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# UNFOLDED PROFILE OF CYLINDRICAL CAMS OF MULTISPINDLE AUTOMATIC LATHE

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**Abstract.** Multispindle automatic lathe is a machine tool of high complexity. Such lathe is used to manufacture large or mass series of products, generally made out of metal bar. Having specialized devices, the lathe can manufacture products out of individual cast or forged work pieces. This paper presents some achievements in multispindle automatic lathe command shaft's cylindrical cams design.

**Keywords:** cylindrical cams, multispindle automatic lathe

## 1. Introduction

Multispindle automatic lathe is a machine tool of high complexity. From a single electric drive, ME, the following parts are driven: 4-6-8-12 spindles AP, 4-6-8 radial slides SR, 4-6-8 longitudinal slides SL, rotational tools, which can be fixed on different slides and command shaft AC, having cylindrical cams KC, and disc cams KD, for longitudinal or radial feed of the different slides and to command an important number of auxiliary synchronized functions, all of them for the automation of the manufacturing cycle (figure. 1).

On multispindle automatic lathe can be done different operations: exterior and interior turning of cylindrical, conical, plane and profiled surfaces, cutting off, threading without threading kinematic chain, milling in special positions of the spindle, polygonal milling, broaching either with the stopped spindle or with synchronized rotational broach with the spindle's rpm.

In order to increase the productivity, because the fact that the product is manufactured during one complete rotation of the command shaft, this shaft is driven:

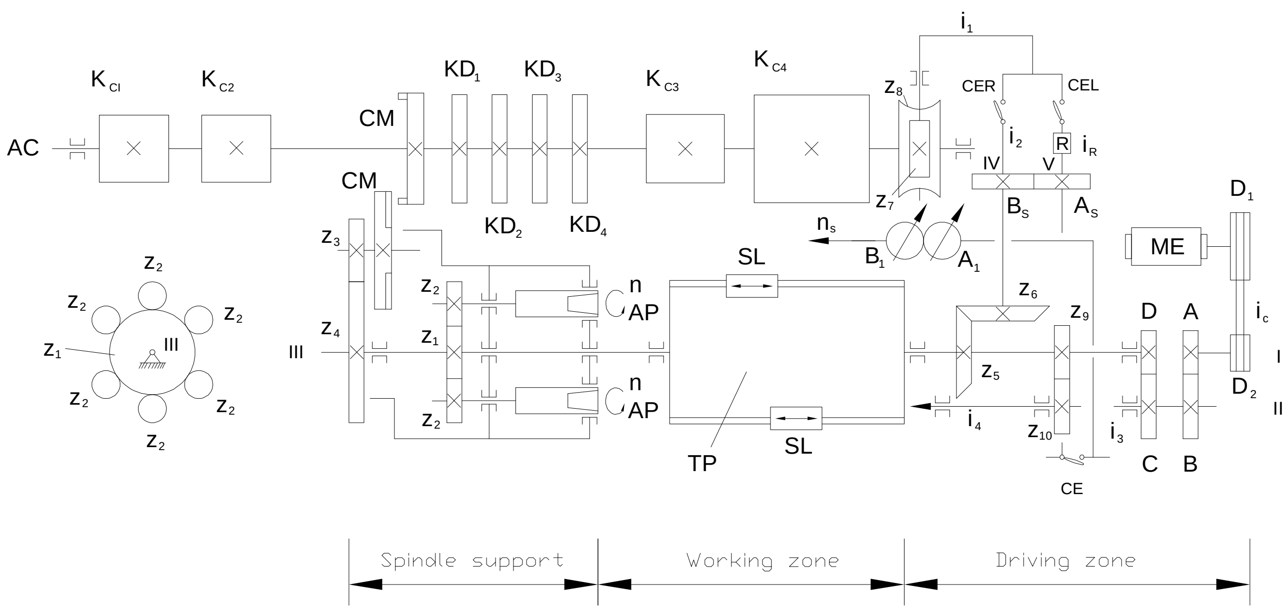


Figure 1. Kinematic scheme of multispindle automatic lathe

- with small number of rpm during the working travel of the slides (fast forward approach – feed motion – fast back movement) for a specific rotation angle, α, of the command shaft;

- with high number of rpm during the auxiliary phases of the manufacturing cycle (indexing and rotation of the spindles' drum TAP, mechanism with Malta cross CM, release of the workpiece metal bar) for the rotation angle (360°-α) of the command shaft.

