International Conference on Economic Engineering and Manufacturing Systems
Brașov, 26 – 27 November 2009

KNIFE THREADING ON MULTI-AXIS AUTOMATIC LATHE AND CNC LATHE

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Abstract. Threading is a largely used operation in equipment, tools, machine tools construction and facilities for making screws and nuts for clenching or movement with different profiles. Most cylindrical or tapered threads are done on lathes, with the knife but also by milling.

In this paper, it is presented in the first part, disk shaped devices, the threading knife with a knife and the pins associated for threading on multi-axis automatic lathe, designed and implemented for production of various components in large series. In the second part is the summary of the possibilities of threading on CNC lathes typically used in small and medium series production, but not only.

Keywords: threading, multi-axis automatic lathe, CNC lathe

1. Introduction

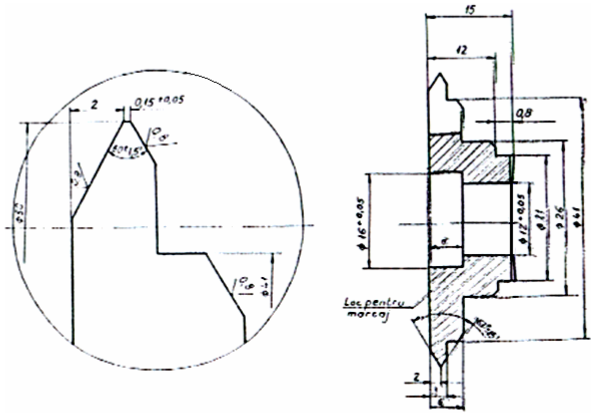
On multi-axis automatic lathe, threading with a knife is used for external threads located behind a collar - a situation in which the die or screw head with prismatic shaped knives does not have access to the area to be threaded - like when the part has two threads.

Threading with the disk shaped knife can run with a single edge knife (figure 1, a), if the value of added processing is small, or knife with two edges, one for attack, the other calibration (figure 1, b) when the value of added processing is high.

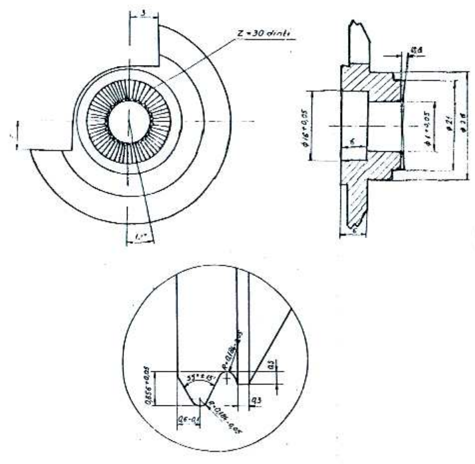
2. Knife threading on multi-axis lathe

Since the multi-axis automatic lathe has no threading driveline, as with other types of machine tools, the threading device (figure 2) takes over the task of step processing of the propeller of the processed part [4].

In this respect, the speed n_0 of the main driveline's turning is harvested through a train of gears, which includes the exchange wheels A / B. By cardan coupling and telescopic transmission, the movement is finally passed to a tree VIII on which are two camshafts mounted: cylindrical cam 3 provides the step of the part's propeller, moving axially in both directions the support 2 of the disk shaped knife 5. Disk cam 6 moves radially the support 2 of the disc knife at each end of the range approaching and withdrawing the knife radially towards the part.



a.



b.

Figure 1. Threading with the disk shaped knife

This way the knife performs a rectangular cycle: radial approach - threading radial withdrawal

- longitudinal withdrawal (axial) radial repositioning, corresponding to each pass required to the part's threading on the whole depth of thread.

