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FUNDAMENTALS OF FORMING CERTAIN FUNCTIONAL SURFACES

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ABSTRACT — *The part processing by cutting is performed using machine tools cutting tools. Machining of workpieces by chip removal is based on certain movements performed by the tool and workpiece and carried out by the metal cutting machine. Each particular machining method needs to be carried out according to a certain regularity provided by the capabilities of a given metal cutting machine.*

Keywords: cutting schemes, functional surfaces, shaping, chip removal

1. INTRODUCTION

The tool can work with several feed movements. In this case, the cutting edge of the tool can create a very complex system of surface groups for cutting the allowance, all feed motions are essential, and only those that take place during the period of contact of the cutting surface with the nominal surface of the workpiece are important for forming. The law on which a system of one or more groups of cutting surfaces is established determines the cut pattern of the allowance and the forming pattern.

The complexity of the forming scheme is determined by the number of feeds, whereby the nominal workpiece surface may coincide with the cutting surface. It may be a wrap-around surface of a one-parameter group of cutting surfaces (in forming, the tool has one feed).

The shaping in terms of the quality of the machined surface and the tool behaviour during machining is influenced by the cutting pattern of the additive. Figure 1 shows three different schemes for machining internal rotary surfaces (holes) with modular drill bits.

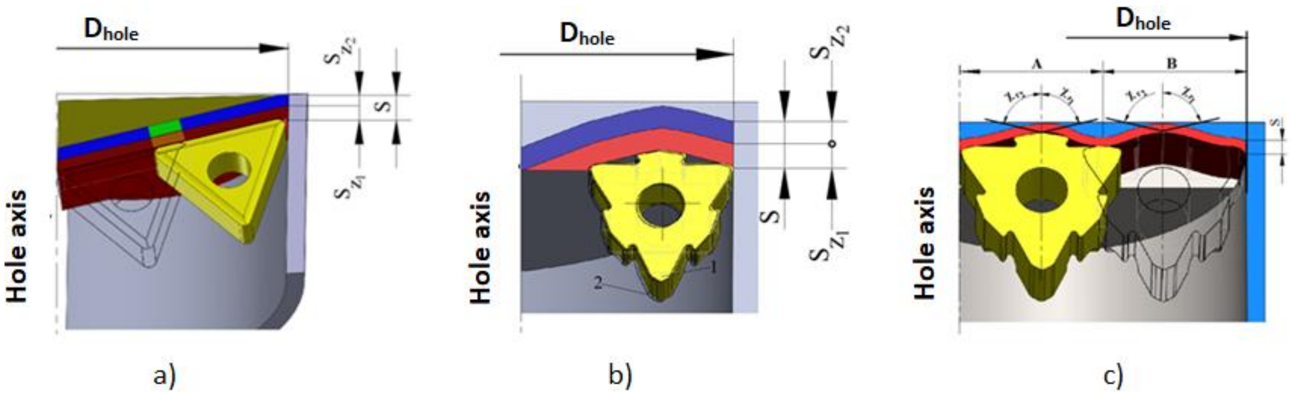

Fig.1.Cutting schemes of the additive in drills with replaceable carbide inserts RCI.
a) division of the width of the cut metal layer; b) division of the thickness of the cut metal layer; c) combined scheme.

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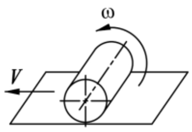
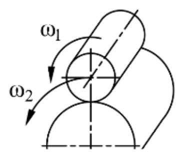
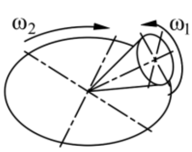
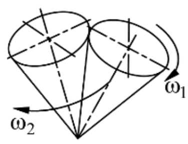
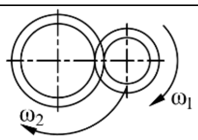
2. BASIC CONCEPTS AND DEFINITIONS

The following basic concepts are introduced to clarify the nature of shaping:

- principle kinematic cutting scheme (PKCS) gives the set of absolute movements of the tool and workpiece during machining without including the so-called idle moves;
- relative working motion trajectory is the movement of points on the cutting edge of the tool along a path relative to the workpiece at speeds and sequences predetermined by the tool-workpiece kinematic pair;

Table 1. Schemes of forming of tool surfaces in kinematic scheme including two rotary or rotary and translational movements.