## 2. Cylindrical cams of radial slides

To achieve the slow rotation of the command shaft AC the electromagnetic coupling CEL is turned on, the small number of rpm being set by the adjustment feed gear AS, BS.

From the kinematic chain which links the spindles AP with the command shaft AC is obtained:

$$n_{ACL} = n \cdot \frac{z_2}{z_1} \cdot \frac{z_5}{z_6} \cdot \frac{A_S}{B_S} \cdot i_R \cdot \frac{z_7}{z_8} \cdot i_1 \qquad (1)$$

where iR is the transmission ratio of the reducing mechanism R and i1 is the product of constant transmission ratios of other gears of this kinematic chain.

This means the transmission ratio of the adjustment feed gear is:

$$\frac{A_S}{B_S} = \frac{n_{ACL}}{n} \cdot \frac{z_1}{z2} \cdot \frac{z_6}{z_5} \cdot \frac{z_8}{z_7} \cdot \frac{1}{i_R \cdot i_1} \qquad (2)$$

Time used for the working travel of the command shaft is:

$$t_l = n_{ACL} \cdot \frac{\alpha°}{360°} \qquad (3)$$

Feed speed of the radial slide SR is:

$$w_R = s_R \cdot n = \frac{h}{t_l} \qquad (4)$$

where $s_R$ is the radial feed value related to the cutter fixed on the slide by means of a fixing device and *h* is the cam's radial difference for the working travel, equal to the radial difference on the workpiece, related to radial turning. This means the radial feed is:

