PROBLEMS ABOUT THE TOLERANCES ESTABLISHMENT AT THE POLYHEDRAL TURNING

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Abstract: For this study it has started from generation principle of polygons on the basis of cyclic curves, available method such for automatic lathes. The precision with that curve approximates the straight lines of theoretical sections is presented in this paper. Thus, the processing of pieces with polyhedral sections is very productive and the resulted accuracy is into tolerated heights limits.

1. INTRODUCTION.

The problem about the polyhedral turning has been studied since of 1964, being applied in the shape of redundant devices at the automatic multi-axes lathes or automatic eccentric lathes. Thus, in [7] a square turning method using a revolving head with two tools is presented, figure 1. The gear wheel with r radius engages with a internal spur gear, thus a nose attached on the gear wheel with r radius, having a motion of translation lengthways the side square and a rotational motion around the O_1 axis that will describe an ellipse with semi-axes a and b. The O_1 center will depict symmetrically given the first tool, in relation with O_1, will describe an ellipse with a big axis in vertical plane. The section from the middle ellipses can be approximately linear considered, thus approaching the square sides.

If are used three tools, an hexangle is generated (figure 2) that plot three ellipses.

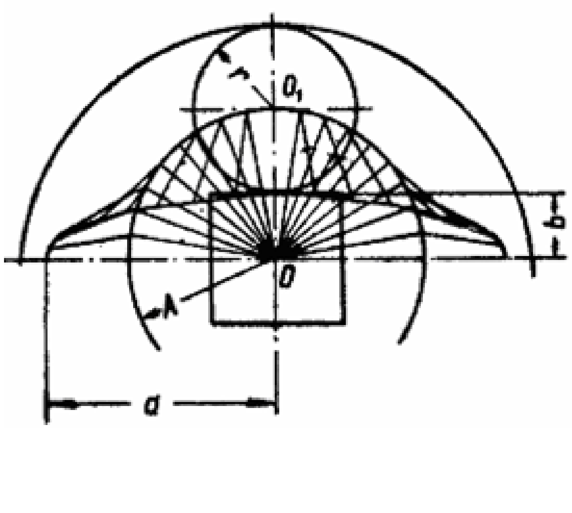


Fig.1.Diagram of a square turning method.

