RESEARCH ON ECCENTRIC MACHININGS AND APPLICATIONS IN CNC INDUSTRIAL TECHNOLOGICAL SYSTEMS

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ABSTRACT: In order to perform eccentric machining, a detailed analysis of the technological system elements has to be unrolled, concerning technological characteristics of the CNC machine/ centre, part sizes and position, characteristics of tools, technological movements, etc. The machining travels must be determined relative to the reference axes. In internal eccentric machining, the adjusting and machining processes are more complex, because the tools are limited in size. In each particular case, there are specific constraints to be satisfied.

KEYWORDS: eccentric, CNC, machining, milling, boring.

1. Introduction

The need for quality products with the lowest possible cost is increasing, and also the need for complex processing, on parts. Eccentricity associated to the processing tools, orientation-fixing devices, but, above all, in the processing itself, is a method to respond to this demand for complex products at the lowest possible cost. Eccentric machining represents a special category, because the axis of the element to be processed is deviated by a certain value equal to the eccentricity from the initial axis and, thus, the tools must be properly dimensioned, the movements within the positioning phases must be accurately calculated, etc.

2. General considerations

In the area of eccentric machinings, there are several methods and means. Examples are machining by internal or external turning, by milling or boring, etc., to which a distance from the initial axis equal to the eccentricity of the machining is applied. However, this type of processing must be treated separately and analysed for each individual situation.

In this regard, a machining proposal for fibre-reinforced polymers [1] is through an eccentric grinding wheel which presents several advantages compared to conventional grinding, such as: the depth of processing to vary progressively, periodicity in the alternation of cutting and non-cutting zones and the different trajectory for each abrasive grain on the disc (Fig. 1, a). Within this way of intermittent and progressive grinding, due to the eccentric disc, much more frequent cooling periods of the tool are allowed, thus resulting in a decrease in the machining temperature, as well as the use of much lower forces.

Another investigation of the eccentricity characteristic was studied on eccentric machining of external threads, on lathe (Fig. 1, b). Thus, it is highlighted that eccentric turning of threads is, in fact, the process of machining threads by milling [2]. In other words, during processing, the teeth of the milling tools are replaced by the turning knife, and due to the eccentricity between the axis of the workpiece and the axis of the lathe, these two tools alternate. External threading can be done in two ways, depending on the position of the workpiece and the turning head of the machine: the workpiece is inside or outside the cutting head. In this case [2], the part is in the lathe head.

The cutting head, which has both milling teeth and 4 turning knives attached, has a rotational movement with respect to the workpiece and, due to the eccentricity between the two centres, the material is removed from the workpiece both by the cutter teeth, as well as by the turning knives, in a continuous alternation of the two types of tools. Thus, the machining of threads on an eccentric turning machine is a very productive cutting method [2], due to the very high cutting speed (contrary to conventional turning, where this speed is very low, i.e. 15-30 m/min [2]) and of the very good quality of the machined surface. In addition, this method decreases lead time by approximately 90% [2] compared to classical turning methods, the chip sizes are very small, and low power electric motors can also be used.