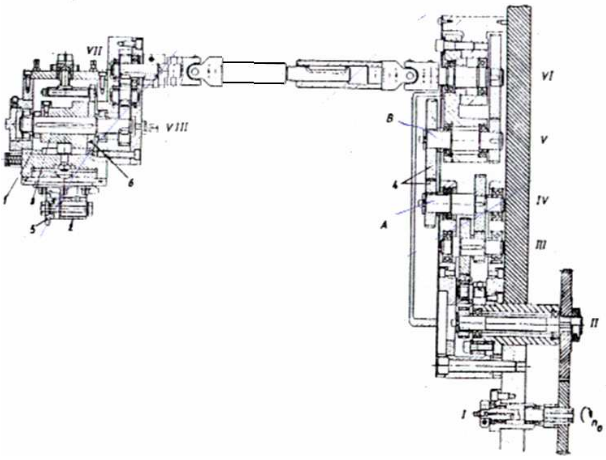


Figure 2. Threading device

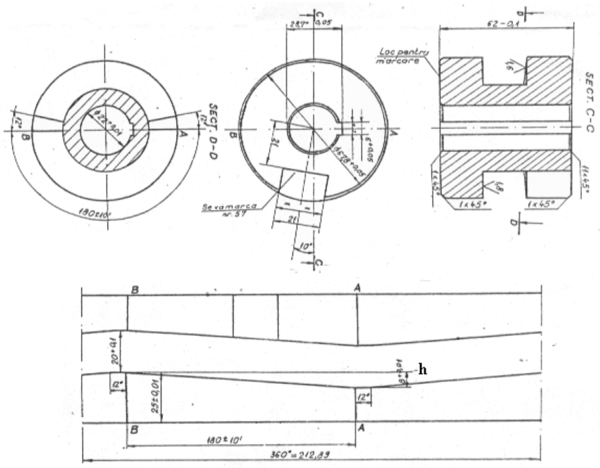


Figure 3. The step of the cylindrical cam

If n is the main shaft speed, chosen from the condition of achieving a certain cutting speeds in the other turning operations, then, to achieve the same axial speed w on the disk shaped knife and on the electrohydraulic cam 3, it is necessary that:

$$w = n \cdot p = n_k \cdot p_k \qquad (1)$$

where n_k, p_k is the cam's speed, 3 is the cylindrical cam's step. From the rotation driveline of the cam:

$$n_k = n \cdot i \cdot A / B \qquad (2)$$

where i is the product of the constant transmission reports of this driveline, and A / B is the gear ratio of the exchange wheels.

The step of the cylindrical cam (figure 3) corresponds to a complete rotation (360^o).

Of the 360^0, this work range length is achieved on a central angle α = 180^o, with other 12^o on the left and on the right the knife's standing position is achieved before and after threading.

If h is the cam's over-height, necessary to perform the threading on the entire length of the thread, but including spaces before engaging the knife in threading and at knife's leaving of the thread, results the cam's step in active range [1]:

$$p_k = h \cdot 360^o / \alpha = 2 \cdot h \qquad (3)$$

From the condition:

$$w = n \cdot p = n_k \cdot p_k \Rightarrow n \cdot p = n \cdot i \cdot A / B \cdot 2h \qquad (4)$$

results the exchange wheels transmission ratio:

$$A / B = p / 2i \cdot h \qquad (5)$$

Exchange wheels from the machine tool kit are chosen, and so, the over-height on the cam is calculated:

$$h = (p \cdot A)/(2i \cdot B) \qquad (6)$$

The cam's step in the withdrawal longitudinal range is p_{1k} = (h · 360^0)/β. You can now calculate the knife's speed in the withdrawal longitudinal range:

$$w_1 = n_k \cdot p_{1k} = n_k h \cdot 360^o / \beta = n_k \cdot h \cdot 360^o / 156 \qquad (7)$$

The cam disks of the threading device along with the knife are carrying out the radial approach and withdrawal (figure 4).

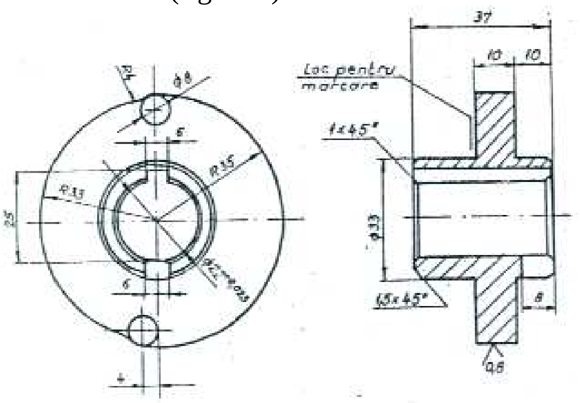


Figure 4. Cam disks of the threading device

For threads whose depth is g, the radial range of the disc knife must exceed the amount (g+1), considering a radial safe space of one millimeter.

The threading device is placed on one of the radial sledges of the lathe. The cam of this sledge continuously repositions the threading device for each rectangular cycle of the knife.

