12th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

A DESCRIPTION OF HIGH – PRODUCTIVE METHOD FOR THREAD CUTTING ON LATHE

Ante Mišković
Faculty of Mechanical Engineering and Computing
Matice hrvatske bb, 88000 Mostar
Bosnia-Herzegovina

Danijel Šogorović
Faculty of Mechanical Engineering and Computing
Matice hrvatske bb, 88000 Mostar
Bosnia-Herzegovina

ABSTRACT
The demands for higher productivity of thread cutting in comparison with productivity realized with lathe tool are given by market conditions. A fulfilment of those demands could be done by using of developed device, which enables an additional movement of tool – head with lathe tools and thread cutting with increased machining speed, improved quality and reduced cutting time. In this paper, a view of method, machining schemes, as well as a kinematics of a process are presented. Machining with cutting in an area defined with small chip diameter and increased cutting speeds is realized. It is clearly shown that using of this device results in higher technical and technological level of a lathe.
Keywords: high – productive, cutting of threads, time of cutting

1. INTRODUCTION
Economies market conditions set up requests for higher productivity in the case of wide consumption products. Production of the threads is considered as one of the difficult operations of elaboration by separating particles, especially quality and increase is required.
Several authors [1,2,3] worked on this problem so the technical inventions that resulted with new products are not rarity in the field of threads production. Developed devices and equipment which can be used by universal lathe machine, increase the precision of work and technical – technological level of machine.
The aim of research and results are: to hastening of elaboration and decreasing of machining time. The project gives a scheme that shows in which way is technologically determinate equipment for production of threads all at once. The elaboration is performed with high speed of cutting, so it achieves the two above – mentioned targets.

2. THE IMPORTANCE OF TECHNOLOGICAL SOLUTION
The production of the thread with device shown on Figure 1. represents a new method for production of threads with higher speed of cutting and, in same time, with higher productivity compared with classical methods (production of thread with lathe tool with help of the leading spindle of lathe machine.
Project represents the whole (aggregate) which is placed in front of lathe machine. This principle of thread production (eccentric cutting, ger: Gewindewirbeln, rus: Vihrevoje) consists of placing of the lathe tool for cutting of thread (Figure 2.) into special head whose axis is inclined toward the axis of the spiral for angle of spiral φ.

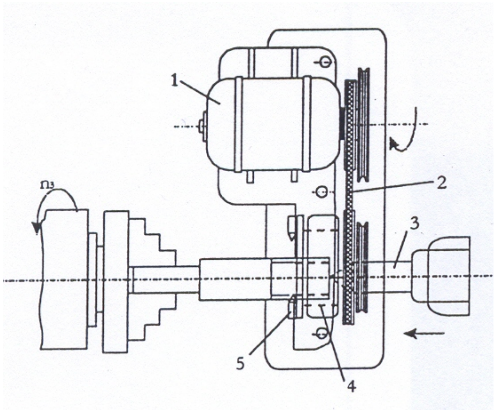

Figure 1. Scheme of moving security (1-electric engine, 2-wedge strap, 3-dead centres, 4-bearing, 5-cutting head

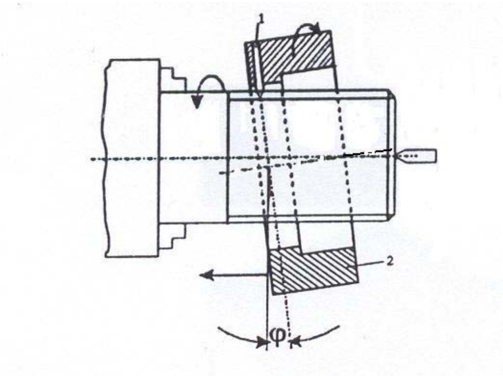

Figure 2. Principal of eccentric cutting of thread

The head with lathe tools produces the main rotation with a high speed (test was done with v = 280 m/min) with simultaneous low longitudinal mowing, while working part placed in contraction part of main spindle making slow miscellaneous rotation. The porter of the head with lathe tools is placed like special device on the porter of the tool and in that way produces longitudinal mowing.