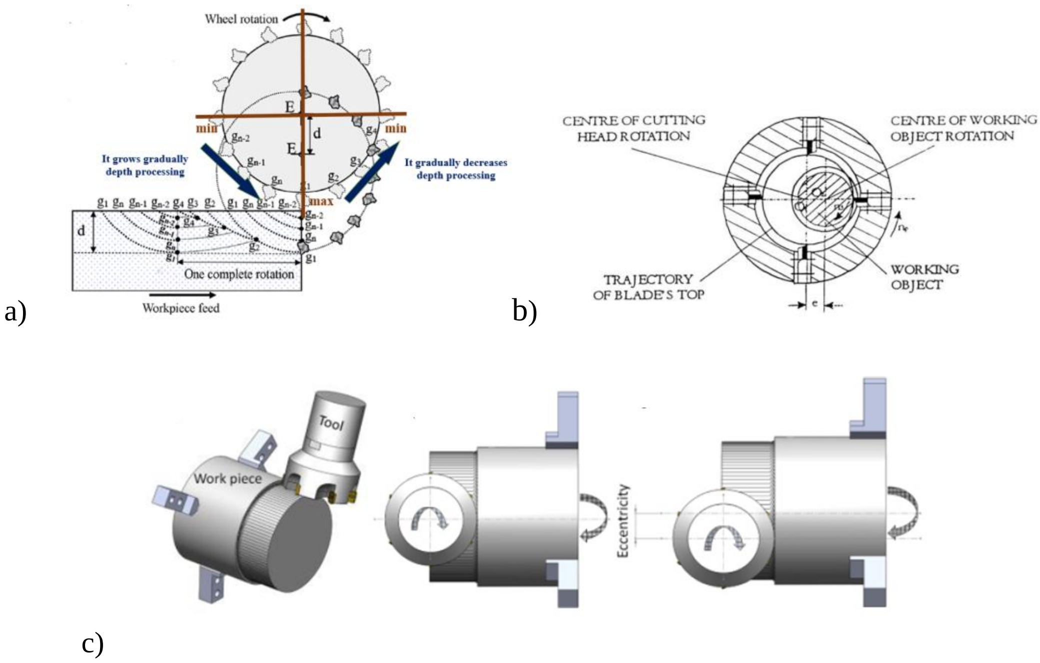


Fig. 1. Eccentric machinings: a) eccentric grinding, after [1], b) eccentric external threading, on lathe [2], c) turn-milling machinings [3]

Another research [3] on turn-milling machinings (Fig. 1, c), highlights the fact that the additional eccentricity parameter between the tool and the axis of the part brings here also advantages such as low cutting temperatures and a lower tool wear. The experiments were carried out on a CNC machine and, thanks to its precision, had reliable results related to the fact that the use of such a model of combined eccentric machining of turning-milling brings the improvement of the material removal rate without influencing the quality of the surface to be processed.

In addition, a very important element to highlight through the experiment in is the fact that there is an optimal value for the deviation of the tool from the axis of the part and once this value is reached, its contribution to a uniform distribution of pressure on the turning tool is very high, leading to an increase of its durability [3].

3. Case study

The case study deals with the problem of machining eccentric channels of the HR01_SS02.01 valve body product.

3.1. Defining elements of eccentric channels and technological operation

The considered product has both the role of sealing the fluid or the air that circulates through it, and of allowing in certain areas of it an easy passage from one bore to another of the working fluid. A 3D image of this product is shown in Fig. 2, a. The bores are with reciprocally perpendicular axes (horizontal and vertical), at the intersection of which eccentric channels are defined (Fig. 2, b - d) as follows: the vertical bores represented in green are connected to the green horizontal bores through two eccentric channels, and the red vertical bores are it connects with the red horizontal bore through two more eccentric channels. A section through these bores highlights the position of two of the four eccentric channels (Fig. 2, b), which are symmetrically with respect to a vertical and middle plane of the part that crosses it longitudinally.

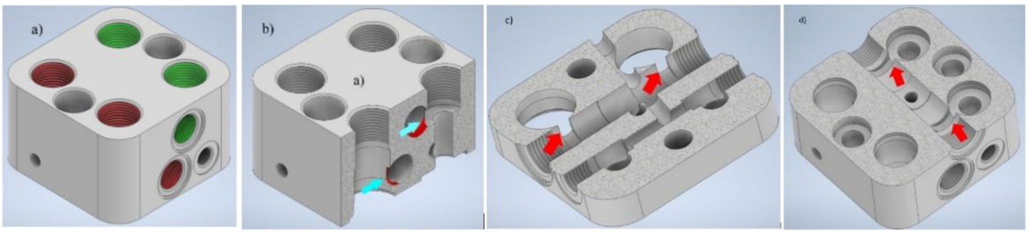


Fig. 2. Representations of the product: (a)3D part, (b, c, d) sections through eccentric channels