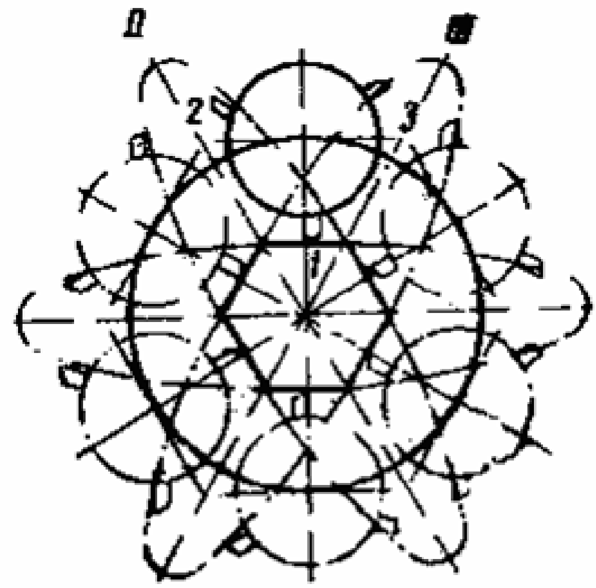


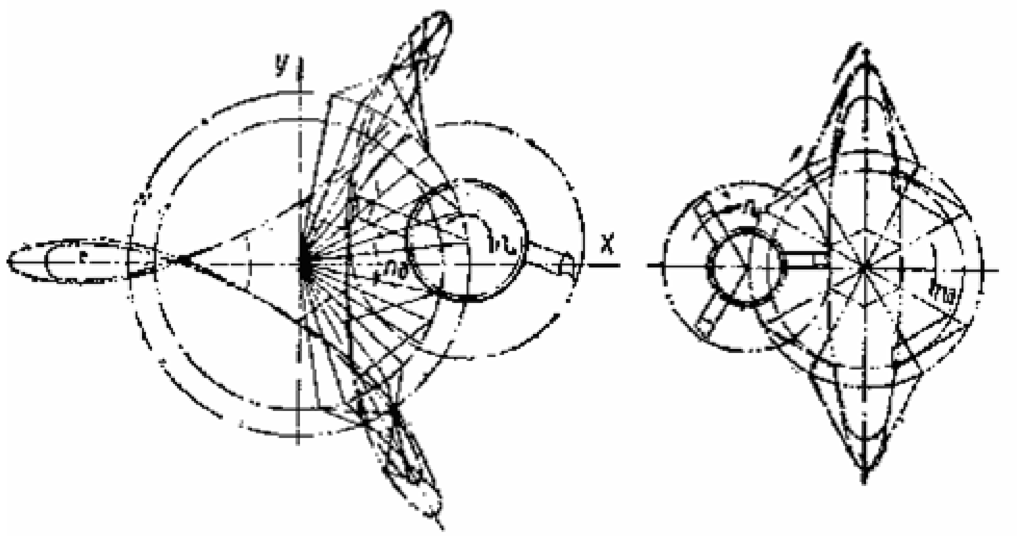
Fig.2. Diagram of a polyhedral turning method.

On the period of these metals cutting, the piece is fixed maintained. The Swedish engineers E. Dalgren and D. Svinson established the polyhedral turning possibility having a piece rotational motion with n_p speed and a rotary motion on the same direction with n_s rotation speed of drill chuck. Thus, using a number c of tools, a polygon with L sides is obtained, on the basis of followings relations:

$$n_p \cdot L = n_c \cdot c. \qquad (1)$$

where L and c have be integers.

In [7] is illustrated with examples a hexagon generation with two tools, like in figure 3.a, obtaining hypocycloids, or with three tools resulting ellipses, as is shown in the figure 3.b. But, in all cases a feed motion lengthways the piece is necessary, such as polygons result only in section and through turning obtaining polyhedral parts.



a. ***b.***

Fig.3. Examples of a hexangle generation methods.

Using the relation (1) and the cyclic curves equations, in [7] has been elaborated generating programs and tabulated the current versions of polygons and even profiles with lobes, generated through epicycloids and hypocycloids.

2. TOLERANCES OF POLYHEDRAL PIECES.

Tolerances problems relate about cylindrical pieces, but, standards stipulates that they are workable for other forms too, arbor being definite such as overall size, if it is not cylindrical, and the bore like an intermediate space, if it is not cylindrical. Thus, the rules from the cylindrical pieces tolerances can be practical at the polyhedral surfaces too.

In tolerances textbooks and standards are presented the tolerances for keys and spindles, and grooved bushings, the most approached of the polyhedral sections which are studied. These are the information's only like tolerance field positions or dimensional discrepancy sizes. Thus, for feather keys (figure 4), in STAS 1004-81 are presented the ultimate deviation at the key depth: h9 for square profile and h11 for rectangular sections. For splined arbors and spline hubs (figure 5), in STAS 6565-79 the fits are indicated in table 1.

Table 1. The fits for spline arbors and hubs.

Tip of fit		Running fit	Tight fit	
Fits for b	Hub	**D9**; F8; **F10**	D9; **F8**	D9; F10
	Arbor	**e8**; **f8**; d9; e9; h9	u6; $\mathbf{j_s7}$	k7

In SR EN 755-4 of 1995 are presented the dimensional and shape tolerances for four-cornered shafts, namely extruded sections of aluminum alloys, depending on size of jaw. For s between 10 and 20 mm, the allowances are included ±0,22 mm and ±1,15 mm, and maximum edge roundness radius between 1 mm and 3,5 mm. The normal misalignment z, figure 6, between 0,01x side s and 1,5x side s are given.

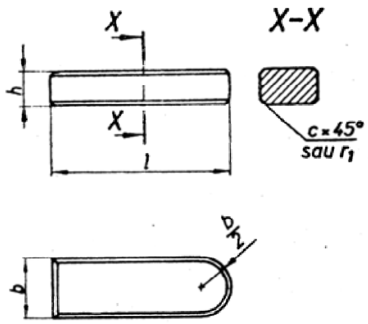


Fig.4. Feather keys.

