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THE TURNING OF POLYECCENTRICAL SURFACES[1]

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ABSTRACT

Tee paper describes the construction of technological equipment, adaptable to the universal lathes. With its help there may be turning the exterior polyeccentrical surfaces with three or four periods. Here are presented the theoretical considerations connected with the kinematics necessary for turning some polyeccentrical surfaces. Here are also presented the principles of construction of the new equipment. Finally, are presented considerations regarding the results obtained experimentally and conclusions in relation with the using of such technological equipments.

Keywords: *turning, polyeccentrical surfaces, technological equipment, machining device.*

1. Introduction

Polyeccentrical surfaces are also known as polygonal surfaces. It is considered that this naming is incorrectly and confuse from many reason [1], [2]. It should be remarked that this abnormality is valuable for all the papers that tackle this problem, although in many countries, such as Germany, France, Austria and Russia, these structures are even standardised. That's why it was proposed in series of papers [1], [2], [3], the naming of polyeccentrical surfaces. We don't detail right now the engendering of this category of surfaces, which is detailed in [1], [2]. So, further we are going to make only a few general considerations regarding the polyeccentrical surfaces.

The polyeccentrical surfaces are cylindrical ones having a periodical curve in the section with an n periods, where $n = 1, 2, 3, 4$. Practically, only the surfaces with three and four periods are more important, bring used as surfaces of assembling collapsible as a shaft – hub. In the papers [1], [2], [3] and other, there were made a series of considerations regarding the theory and technology of modelling these surfaces. We should remark that the professor *Robert Musyl*, from *Graz Technical University*, Austria, about 1940, defined these surfaces.

The naming of polyeccentrical surfaces was proposal by the author of this paper in this entire works. In [1] and [2] is explained in detail the consideration of the necessity of new names for all the surfaces having as a section periodical curve.

In the case of polyeccentrical surfaces the equation of the section, *figure 1*, is:

$$\begin{aligned} x_M &= r.\cos\varphi - \frac{n+1}{2} e.\cos(n-1)\varphi + \\ &+ \frac{n-1}{2} e.\cos(n+1)\varphi \\ y_M &= r.\sin\varphi + \frac{n+1}{2} e.\sin(n-1)\varphi + \\ &+ \frac{n-1}{2} e.\sin(n+1)\varphi \end{aligned} \tag{1}$$

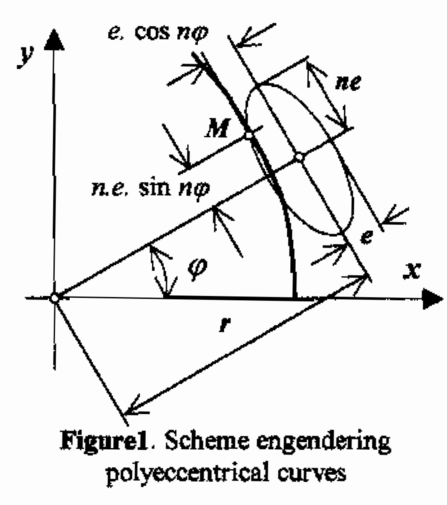

Figure1. Scheme engendering polyeccentrical curves

It is proved that this curve may be generated by more ways. One of then allows as a geometrical place described by a point, which

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makes a movement on an elliptical trajectory, towards the uniform movement of a plane, *figure 2*.