Main movements performed by I and W	Summary relative movement	Relative axoid movements	Graphic image	Axoid of the instrument	Axoid of the detail
none			-		
translational			-	straight line	straight line
rotary			-	straight line	straight line
screw			-		
rotary and translational, perpendicular to the axis of rotation	rotary	rotation of a cylinder on plane		plane cylinder	cylinder plane
two rotary movements around parallel axes	rotary	rotation of a cylinder on cylinder		cylinder	cylinder
two rotary movements around rotary crossing lines	rotary	rotation of a cone on plane		plane cylinder	cylinder plane
two rotary movements, around crossing axes	rotary	rolling cone on cone		cone	cone
two rotary movements	translational	sliding ring by ring		ring	ring

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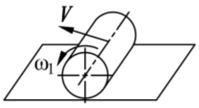
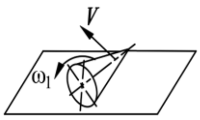
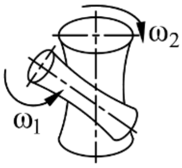
rotary and translational motion, the velocity V is at an angle to the axis of rotation	screw	rolling by sliding a cylinder on a plane		cylinder plane	plane cylinder
rotary and translational motion, the velocity V is at an angle to the axis of rotation	screw	rolling by sliding a cone on a plane		cone	plane
two rotary movements, around crossing axes	screw	rolling with sliding of hyperboloid on hyperboloid		hyperboloid	hyperboloid

- Scheme of forming, showing the kinematic pair in the working position with the type and relationship between the linear and angular velocities of the movements predetermined by the selected principle kinematic scheme of cutting, providing the intended degree of accuracy of the shape of the machined surfaces;
- Cutting scheme is the previously accepted sequence of removing the additive from the workpiece to obtain the machined surface.

Table 1 shows some patterns of forming resulting from different combinations of motions performed by the tool and the workpiece, i.e. under different kinematic cutting schemes.

In the first scheme (Fig. 1.a), the increment is cut by several cutting edges arranged asymmetrically on both sides of the axis of rotation of the hole to be machined (referring to a PKCS based on one rotary and one rectilinear motion). This scheme involves dividing the shearing layer of metal by width. In the second scheme, the cutting edges are arranged so that the shearing layer of metal is divided between them in thickness. To calculate this scheme, two conditions are necessary: identical inserts of different sizes are used; the active part of the cutting edges of the central and peripheral inset along the conical formation and the peripheral inset overlaps the axis of rotation during shaping (Fig. 1.b). The combined scheme (Fig.1.c) in some sections a division of the width and in others a division of the thickness of the sheared metal layer takes place.

3. EXPERIMENTAL RESEARCH

The shaping of functional surfaces requires the analysis of the following basic features, which are related to the design of the cutting tool. In order to ensure the required dimensional accuracy, shape and low roughness of cylindrical holes, it is necessary to determine the notching scheme of the drill type tools, which is an integral part of the additive cutting scheme.

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Proper notching of hole machining tools to ensure most of the requirements listed above, as well as to greatly increase the reliability of the tool operation.