The criticism of technical – technological level of lathe machine with device of head having reference to a lathe machine without device it is criticized according to [3] with $Q_t = 1.16 \pm 1.4\%$. That criticism of technical – technological level is made by group level method.

3. KINEMATCS RELATIONS IN CASE OF HIGH – PRODUCTIVE CUTTING OF THREADS

Eccentric cutting of threads is basically process of production of threads by milling. During the production, tooth of milling tool is replaced with turning tools. They are placed within device – "head for cutting". External cutting of threads is produced with two different ways; depending on placement of workpiece and head of cutting: the workpiece is into head (more often – Figure 3.) and workpiece is out of head.

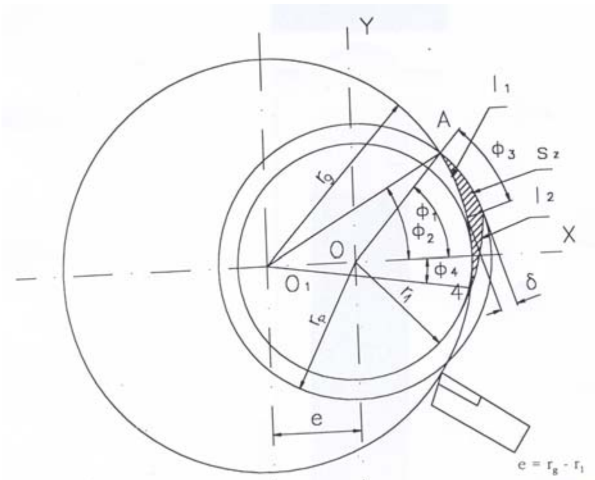

Figure 3. Production of external thread where workpiece is into head of cutting

3.1. Kinematics relations in case of external thread where workpiece is into head

From Figure 3. following parameters are defined as:

d_p – workpiece diameter (main diameter of thread) [mm]

d_1 – internal diameter of thread [mm]

D_g – diameter of head of cutting [mm]

e – eccentricity (distance between axis of workpiece and axis of head) [mm]

s_z – length of arc on workpiece cut by one lathe tool [mm]

z – number of lathe tools in head
n_p – number of revolution of workpiece [min^{-1}]
n_g – number of revolution of head [min^{-1}]
According to [4] the relation is $D_g/d_p = 1,4 – 1,6$.
Speed of head v_g is 140 m/min - 400 m/min which depends on material of workpiece, material of lathe tools, dimension and profile of thread and kind of coolant device.

$$v_g = \frac{D_g \cdot n_g \cdot \pi}{1000}\left[\frac{m}{\min}\right] \quad v_g = 140 - 400 \text{ [m/min]} \qquad \ldots (1)$$

$$n_g = \frac{1000 \cdot v_g}{\pi \cdot D_g}\left[\min^{-1}\right] \qquad \ldots (2)$$

Length of arc s_z is defined by equation:

$$s_z = \frac{\pi \cdot d_p \cdot n_p}{z \cdot n_g}[mm] \qquad \ldots (3)$$

and it's value is in interval of 0,4 – 1,2 mm which depends on characteristics of material of workpiece according to table 1. [4]

Table 1.

Tensile strength of material [N/mm^2]	R_m=550	R_m=650	R_m=750	R_m=850
s_z [mm]	1.0 – 1.2	0.8 – 1.0	0.6 – 0.8	0.4 – 0.6

From equation (3) it is following:

$$n_p = \frac{s_z \cdot n_g}{\pi \cdot d_p} \text{ [min}^{-1}\text{]} \qquad \ldots (4)$$

$$v_p = \frac{\pi \cdot d_p \cdot n_p}{1000}\left[m/\min\right] \qquad \ldots (5)$$