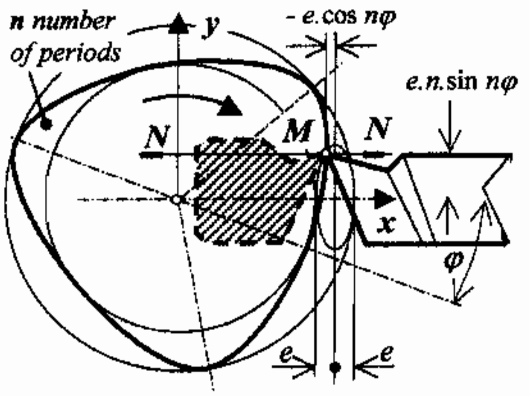

Fig. 2. Turning polyeccentrical surfaces

2. The turning of polyeccentrical surfaces by engendering

The ideal scheme of turning the polyeccentrical surfaces was obtained having as a base some studies also presented in [1], [2]. So, resulted that a point may generate a polyeccentrical structure, which evaluates on a trajectory is correlated with rotation movement on the plane, in an equal report with number n of periods of the polyeccentrical curve. This engendering which has to be realised is:

- the piece perform a movement of rotation wit a constant angular;
- the tool (the turning knife) performs a translation so as its speed point describes an elliptical trajectory, having the little semi axis equal with the eccentricity parameter ***e***, directed in a radial direction, and the big semi axis is equal with ***n.e***. The evolution of ***M*** point has to be made up regarding the following equation, on an elliptical trajectory:

$$x = e \cdot \cos n \cdot \varphi$$
$$y = e \cdot n \cdot \sin n \cdot \varphi \qquad (2)$$

because in this case the tool is always parallel with the normal's direction *N-N* it splits without having variations of the angles of functioning, setting and escaping. That's why the scheme may be characterised as being "ideal". The splitting, regarding this scheme, allows the turning of the polyeccentrical surfaces in identical conditions with the one of cylindrical surfaces.

It is resulted that it had to be conceived a technological equipment to fulfil at the same time the following conditions:

- to realise a translation of the whole support harbour – knife, for the point of the tool to describe an elliptical trajectory;
- the characteristics of the elliptical trajectory don't have to be influenced of the position of the tool;
- to permit the achievement if a stiff constructions, without movements, with surfaces of gliding big enough for having an easier wearing in time;
- to permit a permanent adjustment of the parameter of eccentricity ***e*** and, at the same time, to keep the report between the size of the semi axis equal with n;
- the report between the semi axis may be regulated in steps in according to the values ***n*** = *3, 4*;
- the size of the whole ensemble to permit the placing as an accessory of some universal lathes.

From all these condition the most difficult to be fulfilled proved to be the report of the semi axis regulated in steps. Giving up to this condition there may be conceived a variants of technological equipments, [2]. So, we are going to present only one variant they may also realise interior surfaces.

For this variant they started from the premise that the turning is only a roughing method. So, there may be accepted a kinematics that realises appreciatively the polyeccentrical structures, but that brings up to errors of considerable sizes.

There have been studied two principles of conception of such generating devices, having as basis mechanisms that realise quasi – elliptical trajectories.

In *fig. 3* there is the "classical" mechanism piston - connecting rod and in *fig. 4* there is one of its variants. In this case a point ***M*** situated at a distance ***a*** = ***1/3*** from length, describes a quasi–elliptical curve having the following equations:

$$x = a \cdot \sin \psi$$
$$y = 2a + 3e \cdot \sin 3\varphi - 2a \cdot \cos \psi \qquad (3)$$
$$\psi = \arcsin \frac{e \cdot \cos 3\varphi}{a}$$

for the mechanism, *variant I*, from *figure 3*, and:

$$x = 3e \cdot \cos 3\varphi - 2a \cdot \sin \psi$$
$$y = 2a + 3e \cdot \sin 3\varphi - 2a \cdot \cos \psi \qquad (4)$$
$$\psi = \arcsin \frac{e \cdot \cos 3\varphi}{\sqrt{e^2 + a^2 + 2e \cdot \cos 3\varphi}}$$

for the mechanism, *variant II*, *figure 4*.

If the length of the connecting rod ***l*** is much bigger than the maximum eccentricity e_{max} than the trajectory of the point ***M*** is very war from an ellipse. The centre ***O*** of the ellipse stands immobile.

For the regulation of the size of the semi axis is enough to be modified the eccentricity ***3.e***.

