cdot r_{rm}, \quad (1)$$

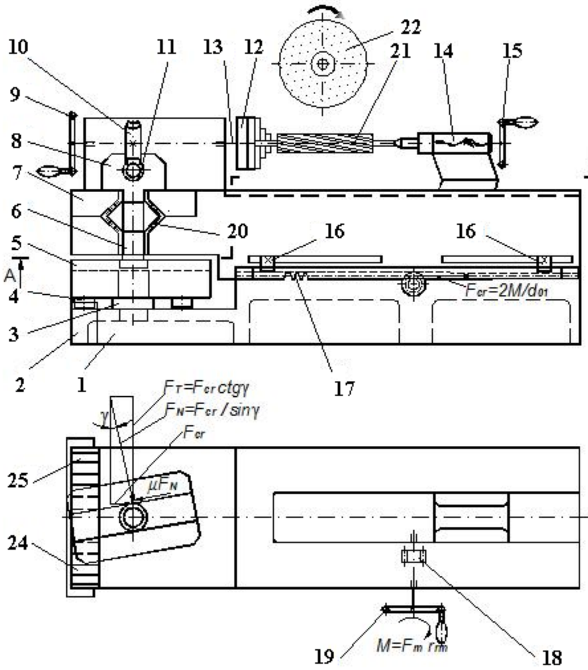

Fig. 12. The draft of the device for helical surface grinding with tilting slider

where: F_m is the manual force of actuating the device hand wheel (approx. 50 N), respectively r_{rm} is the radius of the device hand wheel (r_m = 37 mm).

The force F_{cr}, that appears in the rack, due to the manual moment *M*, is calculated:

$$F_{cr} = \frac{2 \cdot M}{d_{01}} \quad (2)$$

where, $d_{01} = z \cdot m$ is the index diameter of the pinion (with $z = 30$ and $m = 2\,mm$) that actuates the rack.

The rack drives the tilting slider to a γ angle.

The normal force that acts on the sliding block is given by:

$$F_N = \frac{F_{cr}}{\sin\gamma} \quad (3)$$

with the components:

$$F_T = F_{cr} \cdot ctg\gamma \quad (4)$$

That act on the spiral wheel (10) şi F_{cr}, that actuates the slider (5) (figure 12).

The normal force F_N generates the frictional force $\mu \cdot F_N$ in the slider.

The force F_T is transmitted through the worm (11), having the axial modulus $m_a = 1{,}5\,mm$, through which the spiral wheel (10) is actuated, having a number of teeth $z_{rm} = 45$, which performs the rotation motion component of the helical motion os the tool (27).

The adjustment of the tilting slide (5) is performed based on the principle of the sine ruler, the package of gauge blocks *B* will be determined using the equation presented further on.

The rotation angle of the tool is denoted by α when the tool is moving with $100\,mm$.

The step of the helical surface given on the tool work drawing is denoted by p_E.

The α angle is calculated using the equation:

$$\alpha = \frac{100 \cdot 360^0}{p_E} \quad (5)$$

In order to have an α angle, the tool should move with the displacement *C*, respectively, the MN segment according to figure 13.

The axial step of the worm (11), is calculated using the equation:

$$p_s = \pi \cdot m \quad (6)$$

The α angle also results from the equation:

$$\alpha = \frac{C}{p_s} \frac{360^0}{z} \quad (7)$$

The *C* value can be obtained by equaling equations (5) and (7):

$$\frac{C \cdot 360^0}{p_s \cdot z} = \frac{100 \cdot 360^0}{p_E} \quad (8)$$

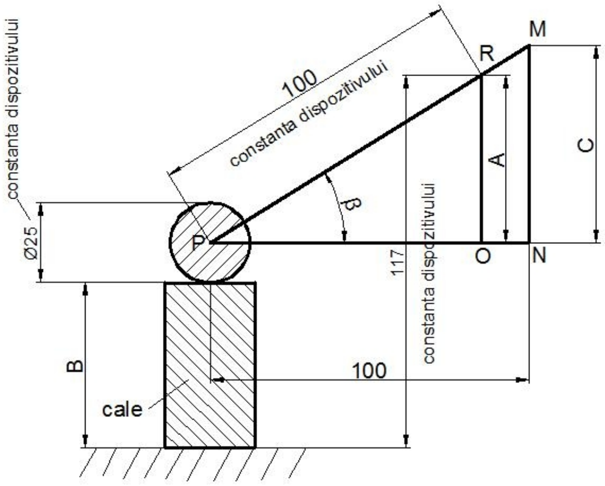

Fig. 13. Draft of the sine ruler of the device with adjustable step for helical surface grinding with tilting slider