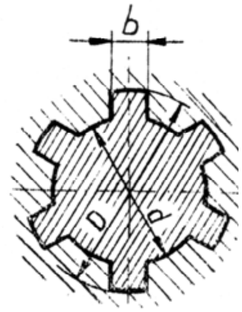


Fig.5. Spline arbor and hub.

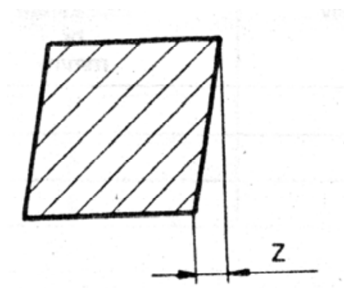


Fig.6. The normal misalignment z.

Analogous, in SR EN 755-6/1995 the same values for six-angle profiles are presented.

3. DEVIATIONS OF POLYHEDRAL TURNING.

On the basis of Cardan circles C_1 and C_2, presented in figure 7, and cyclic curves generation in [4] is indicated how the tool a_1 describes an ellipse and if are used the tools a_1 and a_2 they are generated two ellipses and therefore the hachured square. If three tools a_1, b_1, c_1 are used will generate a hexangle.

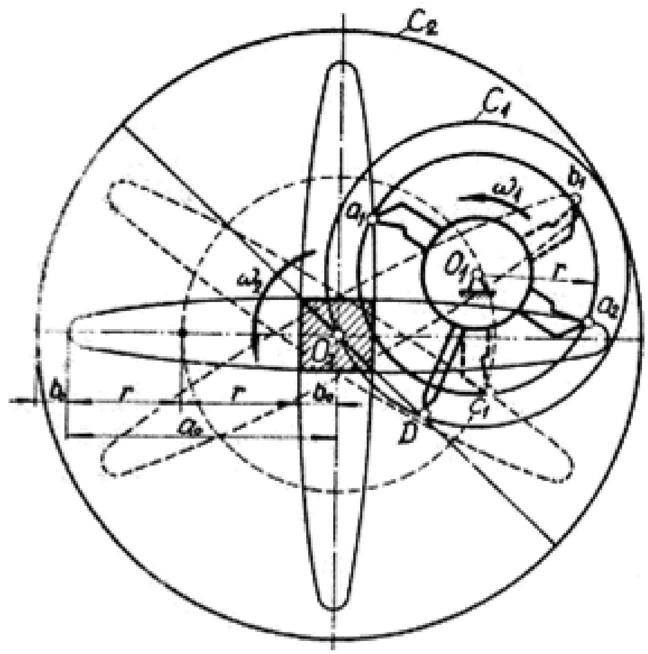


Fig.7. Cardan circles

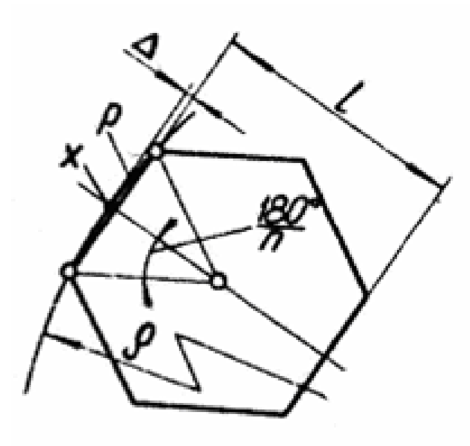


Fig.8. Basic diagram a hexangle generation.

With the notations from the figures 7 and 8, having the size of jaw "l" and the polygon with "n" sides, the distance "a" on fixed centre O_1O_2 is calculated:

$$a = O_1O_2 = \frac{a_0 + b_0}{2}; \qquad (2)$$

$$r = \frac{a_0 - b_0}{2}; \qquad (3)$$

then, using figure 8, ellipse section is exchanged with the adequate osculating circle having the radius:

$$\rho = \frac{a_0^2}{b_0} \approx \frac{2a_0^2}{l}. \qquad (4)$$

Having the permissible deviation of the straight zone of polygon, Δ, followings relations are obtained:

$$\Delta(2p - \Delta) = \left(\frac{1}{2}\,tg\frac{180^0}{2n}\right)^2; \qquad (5)$$

$$a_0 = \sqrt{\frac{1}{4}\left(\frac{l^2}{4\Delta}tg^2\frac{180^0}{2n} + \Delta\right)}. \qquad (6)$$

4. THE DEVIATIONS AT THE UTILISATION OF ELONGATED EPICYCLOIDS.

Manufacturing a device formed by two circles that rolled each other, the motion is conducted from two gear wheels coaxial with these circles, a point of the driven wheel generates an elongated epicycloids. On the driving wheel plane, if that point is occurred on the outside of pitch line. Thus, a hexangle with curvilinear sides can be obtained, like in figure 9.