The number of passes z, that the knife performs, considering that the speed of the part doesn't achieve the cutting speed required to the threading, but the one necessary to the turning, which is much higher. The number of passes represents the ratio between the number of revolutions that the main shaft makes in the working range length z_l-calculated by the known methodology-and the number of turns that the main shaft performs for each rectangular cycle of the knife z_c:

$$z_c = 2h / p \tag{8}$$

Resulting in the number of threading passes of the knife:

$$z = z_1 / z_c = (p \cdot z_1) / 2h \tag{9}$$

Overlapping the axial movement speed *w* of the knife, with the movement speed of the radial sledge of the lathe w_r, resulting in a cone which has the semi-angle at the peak given by (figure 5):

$$tg\gamma = w_r / w = (n_{kr} \cdot p_{kr}) / n_k \cdot p_k \tag{10}$$

where n_{kr}, p_{kr} is the control shaft's speed, respectively the step of the radial sledge cam, in the working range.

The cylindrical cam's speed of the threading device is several times larger than the control shaft's – on which is mounted the lathe's radial sledge cam – and the radial sledge cam's step of turning is:

$$p_{kr} = (h_r \cdot 360^o) / \alpha_1 \tag{11}$$

where h_r is the over-height of this cam, α_l the angle of the working range on the control shaft.

Resulting in:

$$tg\gamma = n_{kr} / n_k \cdot h_r / h \cdot \alpha / \alpha_l \tag{12}$$

Frequently h_r<*h*, *α* and α_l are comparable, so that the angle γ is small, almost negligible, especially for significant lengths of threaded area of the part. In such situations, the thread of the part can be considered practically cylindrical. The repositioning of the tip of the knife on different passes is done on the bisectix of the angle on the top of the thread of the part.

3. Threading on CNC lathe

On the latest CNC lathes, thread processing possibilities are much greater, using threading knives, and also threading mills. Threads can be made cylindrical, conical or flat (spiral) with one or more beginning with different programming options translational axis interpolation with the rotation axis, with different variations of repositioning the tool against the part at different passes. On the latest CNC lathes the cogwheels are missing both from the advance driveline of the lathe's scheme in figure 5 and also from the gearbox CV and gear units R.

The main electric motor MEP is integrated into the main shaft and the advance electric motors MEX, MEZ are linked directly with conductor screws with ball nuts SCZ SCX. The rotary transducers TRX and TRZ, indirectly measure the displacements of two sledges SL and SR (longitudinal sledge and radial sledge).

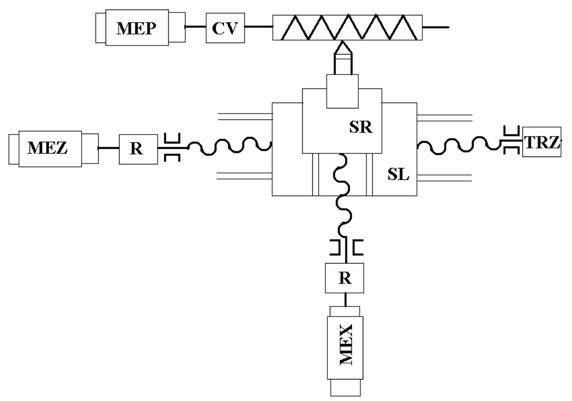


Figure 5. The advance driveline of the lathe's scheme

At speeds of translation the conductor screws disappear, linear electric motors being used. Threading on CNC lathe can be achieved by turning with the knife or by milling, with the mill for threads.

3.1. Threading by turning with the knife

You can obtain cylindrical, conical, flat threads (Archimedes spirals) and cylinder-conical concatenated threads. The thread step may be constant or linearly variable.

The repositioning of the knife's tip for the various threading passages can be done on the bisectrix of the angle to the top of the part's thread (γ = 0°), on the thread flank part (γ <ε or γ = ε) or alternatively, on the two flanks of the thread part (figure 6).

For the cutting depth *t* of different passes, we may adopt one of the following options:

- with constant cutting depth *ΔX* = *t*, *t* is the depth of cutting, the same at all passes, at least in the roughing (figure 6,a);
- with variable cutting depth $\Delta X_i = t_i$, so the fragment's section *ΔXi* at different passes is constant, leading to constant cutting forces between different passes(fig. 6,b,c,d).