namely,

$$C = \frac{21205{,}755}{p_E} \quad (9)$$

The following are known in ΔPMN:

$$\overline{MN} = C; \quad \overline{PN} = 100.$$

Therefore,

$$tg\beta = \frac{C}{100}.$$

From ΔPOR, it results:

$$A = 100 \cdot \sin\beta. \quad (10)$$

The package of gauge blocks used for the adjustment of the device sine ruler is calculated using the following equation:

$$B = 117 - (A + 12{,}5) \quad (11)$$

where:

- 117 is the device constant;
- A is the leg of the ΔPOR;
- 12,5 is the radius of the caliber of the device sine ruler.

The final equation of the package of gauge blocks used for the adjustment of the sine ruler of the device with adjustable step for helical surface grinding with tilting slider is :

$$B = 117 - \left[\sin\left(arctg \frac{21205{,}755}{100 \cdot p_E} \right) \cdot 100 + 12.5 \right] \quad (12)$$

4. CONCLUSION

There are two device versions presented in this paper, for which the helical surface generation is performed through a tilting slider following de sine ruler principle. On the slider slot guide there is a sliding block that actuates a rack which is geared with a pinion that ensures the rotation component of the helical motion, the translation component of the helical motion being obtained by the displacement of the main carriage.

The second version of the device for helical surface generation is more complex, with a more general use in industrial practice. The adjustment of the helical surface step is performed with high accuracy by tilting the slider with gauge blocks based on the sine ruler principle.

The sliding block actuates in a transversal motion in relation to the device axis, a worm that fulfills the role of a rack, but, in gearing with a spiral wheel ensures the rotation component of the helical motion. Obviously, the translation component results by moving the device longitudinal saddle/slide.

This version of the device has been manufactured at the U.M. Cugir in order to conduct the experimental research.

ACKNOWLEDGEMENT: This paper is supported by the Sectorial Operational Programme Human Resources Development POSDRU/159/1.5/S/137516 financed from the European Social Fund and by the Romanian Government.

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DISPOZITIV PENTRU GENERAREA SUPRAFEŢELOR ELICOIDALE PREVĂZUT CU CULISĂ INCLINABILĂ UTILIZAT LA ASCUŢIREA FREZELOR CU PROFIL ELICOIDAL

Abstract: *Generarea suprafeţelor elicoidale poate fi realizată prin compunerea mai multor mişcări. Maşinile unelte care realizează generarea unor suprafeţe elicoidale necesită utilizarea mai multor axe, având ca efect un consum energetic ridicat. Lucrarea prezintă un dispozitiv pentru generarea suprafeţelor elicoidale prevăzut cu culisă înclinabilă, utilizat pentru ascuţirea frezelor. Prin utilizarea acestui dispozitiv se pot prelucra suprafeţe elicoidale de maşini convenţionale, cu consumuri energetice mai reduse.*

Alexandru MICACIU, Eng., amicaciu@yahoo.com, Ciocîrliei nr. 8, Cugir, Jud. Alba, 0737030532.

Ioan Gheorghe VUŞCAN, Professor, Technical University of Cluj-Napoca, Department of Manufacturing Engineering, Gheorghe.Vuscan@tcm.utcluj.ro, 0264 - 401600.

Radu Mircea MORARIU-GLIGOR, Lector, Technical University of Cluj-Napoca, Department of Mechanical Engineering Systems, Faculty of Machine Building, rmogli70@yahoo.com, Arieşului 102/107, Cluj-Napoca, 0743 - 120463.