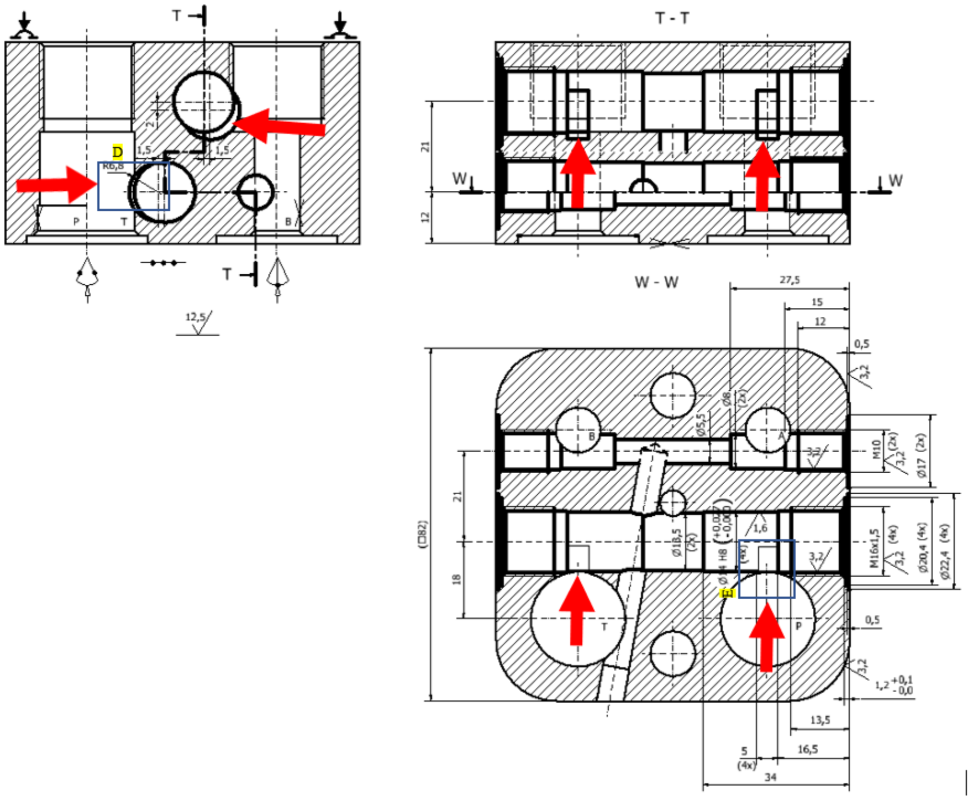


Fig. 3. Extended machining operation sketch

It is to be noted that, within the considered operation sketch, the workpiece orientation-fixation scheme includes base plate, movable smooth conical bolt and movable milled conical bolt.

Two applicative options for performing the eccentric machining from the considered operation are proposed. The first variant concerns the machining of eccentric channels with a boring head equipped with a metallic carbide monobloc cutter, and the second machining variant is with a side milling cutter.

It is emphasized that the prescribed radius of the eccentric channel is R 6.8, and its axis is defined through distance 2 mm or distances 2 mm and 1,5 mm with respect to the axis of Ø14H8 bore, as presented in Fig. 3, i.e., the rotation trajectory of a tool cutting edge is Ø13.6, and the accessing bore for the tool is of Ø14H8. Thus, all these geometrical elements are to be considered for calculus of main position coordinates defining the system adjustment and phase travels [4].

3.2. Machining of eccentric channels with a boring head

The boring head, for machining of considered eccentric channels, includes a cutter made of metal carbide type K20, of a specific shape, with an active edge of 5 mm width and Ø13.6 diameter of the rotation trajectory (Fig. 4).

A first adjustment movement is to position the tool axis on the axis of the Ø14H8 bore (Fig. 4, a). After this, in order to machine one eccentric channel, the entrance safety feed travel is of 0.2 mm (Fig. 4, a) and, then, the machining feed travel of 1.3 mm - for actual machining i.e., a total feed travel of 1.5 mm is unrolled (Fig. 4, b).