The value $\Delta X_i = X_i - X_{i-1} = t_i$, represents the difference of coordinates between two homologous faces, situated on two consecutive passes, of order *i* and (*i-1*), for example [6]:

$$t_i = t_1 \cdot \left(\sqrt{i} - \sqrt{i-1}\right) \tag{13}$$

where t_1 is the depth of the first pass.

If the repositioning of the part's top is made on the thread's flank of the part, then between the two corresponding points located on two consecutive passes, there are differences of coordinates also on the longitudinal axis:

$$\Delta Z_i = X_i \cdot tg\varepsilon / 2 \tag{14}$$

where *ε* is the angle at the top of the part's thread.

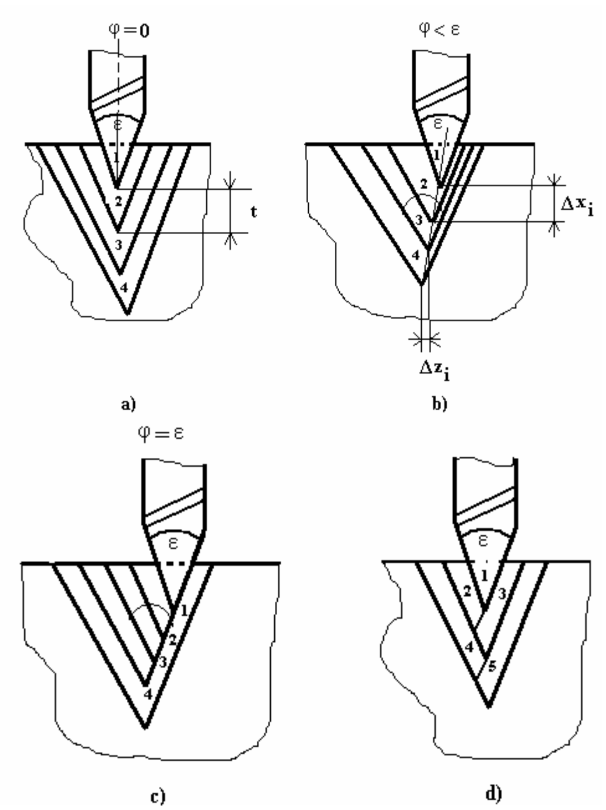


Figure 6. The repositioning of the knife's tip for the various threading passages

Preparatory functions are standardized: G33–threading with constant step; G34–threading with ascending step; G35–threading with descending step.

The step size p is programmed under Kp addresses (cylindrical thread), Ip (flat thread), Ip * tg α Kp for conical thread, the cone having the top angle α (the step can be expressed in mm or the number of steps). For threads with variable step the initial step p_0 and the constant variation ± Δp of two consecutive steps are programmed, the sign indicating the step ascending, respectively descending.

3.2. Thread milling on CNC lathe

The programming of the thread milling can be realized using a combination of two preparatory functions [3, 5]:

– one for the selection of the work plan (G17 - XC plane, G18 XZ - plane, G19 YZ - plane);

– one for selecting the direction of the mill's rotation movement on the part's propeller (G02–reverse counterclockwise sense, G03–counterclockwise sense).

Also, there can be programmed:

– the coordinates the final point of the part's propeller;

– the movement of the tool Z_1 along the part's propeller axis;

– the coordinates of the cylinder's center on which is wrapped the part's propeller;

– the number of steps of the part's propeller Z, the step length is:

$$l = (Z_1 \cdot 2\pi)/(2\pi \cdot Z + \theta) \text{ [mm]} \qquad (15)$$

where the angle θ is:

$$\theta = \theta_f - \theta_s = tg^{-1}(y_f / x_f) - tg^{-1}(y_s / x_s) \quad (0 < \theta < 2\pi) \qquad (16)$$

where y_s and x_s represents the relative coordinates of the start point towards the center of the circle, and y_f and x_f represents the coordinates of the final point towards the center of the circle.

4. Conclusions

On the automatic lathes with cams, for processing parts in mass or large series, threads can be obtained using a tapping device with a knife, equipped with two camshafts, for obtaining a rectangular cycle, consisting of displacements in two ways, on the two directions: longitudinal and radial. This paper presents the calculation of the kinematic and geometrical relations for the two camshafts, and also the construction of disc profile knives for threading.

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