The analyse of the theoretical errors of engendering, for the two variants, was done by using a computer programme. For comparison in the *table 1* are presented a few results obtained by using this programme, for the number of periods $n = 3$, different values r of the middle rays of the profiles and more eccentricities e.

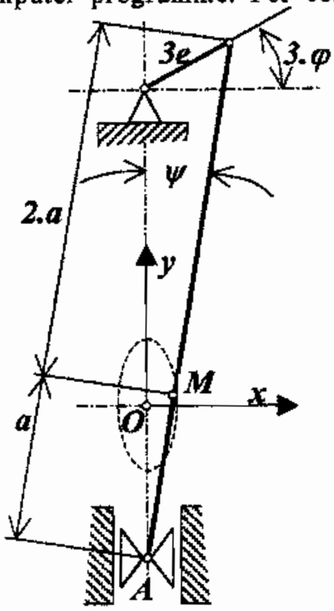

Fig. 3. *Mechanism Variant I*

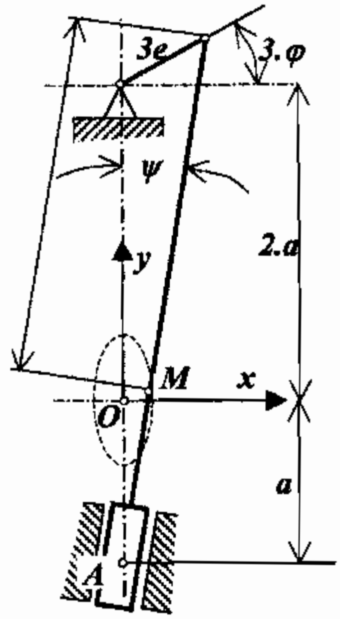

Fig. 4. *MechanismVariant II*

Table 1

n = 3 a = 100 mm								
r	10	20	25	32,5	36	40	45	50
e	0,63	1,40	1,80	2,45	2,80	3,40	4,00	4,50
d_{max} var. I	*0,004*	*0,019*	*0,032*	*0,060*	*0,078*	*0,115*	*0,160*	*0,202*
d_{max} var. II	*0,009*	*0,043*	*0,070*	*0,130*	*0,169*	*0,2488*	*0,341*	*0,429*

Analysing the size of the engendering errors from the *table 1*, we may conclude that both variants are satisfying from the theoretical of view, because the appreciatively profile "is getting dress" the theoretical one, *figure 5*, 'dropping" additions of supplementary processing, equal with the errors of approximation.

From the constructive point of view, the *variant II* would be a little bit more simply, but after the size of errors d_{max} are more than double at the *variant II.*

For the peak of the turning knife tool to be placed in point *M* of the engendering mechanism it was adapted for a special construction of a support for a little plate made of metallically carbides. The advantage of this construction is that the repairing of the splitting part is made up from the simply replacing of the plate its peak *M* having the same position as the initial adjustment.

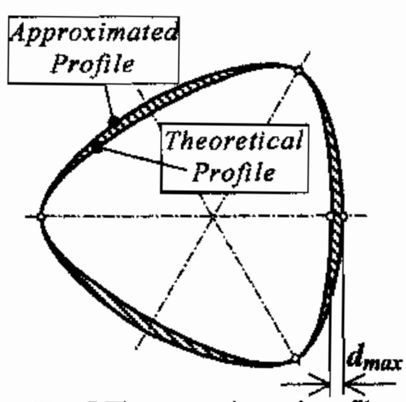

Fig. 5 The approximated profile and theoretical profile

The connecting rod was realised as a plane piece, guided with a slide movement between the two walls, *figure 6*. The whole construction of the engendering mechanism is fixed on the perpendicular sledge of a universal lathe. In order to be used a mechanism with ***a = 100*** mm, its positioning was made up on the lateral space of the perpendicular space, permitting the fitting with clearance diagram und the level of the perpendicular sledge, *figure 7*.

