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ASPECTS REGARDING OF SURFACE ROUGHNESS OBTAINED FROM PROCESSING ARCHIMEDIAN WORMS ON CNC MACHINES WITH FRONTAL-CYLINDRICAL MILLING TOOL

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Abstract

The purpose of this work is to demonstrate that by milling the archimedian cylindrical worm on CNC machines using frontal-cylindrical milling tools are obtained roughness higher than those obtained by classical methods of turning. Now worms produced from improving steel are finishing through turning and worms produced from case-hardening steel are finish through grinding. Surface roughness obtained by turning is comprised in the range between 3.2 -6.3 μm and the surface roughness obtained by milling is in the range 1.6-3.2 μm. The worm producers are interested in increasing the possibilities of processing the worms on the CNC machines with specific tools with productivity and as well as higher accuracy. The experiment which form the basis of the work has been done on CNC machine, OKUMA MULTUS B300 by processing a batch of archimedian worms with m_a = 10, z_1 = 2 with the use of a mills FRANKE, code 2887A.010. The paper demonstrates that surface roughness obtained by milling through the use of a frontal-cylindrical milling tool from carbide mono-block is comparable to that obtained by grinding.

Keywords: worms, CNC milling, frontal-cylindrical milling tool, finishing, roughness

1. Introduction

Helical surface [1], [4], [9], [10] of the worm flanks type ZA is generated with a straight line positioned in the axial plane of the worm [6], [7]. This straight line is materialized by the tool used.

Finishing processing of the archimedian worms through milling with frontal-cylindrical milling tool on CNC machine OKUMA MULTUS B300 [14] is done with the mill positioned in a plane parallel to the axial one located at a distance from the axial plane "e" named eccentricity, milling being inclined to the normal plane to the symmetry axis of the semi-product by an angle γ [2] (Fig.1).

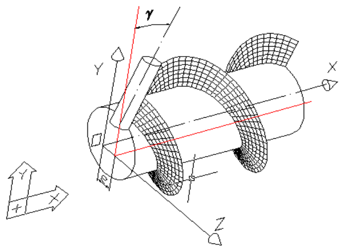

Fig.1: Position of the milling tool

The eccentricity "e" and the angle of inclination of the mill can be determined using an appropriate program, so that deviations from the theoretical profile to be minimal [3]. Milling can be done in two ways: for the purposes of the advance, in contra advance.

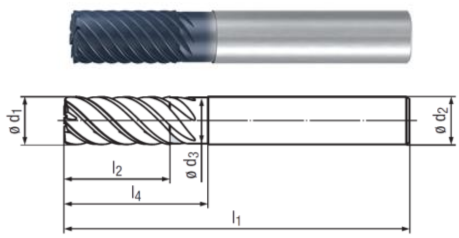

Fig. 2: Milling tool used for finishing Ø 10 mm [13]

2. Milling tool used, route and milling parameters

The chosen tool for processing finishing is a frontal-cylindrical milling tool from carbide mono-block like in [11], Franke tool Code: 2887A.010, Ø

10 mm (Fig.2.) with the characteristics listed in (Tab.1).

Table 1: The characteristics of the mill [13]

d_1	l_2	l_1	d_3	l_4	d_2	Z
10	22	72	9,5	30	10	10

Finishing the flanks is done in two passes for each start, separately for the left flank of the worm and for the right flank as shown in (Fig.3).

As a result of running the program designed to determine the optimal position of the frontal-cylindrical milling tool chosen for finishing so that deviations from the theoretical profile of the archimedian worm are minimal, we obtained the values shown in (Tab.2).

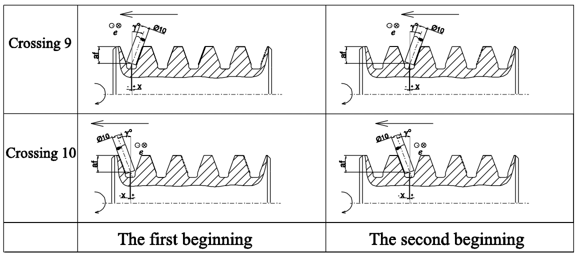

Fig.3. Finishing of the flanks with frontal-cylindrical milling tool Ø 10 mm

Table 2. Adjustment of the milling tool at finishing

Depth of milling, "af" mm]	17.848
Angle of inclination of the milling cutter γ [˚]	19,8
Displacement on the axis OY of the milling cutter, "e" [mm]	1,8
Displacement on the axis OZ of the milling cutter, x [mm]	+0,6224

The program was designed using coordinate transformations [8], [12]. As shown in (Fig.3.) the left flank of the worm mill is made in sense of advance and the right flank mill of the worm is against the sense of the advance, to be able to study in which of the two types of milling surface roughness is the best.

According to recommendations of the manufacturer of mill [13] and [5], are presented parameters of milling in (Tab.3.):

Table 3. Milling parameters

Crossing/ beginning	9/1	9/2	10/1	10/2
Rotation of the mill (n) [rot/min]	4775	4775	4775	4775
Advance speed (vf) [mm/min]	1840	1840	1840	1840
Cutting speed (vc) [m/min]	150	150	150	150
Advance on the tooth (fz) [mm/tooth]	0,04	0,04	0,04	0,04

Images during processing the flanks of the worm are shown in (Fig.4).