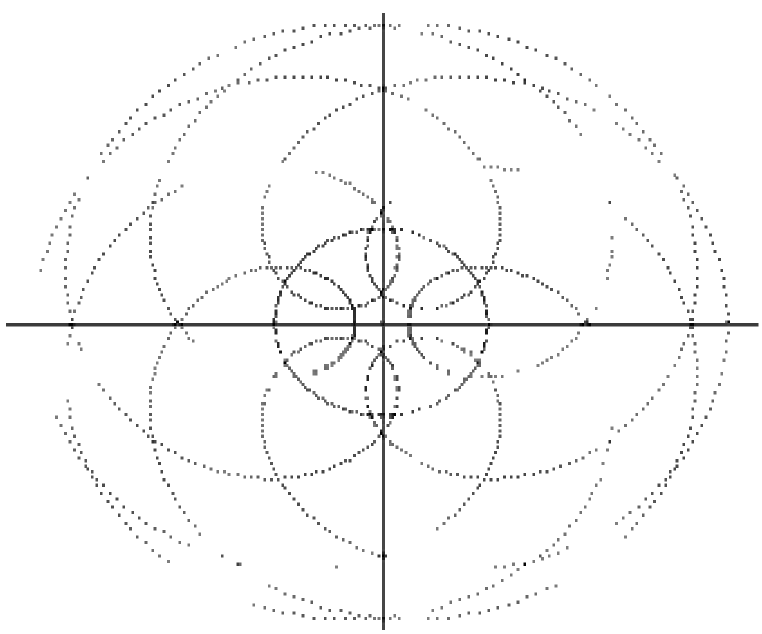
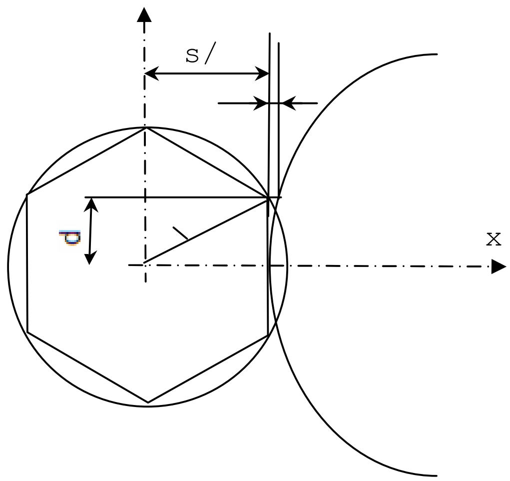


Fig.9. Hexangle with curvilinear sides.

From the figure 10 it comes out that the strand hexangle side on the cross point with x axis thus appears deviations between curve and side. The maximum height of these deviations is h.



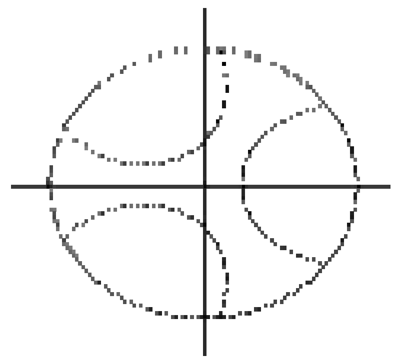


Fig.10. Basic diagram for hexagon side calculus. *Fig.11. Three strands plotted on the pitch line.*

In the figure 11 three strands plotted only on the piece pitch line are indicated. for h value rating will define the differences between curve and line. The evaluation has been made for a half RP from hexangle side because, geometrically, the errors will be identically for all hexangle sides.