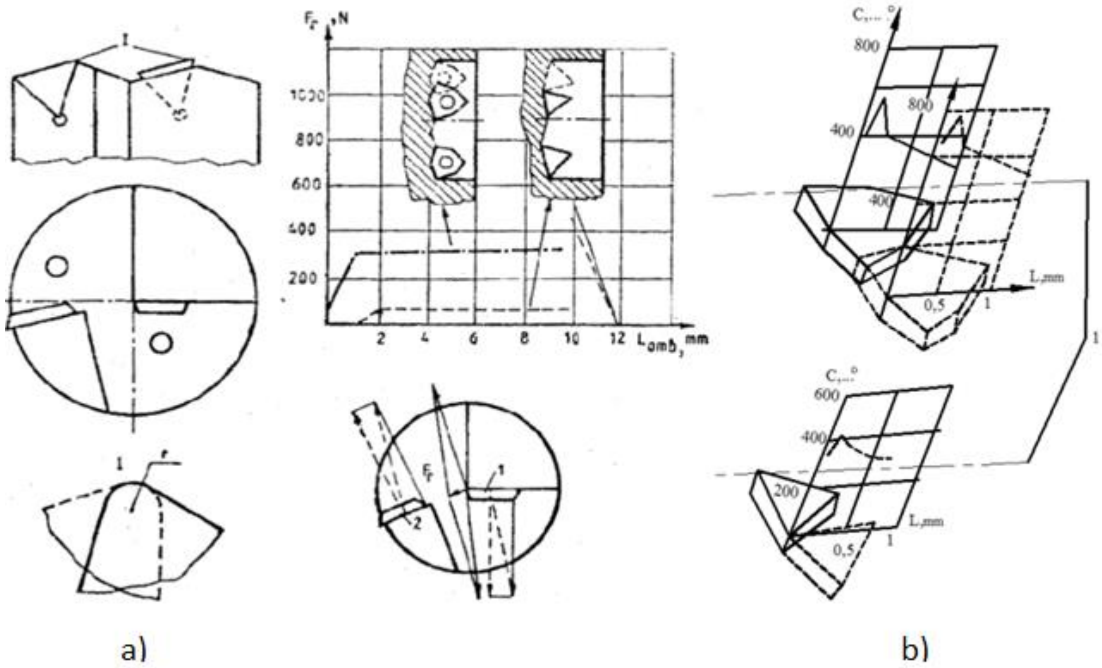

Fig.2. Progressive notching scheme. a) radial force variation; b) thermal loading of notching tips.

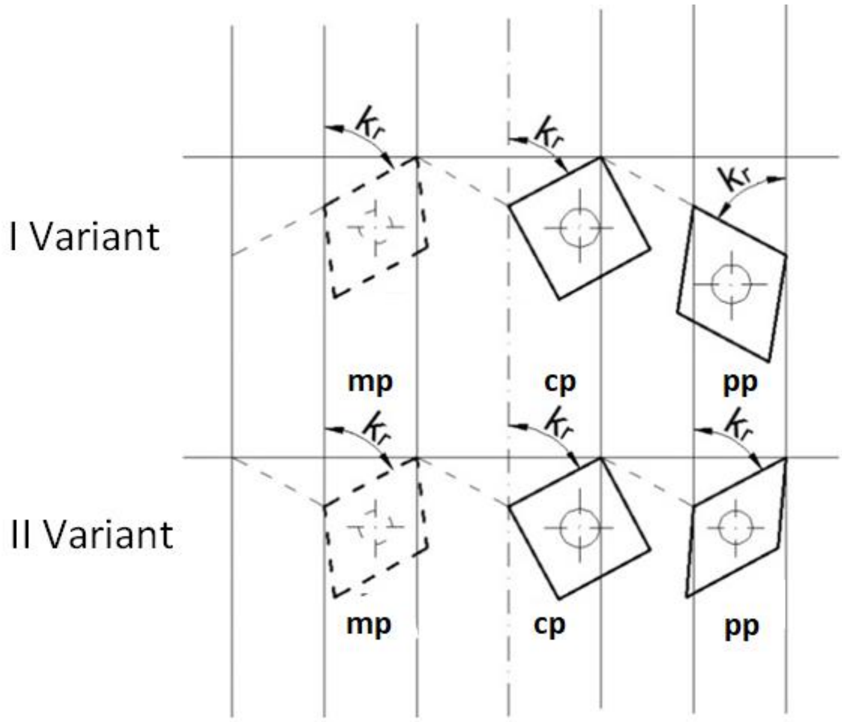

Fig.3. Schemes of cutting inserts placement in deep hole drills.
I variant - with sequential cutting insertion of the cutting tips; II variant - simultaneous cutting insertion of the cutting tips (pp - peripheral plate; cp - central plate; mp - middle plate).