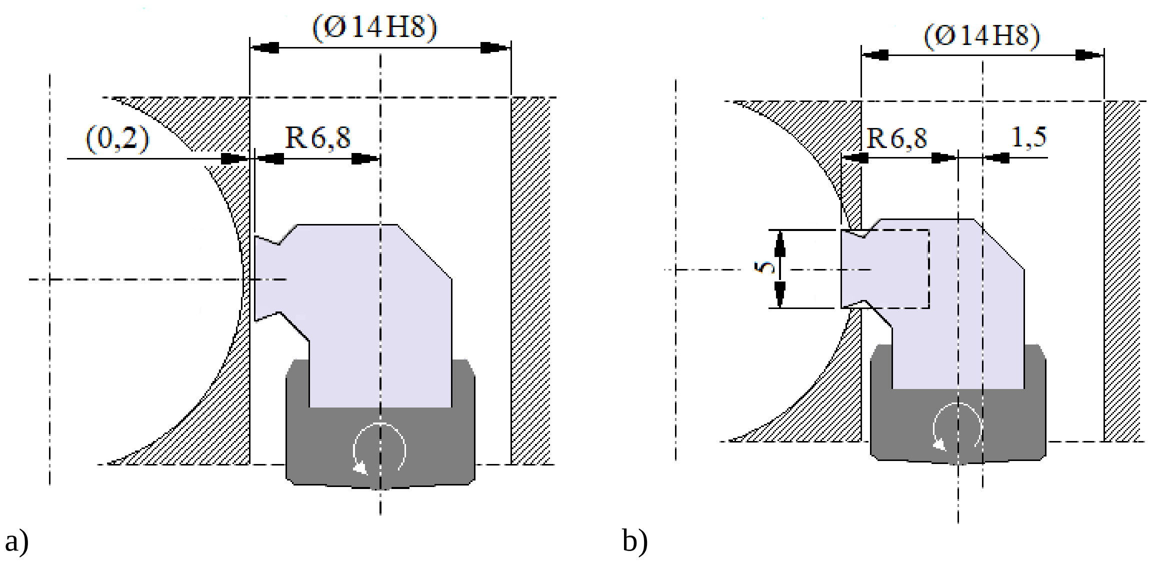
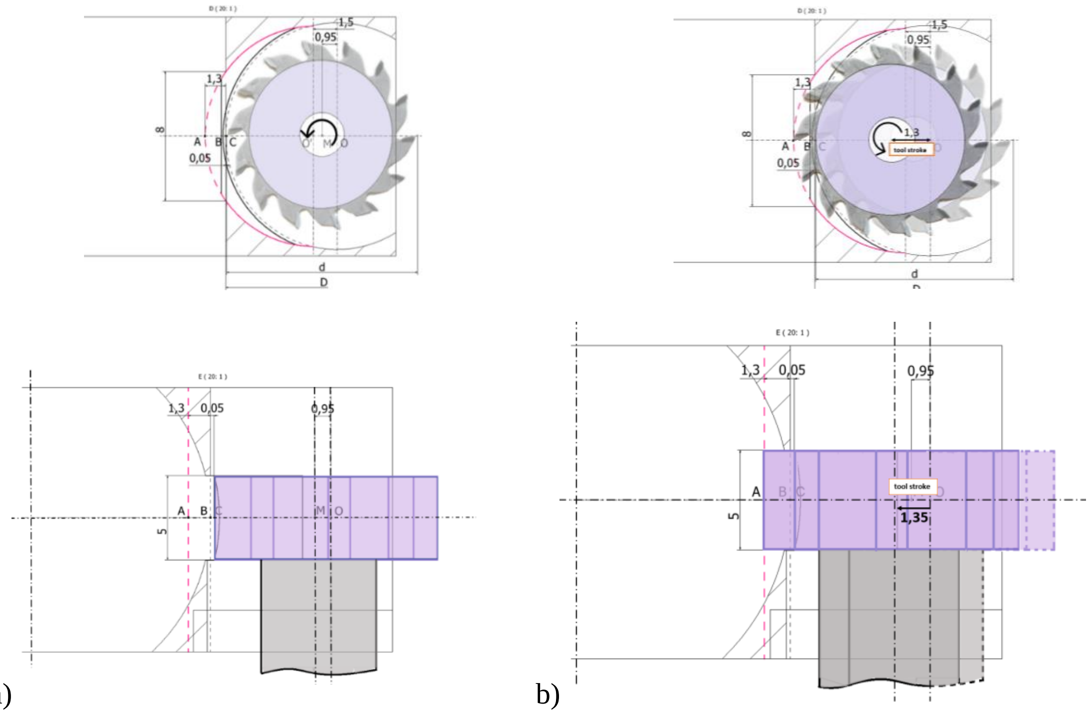