In *figure 8* is presented the image of the whole technological – experimental equipment together with the multiplier mechanism that provides the kinematics relation between the rotation movement of the principal axis and the movement of the turning device.

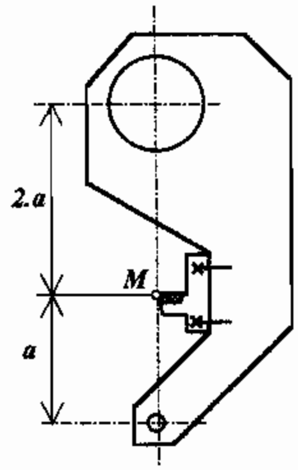

Fig. 6. Connecting rod construction

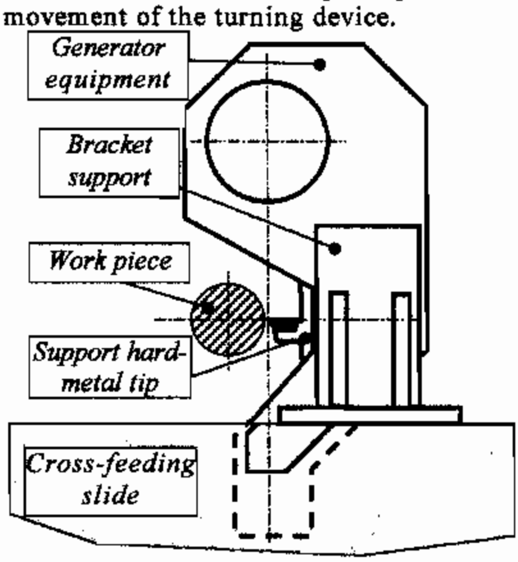

Fig. 7. Disposition equipment on lathe

We should remark that this equipment, having a base the scheme from *figure 3*, has two "imperfections":

- it realises for the peak of the tool an almost elliptical trajectory (quasi – elliptical);
- during the processing, the knife splits in the conditions of a variation of the functional angles of setting and escaping. This fact is owed to the movement of the piston rod with au ψ angle witch determines a variation of this angles with a maximum of $\pm\psi$. If the length of the piston rod is big enough, then the maximum value of the ψ angle is reduced.

For example, for ***a = 100*** mm and ***e = 6*** mm results that $\psi_{max}<3,40^0$, that provides negligible variations of the setting and escaping angles.

The regulation of the equipment consists in two actions:

- the closing and the assembly of the wheels to be exchanged in order to realise the report of multiplication equal with *3* or *4*;
- the regulation of the eccentricity is equal with ***3.e***. We should remark that for the turning of the polyeccentrical surfaces with four periods, the eccentricity is also regulated to be ***3.e*** because only this way, the little semi axis of the ellipse is equal with ***e***. The regulation system is simple, the type with two eccentricities placed angular corresponding to the total eccentricity necessary for the engendering of the profile.