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Fig. 2. shows a comparison between one progressive notching scheme compared to the most commonly used one implemented with a W-type insert.

The comparison is based on the measured radial force and temperature on the initial stage of machining. In a notching scheme starting from the overlapping tips of the cutting inserts (Fig. 2.a), the radial force has the greatest influence on the size and shape of the machined hole. The radial force at the very beginning, when the tool is directed to form the machined surface (Fig. 2.a) the value of Fz is negligibly small and also has a significant influence on the straightness of the hole axis.

The overall durability of the drill bit and reliability in service depend on the use of the notching sections. The evaluation criteria here is the recorded maximum temperature at the initial moment. The peak superimposed on the graphs is characterized for the contact area along the front surface of the cutting wedge. The recorded difference increases the tool life more than 20%.

It is obvious that the cutting pattern of the additive predetermines the design of the cutting tool parts.

Figure 3 shows two variants of the construction of the cutting scheme of the additive characteristic for drills for deep hole machining. At the first variant, the peripheral plates are displaced relative to the incision plane. In the second variant, all cutting inserts are cut at the same time.

Figure 4 shows the change in radial force depending on the length of the incision.

When processing deep holes, the tools have guiding elements that smooth the machined surface by plastic deformation. In the notching scheme shown in Fig. 3 (variant I) the deviation is 35µm (Fig. 5a), and in variant II (Fig. 5b) the deviation is 20µm.

All the procedures for selecting the forming scheme ultimately result in the construction of the tool.

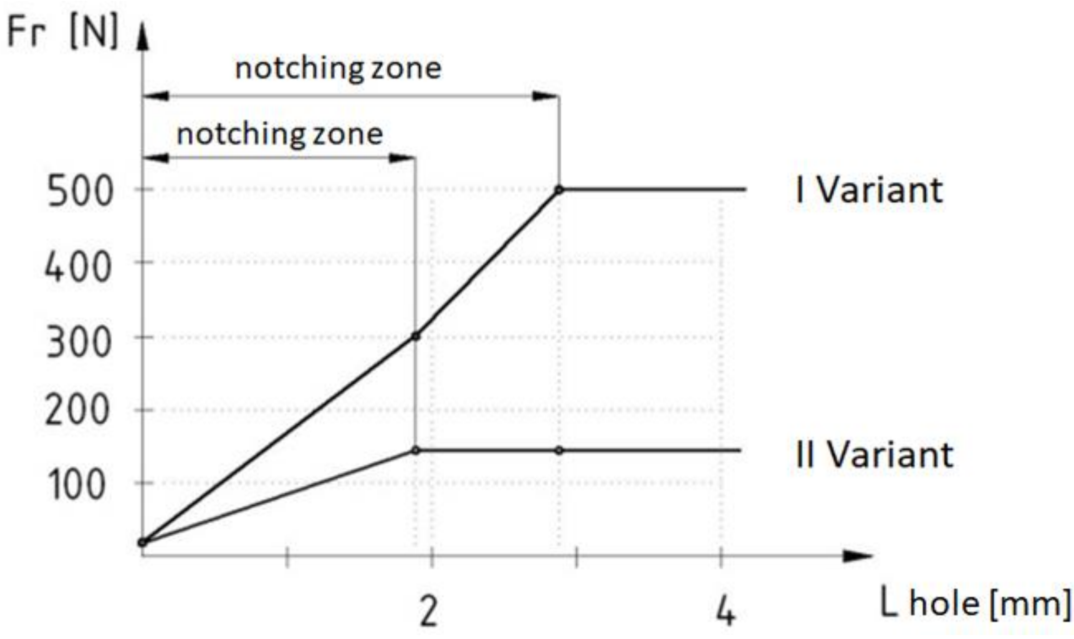

Fig.4. Variation of radial force versus notch length.