It calculates:

$$r_6 = \frac{s}{2\cos 30^0}; \qquad (7)$$

$$d^2 = r_6^2 - \left(\frac{s}{2}\right)^2. \qquad (8)$$

and conditions asses only for coordinates which:

$$x > 0;$$
$$y > 0;$$
$$x < \frac{s}{2} + h_3 \ ; \qquad (9)$$
$$y < d.$$

where h_3 is a protector value for h (it took into account h = 3 mm).

In the figure 12 the curve section that representing half from hexangle side is shown.

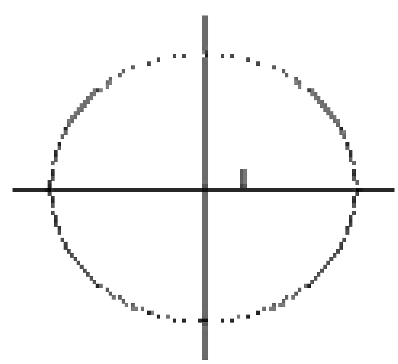


Fig.12. Curve section representing half from hexangle side.

In the table 2 the calculated values are presented.

Also, in figure 13 is given the diagram that represents the deviations on the abscissa direction between plotted curve and hexangle side depending on piece rotation angle.

Table 2. The calculated values.

φ	x	y	h
360.1128	5.000288	7.84E-02	2.880097E-04
360.2128	5.001024	.148262	1.023769E-03
360.3128	5.00225	.2180902	2.250195E-03
360.4128	5.003942	.2878824	3.942013E-03
360.5128	5.006076	.3576657	6.075859E-03
360.6128	5.0087	.4274383	8.699894E-03
360.7128	5.011808	.4972499	1.180792E-02
360.8128	5.015293	.5669641	1.529265E-02
360.9128	5.019335	.6367126	1.933479E-02
361.0128	5.023797	.7064148	2.379656E-02
361.1128	5.028748	.7760931	2.874804E-02
361.2128	5.034141	.8457449	3.414059E-02
361.3128	5.04	.9153694	3.999996E-02
361.4129	5.046314	.9850185	4.631424E-02
361.5129	5.053104	1.054581	5.310345E-02
361.6129	5.06036	1.124106	6.035996E-02
361.7129	5.068081	1.193597	6.808043E-02
361.8129	5.076261	1.263072	7.626057E-02
361.9129	5.084895	1.332454	8.489513E-02
362.0129	5.094005	1.401847	9.400511E-02
362.1129	5.103557	1.471192	.1035566
362.2129	5.11358	1.540464	.1135802
362.3129	5.12407	1.609681	.1240702
362.4129	5.13505	1.678845	.1350498
362.5129	5.146452	1.74801	.146452
362.6129	5.158337	1.817062	.1583371
362.7129	5.170666	1.886053	.1706653
362.8129	5.183457	1.954983	.1834569
362.9129	5.196692	2.023849	.1966915
363.013	5.210439	2.092645	.2104387
363.113	5.224604	2.161373	.2246041
363.213	5.239233	2.230087	.239233
363.313	5.254352	2.298669	.2543521
363.413	5.269877	2.367151	.2698765
363.513	5.285913	2.435605	.285913
363.613	5.302404	2.503951	.3024035
363.713	5.319332	2.572272	.3193317
363.813	5.336695	2.640424	.3366952
363.913	5.354543	2.708542	.3545423
364.013	5.372844	2.776547	.3728438
364.113	5.39159	2.844454	.3915897

From table 2 and figure 13 the followings are established:

- Respective zone is plotted at the second rotation of piece;
- The deviations increase from minimum (on x-coordinates axis) until peak value of h = 0,3915897;
- The proper values of dimensional discrepancies can be read in table 2;
- For analyzed case, it established that the plotting of a side occurs at piece rotation time with 5 degrees, which means that the tool comes into contact with the piece for a very brief time and this is advantageously in point of tool cooling and edge endurance.

On the basis of SR EN 20286-1 of 1997 it establishes that the upper deviation from table 2 approximately complies with fundamental tolerance with IT13 precision, at h13 for arbors or H13 for bores tolerance field position, SR EN 20286-2 of 1997.