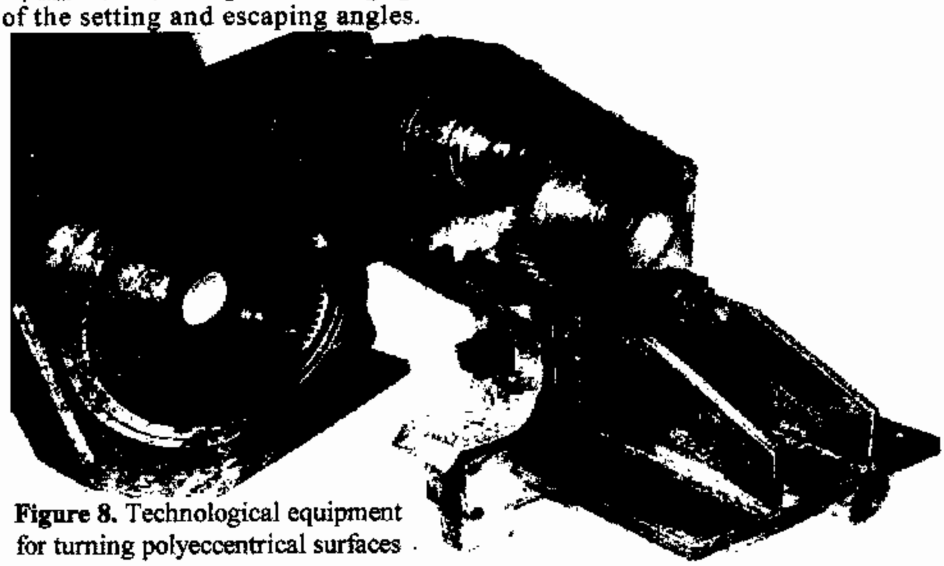

Figure 8. Technological equipment for turning polyeccentrical surfaces

3. Conclusion

The experimentation of the technological equipment described, emphasized the obtaining of some superior performances of other type of equipments, so as maximum revolutions at the so as maximum revolutions at the turning tool, and so as the intensity of the splitting system. The equipment resulted with a great rigidity, having a great dynamic involving.

In conclusion, the technological equipments, based on the described principle, may be recommended for the turning of the exterior polyeccentrical surfaces, because:

- they are more simply, so they may be executed easier and cheaper;
- they are rigid, because they have little elements and the references with a relative movement may be guided on greater surfaces;
- the may be regulated easy and faster;
- they permit the application of some systems of intensive turning, so they offer a great productivity;
- the turning may be done with little plates from changeable carbides, which offer a comfort when it's necessary the remaking of the used turning part.

We may appreciate, finally, that the processing of the polyeccentrical surfaces by turning is the most favourable method of roughing.

The technological equipment described is relative simply they have a great degree of universality, offer advantageous technical and economical conditions.

Even more, it is remarked that only by turning there may realise bevel cants outlined polyeccentrical. And also that only by turning there may be processed escaping for rectification in the zone where a polyeccentrical section continues with an other one, having one step.

Reference:

1. **Ghiţă Eugen** – *« Contribuţii la studiul prelucrabilităţii prin aşchiere a suprafeţelor poliforme"* , Paper for Ph.d. degree, University „Dunărea de Jos" of Galati, 1990;

2. **Ghiţă Eugen** – *„Teoria şi tehnologia suprafeţelor poliforme"*, Editura BREN, Bucureşti, 2001;

3. **Ghiţă Eugen, Emil Ţaru** – *„Consideration on polyeccentric surface milling"*, The Annals „Dunărea de Jos" University of Galaţi, Fascicle V, 1995.

STRUNJIREA SUPRAFEŢELOR POLIEXCENTRICE
(Rezumat)

Lucrarea descrie construcţia unui echipament tehnologic, adaptabil pe strungurile universale. Cu ajutorul lui pot fi strunjite suprafeţele poliexcentrice exterioare cu trei şi patru perioade. Sunt prezentate consideraţiile teoretice legate de cinematica necesară strunjirii unor suprafeţe poliexcentrice. Se prezintă principiile de construcţie ale noului echipament. În final sunt făcute consideraţii referitoare la rezultatele experimentale obţinute şi sunt sintetizate concluzii în legătură cu utilizarea unor asemenea echipamente tehnologice.

TOURNER DES SURFACES POLYEXCENTRIQUES
(Résume)

L'article de pièce en t décrit la construction du matériel technologique, adaptable aux tours universels. Avec son aide là peut être tourné les surfaces polyeccentrical extérieures avec trois ou quatre périodes. Ici sont présentés les considérations théoriques liées à la cinématique nécessaire pour tourner quelques surfaces polyeccentrical. Ici sont également présentés les principes de la construction du nouveau matériel. En conclusion, sont présentés des considérations concernant les résultats obtenus expérimentalement et des conclusions en relation avec l'utilisation de tels matériels technologiques.

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