$$s_R = \frac{w_R}{n} = \frac{h}{n \cdot t_l} \qquad (5)$$

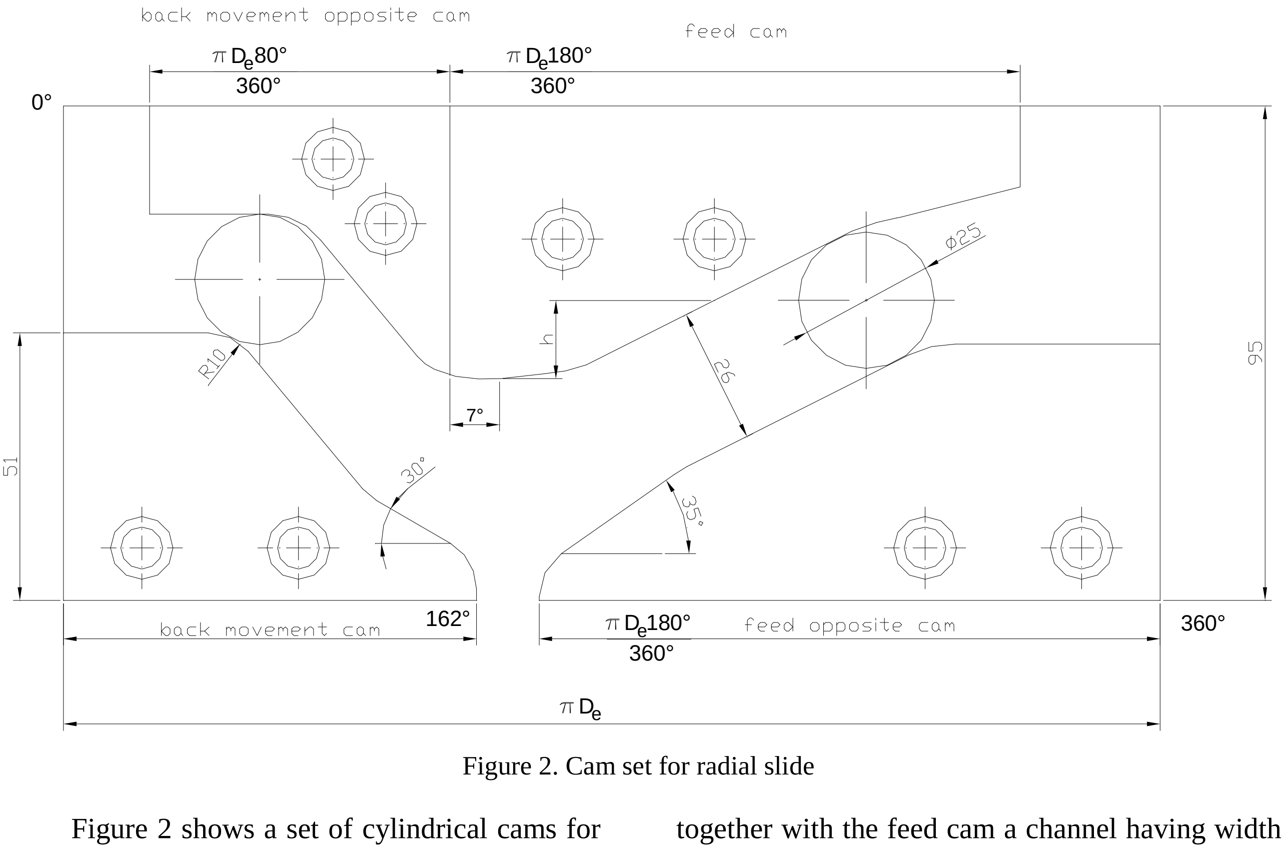


Figure 2. Cam set for radial slide

Figure 2 shows a set of cylindrical cams for one radial slide, consisting of:

- feed cam, which guides the roller lug both in the working travel and in the fast forward approach travel of the radial slide;

- feed opposite cam, which determines together with the feed cam a channel having width a little bit larger than the diameter of the roller lug;

- back movement cam, which guides the roller lug during the fast back movement of the radial slide;

- back movement opposite cam, which

determines together with the back movement cam a channel having the same width like in case of fast forward travel.

These four segments are made of thick metal sheet, fixed by minimum two screws on the drum of cylindrical cam on the command shaft. The centered angle of each segment is not bigger than 180°, in order to permit the assembly.

On the feed cam a stationary zone can be seen, which determines stop of the feed simultaneous with the continuous rotation of the spindle. Thus, the workpiece calibration is done.

## 3. Cylindrical cams of longitudinal slides

In order to achieve the axial feed motion longitudinal slides SL with independent feed movement are used, assembled on the 4, 6, 8 or 12 plane surfaces of the polygonal drum TP (fig. 1).