Fig. 4. Calculus elements for machining phase of one eccentric channel with a boring head:
a) initial position, b) final position

3.3. Machining with a side mill

The second variant of machining was applied in collaboration with Dr. Köcher S.R.L. company [5]. A side mill (Fig. 5) with the cutting diameter of Ø12 mm, width of 5 mm and 6 teeth was used. The adjusting movements, within the machining phase of the eccentric channel, have to achieve the tool axis positioning on the axis of the Ø14H8 bore and, then, radial approach travel on the distance of 0.95 mm from previous position. The machining phase can start: an entrance safety feed travel of 0,05 mm and, then, machining feed travel of 1.3 mm - for actual machining i.e., a total feed travel of 1.35 mm is unrolled (see Fig. 6).

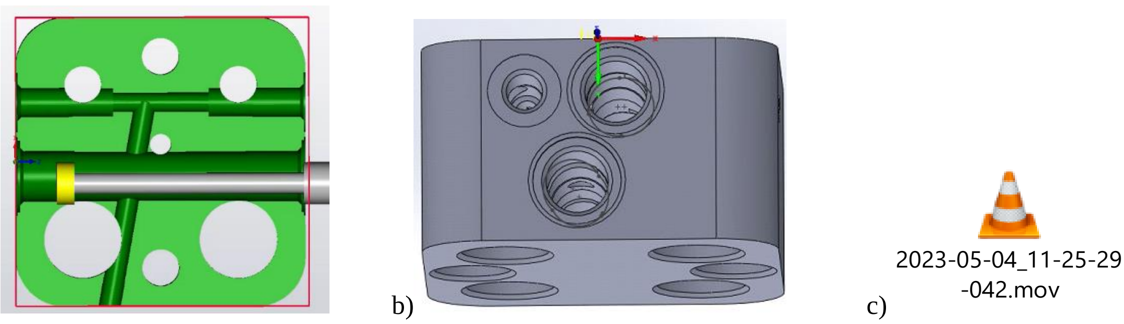
Fig. 5. Side mill used for machining eccentric channels [4]



a) b)

Fig.6. Calculus elements for machining phase of one eccentric channel with a side mill:
a) initial position, b) final position

Simulation **e**lements of machining with a side mill of the considered eccentric channels are presented in Fig. 7.



a) b) c)

Fig. 7, a, b, c. Simulation elements of machining with a side mill of eccentric channels

4. Conclusions

There are a variety of eccentric machining – by turning, milling, turn-milling, grinding, etc.

Eccentric machining represents a special category. In the present paper, a number of elements were analysed - the type of tool, the working travel, the technological movements, etc.

The experimental research carried out demonstrates the fact that the machining of eccentric bores requires the consideration of specific elements, such as: the position between the surfaces of the part and the tool, components of the working travel, etc.

The development of theoretical and experimental research on eccentric machining leads to the thoroughgoing study of specific knowledge, in order to optimize the machining conditions in industrial conditions.

5. References

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