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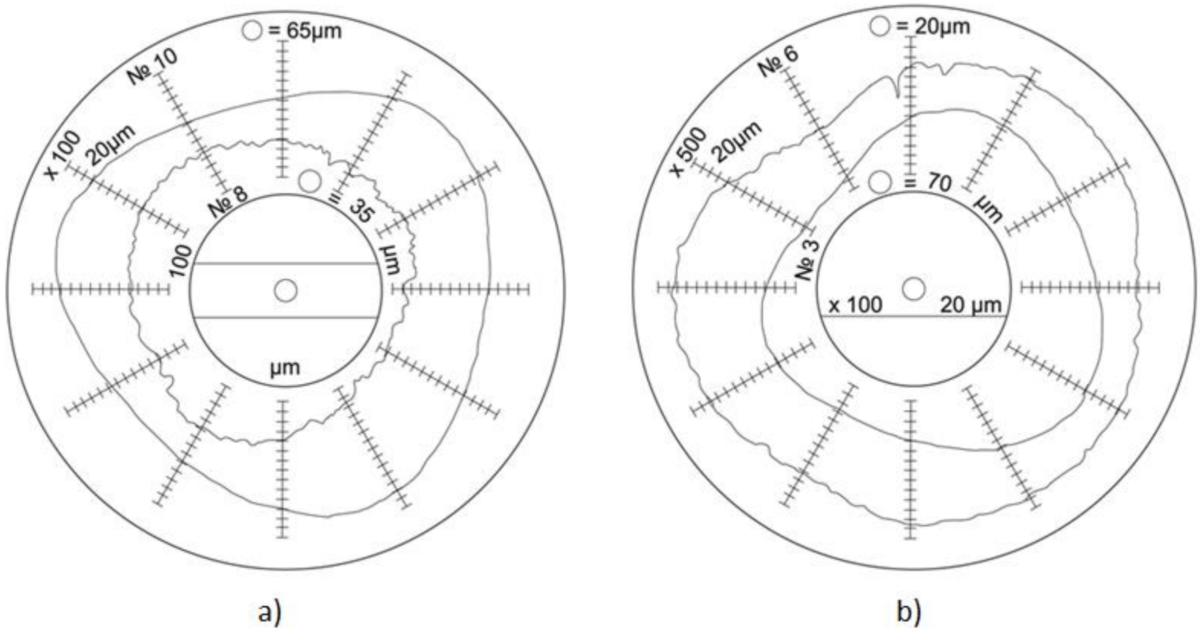

Fig.5. Circlograms obtained by machining holes with prefabricated drill bits.
a) machining of deep holes; b) machining of holes with L/D=4.

5. CONCLUSIONS

A first variant of the construction of the cutting scheme of the additive characteristic for drills for deep hole machining, shown in Fig. 3, is characterized by a displacement of the peripheral plates relative to the plane of the notch. This plate is finally involved in the formation of the machined surface.

In the second variant, all cutting inserts are cut simultaneously, and the tool operates according to a scheme dividing the width of the cut metal layer. The measurement of the radial force variation during notching shows a significant difference in the initial load on the tool (Fig. 4.).

This point of operation of the hole machining tools appears to be critical for tool failure. In the first variant, the notching area is significantly larger. The value of the radial force determines the reliability of the tool operation, the accuracy of the machined surfaces. In some cases, the second cutting scheme is more suitable for use.

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