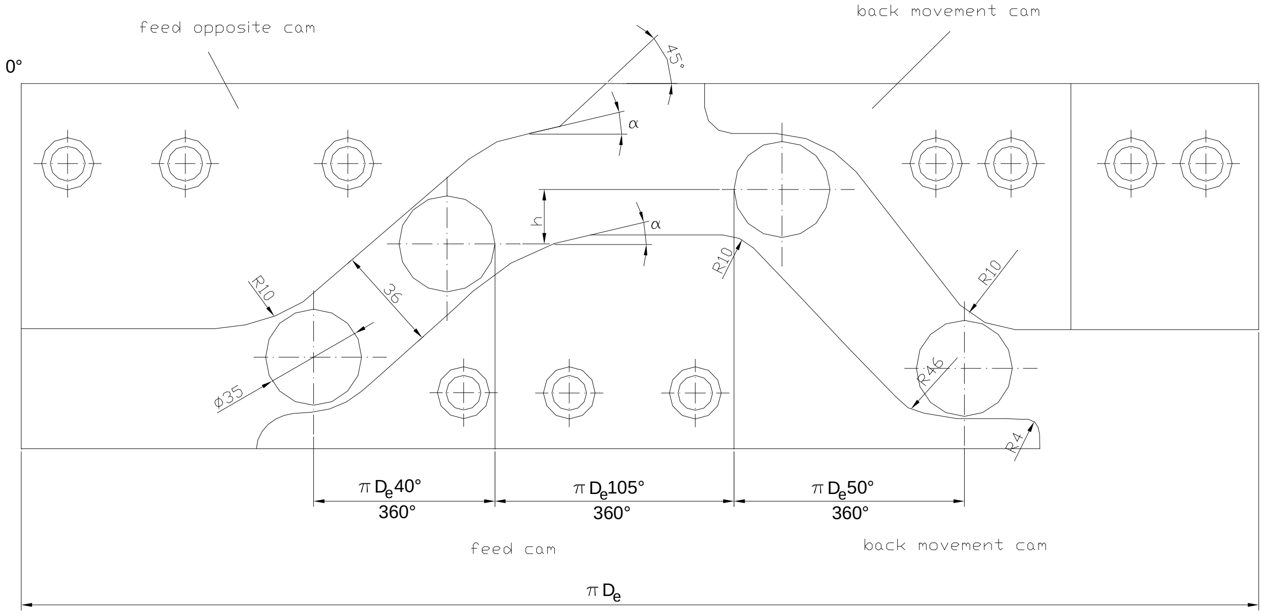


Figure 3. Cam set for longitudinal slide with independent feed

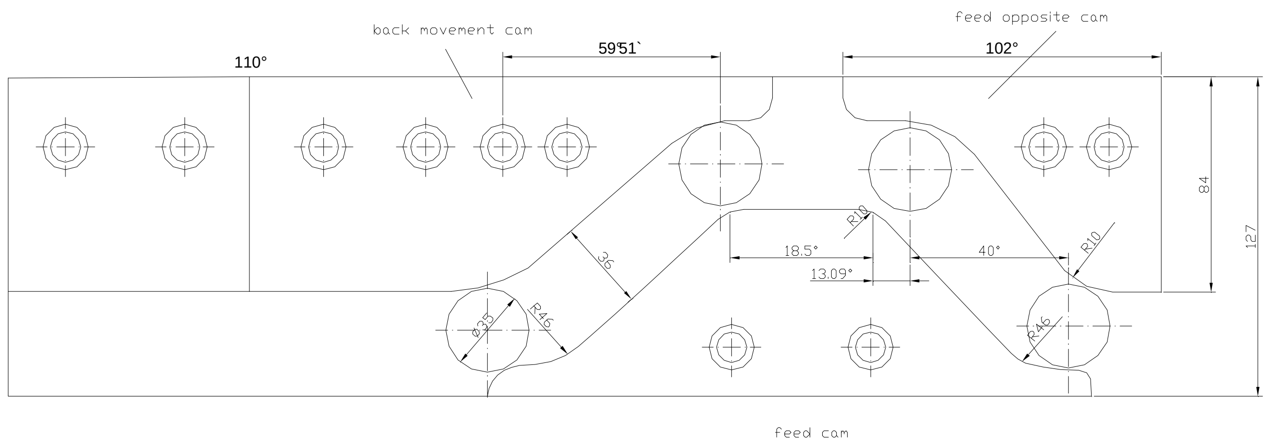


Figure 4. Cam set for longitudinal slide with independent feed, used for round profile thread Rd 8x2 left

For the achievement of the rotational movement of rotational cutting tools on these slides, the rotation of the spindles is taken through shaft gear z9/z10 and then:

– nS1 can be achieved, adjusted by gear A/B, or

– constant nS2 is achieved.

From kinematic chain which links the spindle AP and the rotational tool shaft the number of rpm of the cutting tools on longitudinal slides is obtained:

$$n_{S1} = n \cdot \frac{z_2}{z_1} \cdot \frac{z_9}{z_{10}} \cdot i_3 \cdot \frac{A}{B}; n_{S2} = n \cdot \frac{z_2}{z_1} \cdot \frac{z_9}{z_{10}} \cdot i_4 \quad (6)$$

where $i_3$ is the product of transmission ratios of the gears of the mentioned kinematic chain.

The transmission ratio of the adjustment gear is:

$$\frac{A}{B} = \frac{n_{S1}}{n} \cdot \frac{z_1}{z_2} \cdot \frac{z10}{z_9} \cdot \frac{1}{i_3} \tag{7}$$

Feed speed of longitudinal slide SL is:

$$w_L = s_L \cdot n = \frac{h}{t_l} \tag{8}$$

where $s_L$ is the axial feed value related to the cutter fixed on the slide and h is the cam's radial difference for the working travel.

Figure 3 presents a cam set for one longitudinal slide with independent feed. This set is similar to the one in previous figure, but has one more part to complete 360° on the cam's profile. Diameter and width of the drum on the command shaft are larger than in case of previous set, because the axial cutting force is bigger than the radial cutting force.

Figure 4 shows another set of cams for one longitudinal slide with independent feed, used for threading with tap a round profile thread Rd 8x2 left.

The equal slopes of the two flanks of the cam can be observed. The speed of the lug during the back movement must be equal to the one during threading, in order not to deteriorate the thread during the back movement. Difference between the values of tap pitch and feed is compensated by the tap fixing device. After the working travel of 13°09' a stop for 12° follows, when the feed stops but the spindle rotates together with the workpiece. The calibration of the new cut thread is done.

The slope of the feed cam is the same in all three phases of the threading cycle: approach, threading, back movement.

## 4. Conclusions

Automatic multispindle lathe has a high productivity, but its adjustment is difficult, time consuming for cutting tools and cams adjustment. This is the reason it is economically used in case of large and mass series of products.

On the command shaft of this lathe several cams are fixed. These cams are made of thick metal sheet segments, fixed on each cam's drum by means of screws.

In the paper some cam sets designed by the authors are presented, for the radial and longitudinal slides of the lathe. Some cam sets are changed depending on the manufactured product type. Others were necessary to change the original cam set because of wear due to the years of functioning in 2 or 3 shifts.

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