Feed rate "s" is equal to feed of thread.
The main machining time is calculated according to equation:

$$t_g = \frac{L}{n_p \cdot s}[\min] \qquad \ldots (6)$$

where are:
L – the effective length of thread enlarged for empty travel
s – feed of thread
n_p – number of revolutions of workpiece

3.2. Analyses of chip intersection

The equation of arc l_1 of chip intersection in polar coordinates (Figure 3.):

$$x = r\cdot\cos\phi \qquad e = r_g - r_1$$
$$y = r\cdot\sin\phi \qquad \ldots (7)$$
$$(e + x)^2 + y^2 = r_g^2.$$

If change value of x and y:

$$(e + r\cdot\cos\phi)^2 + r^2\cdot\sin\phi^2 = r_g^2$$
$$e^2 + 2\cdot e\cdot r\cdot\cos\phi + r^2\cdot\cos\phi^2 + r^2\cdot\sin\phi^2 = r_g^2$$
$$e^2 + 2\cdot e\cdot r\cdot\cos\phi + r^2 = r_g^2$$
$$r^2 + 2\cdot e\cdot r\cdot\cos\phi + e^2 - r_g^2 = 0$$

$$\boxed{r = -e\cos\phi + \sqrt{e^2\cos^2\phi + r_g^2 - e^2}} \qquad \ldots (8)$$

The coordinates of endpoint A of arc l_1 can be determinate according to following equations:

$$x_A^2 + y_A^2 = r_p^2$$

$$(e + x_A)^2 + y_A^2 = r_g^2$$

$$e^2 + 2 \cdot e \cdot x_A + x_A^2 + y_A^2 = r_g^2$$

$$e^2 + 2 \cdot e \cdot x_A + x_A^2 + r_p^2 - x_A^2 = r_g^2$$

$$x_A = \frac{r_g^2 - r_p^2 - e^2}{2e} \quad \dots (9)$$

$$y_A = r_p^2 - x_A^2 \quad \dots (10)$$

The angles of endpoint A and coordinate axis X in relation with points O and O_1 can be determinate according to following equations:

$$\phi_1 = \arccos \frac{x_A}{r_p} \quad \dots (11)$$

$$\phi_2 = \arcsin \frac{y_A}{r_g} \quad \dots (12)$$

The angle ϕ_3 (angle of workpiece revolution between two tool contacts) is calculated:

$$\phi_3 = \frac{s_z}{r_p} = \frac{2 \cdot \pi \cdot n_p}{z \cdot n_g} [rad] \quad \dots (13)$$

The lengths of arcs l_1 and l_2 are:

$$\phi_4 = arctg \frac{y_4}{e + x_4}$$

$$y_4 = \left(-e \cos \frac{\phi_3}{2} + \sqrt{e^2 \cos^2 \frac{\phi_3}{2} + r_g^2 - e^2} \right) \sin \frac{\phi_3}{2}$$

$$x_4 = \left(-e \cos \frac{\phi_3}{2} + \sqrt{e^2 \cos^2 \frac{\phi_3}{2} + r_g^2 - e^2} \right) \cos \frac{\phi_3}{2}$$

$$l_1 = r_g (\phi_2 + \phi_4) \quad \dots (14)$$

$$l_2 = r_g (\phi_2 - \phi_4) \quad \dots (15)$$

Finally, the size of chip can be calculated by equation:

$$\boxed{\delta = r_p + e \cos(\phi_1 - \phi_3) - \sqrt{e^2 \cos^2(\phi_1 - \phi_3) + r_g^2 - e^2}} \quad \dots (16)$$

The size of chip is in interval δ = 0,05 – 0,15 mm.

4. CONCLUSION

In regard to shown, it can be claimed the following:

- by using of the device for eccentric cutting of threads, it can be achieved a high efficiency, especially for long threads with higher diameter,
- by developed method, the thread can be produced in one passage which decreases the time of production for cca 90% in comparison to threads made by classical method on lathe machine,
- results of testing show that with using of device it can be realised high productive method of thread production on universal lathe machine.

5. REFERENCES

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