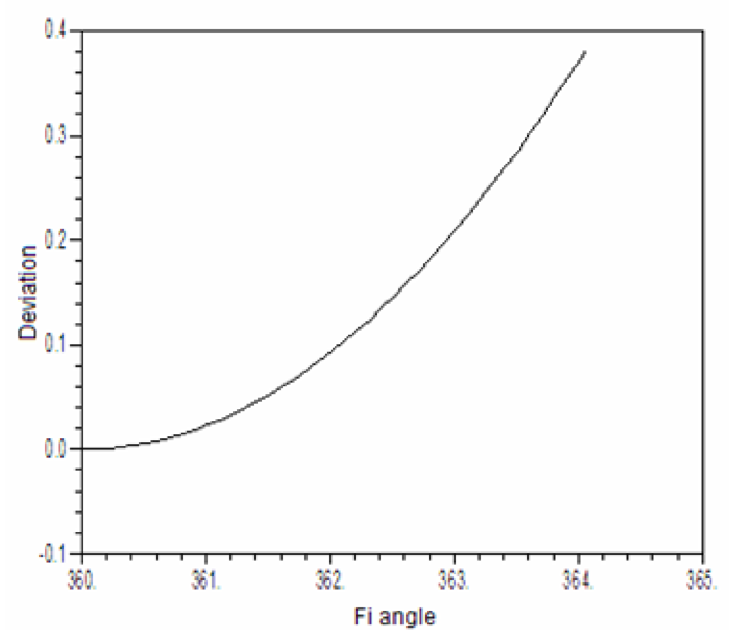


Fig.13. The deviations on the abscissa direction.

Analogous, in figure 14 the deviations for a hexangle with 14 mm size of jaw are presented.

From this case, an approaching fundamental tolerance of IT15 precision is obtained, according to SR EN 20286-1 of 1997, and for tolerance field position, according to SR EN 20286-2 of 1997, h15 for arbors or H15 for bores.

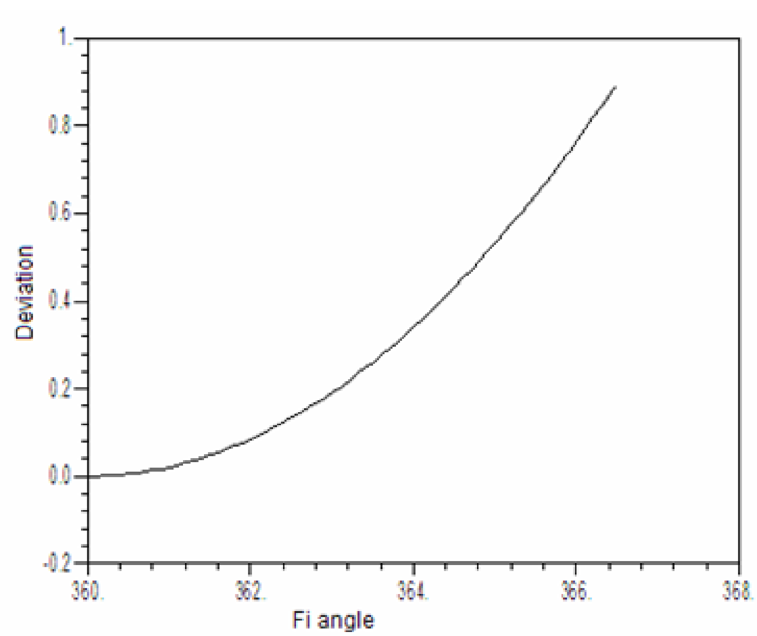


Fig.14. The deviations on the abscissa direction for a hexangle with 14 mm size of jaw.

It comes out that such processing methods are not highly precisely but still they subsume into precision limits for which are prescribed tolerances. Also, the resulted curves of diagrams have a large slope to the zone with maximum deviations and thus the peak value is only in one point and the large values are located into a strap which at first jaw exploitation splays because of plastic deformation.

5. CONCLUSIONS.

a. The prismatic pieces tolerances are not explicit provided in standards than in exceptional cases such as: at some unfinished goods obtained through extrusion, for wedges and grooves.
b. Also, the cylindrical pieces tolerances can be used for these pieces.
c. The processing of pieces with polyhedral sections is very productive and the resulted accuracy is accepting.

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