At processing right flank semi-product executes a rotary motion in the opposite direction clockwise, frontal-cylindrical milling tool rotates in the direction of rotation clockwise and execute a movement from right to left. In this case the milling is done in contra advance. In the case of milling the left flank of the worm, movements executed by semi-product and mill are the same except that the milling tool is sitting in this case on the left flank of the worm as shown in (Fig.3.) crossing 10.

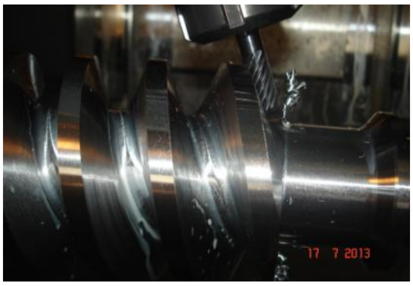

Fig. 4: Finishing right flank

The obtained worm from finishing processing is presented in (Fig.5).

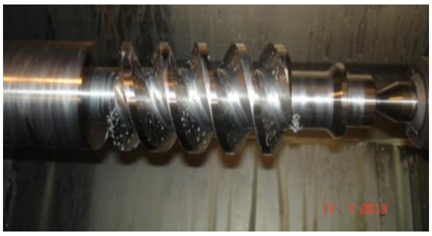

Fig. 5: The worm obtained after finishing

As a result of processing it may be concluded that the cylindrical archimedian worms can be processed by milling with frontal-cylindrical milling tool eccentric positioned and inclined with an angle to the normal plan to the axis of symmetry in normal technological conditions.

3. Measurement of the flanks roughness

Examination of the condition of the worm flanks was carried out using a stereo microscope Olympus with magnification of 22 times (Fig.6.)

Fig. 6: Stereo microscope Olympus

The two flanks of the worm were photographed using a camera positioned directly on one of the microscope objectives, increasing the image photographed by another 2-3 times.

Thus it can be seen from the macro pictures obtained the fact that the right flank (Fig.7.) has a roughness less compared to the left one (Fig.8).

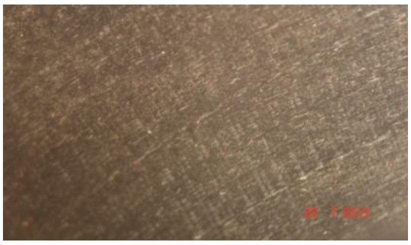

Fig.7. Right flank

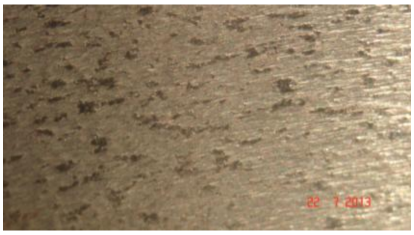

Fig.8. Left flank

The apparatus used to measure the roughness is Taylor Hobson Surtronic 25 (Fig.9).

Fig.9. Taylor Hobson Surtronic 25 [15]

It is a portable and flexible tester, suitable for measuring a wide range of parts and components even if the areas are difficult to access.

Fig.10. Roughness measurement along generators

The used stylus is from diamond with a radius at the peak of 5 µm and can travel a distance of 0-25 mm with a speed of 1 mm/sec. Device resolution is 0.01 µm and accuracy of 2%.

The worm flanks roughness was measured in two directions, the first direction is along the right flank of the generators located in the axial plane of the worm (Fig.10.), and the second one being perpendicular to the direction on the flank of the worm (Fig.11.)

Surface roughness obtained for right flank along the direction of the generators was measured over a

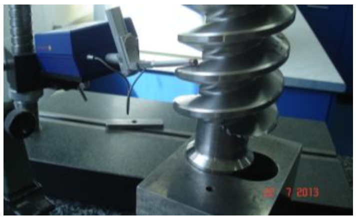

Fig.11. Roughness measurement perpendicular to the generators of the flank

distance of 12.5 mm (Fig.12.), and perpendicular to the generators over a distance of 4 mm (Fig.13).

ISO 4287			
Amplitude parameters - Roughness profile			
Ra	0.287	µm	Gaussian filter, 2.5 mm
Ra	0.172	µm	Gaussian filter, 0.8 mm
Rz	2.15	µm	Gaussian filter, 2.5 mm
Rz	1.19	µm	Gaussian filter, 0.8 mm
Amplitude parameters - Waviness profile			
Wt	4.77	µm	Gaussian filter, 2.5 mm
ISO 12085			
Roughness motif parameters			
R	0.613	µm	A = 0.5 mm, B = 2.5 mm
Other 2D Parameters			
Roughness profile parameters			
Rmax	2.60	µm	Gaussian filter, 2.5 mm

Fig.12. Roughness of the right flank obtained along the generators

ISO 4287			
Amplitude parameters - Roughness profile			
Ra	*****	µm	Gaussian filter, 2.5 mm
Ra	0.585	µm	Gaussian filter, 0.8 mm
Rz	*****	µm	Gaussian filter, 2.5 mm
Rz	4.09	µm	Gaussian filter, 0.8 mm
Amplitude parameters - Waviness profile			
Wt	*****	µm	Gaussian filter, 2.5 mm
ISO 12085			
Roughness motif parameters			
R	1.75	µm	A = 0.5 mm, B = 2.5 mm
Other 2D Parameters			
Roughness profile parameters			
Rmax	*****	µm	Gaussian filter, 2.5 mm

Fig.13. Roughness of the right flank obtained perpendicular to the generators

It is observed that the roughness R_a obtained for the right flank of the worm by finishing with frontal-cylindrical milling tool on both directions is comparable with the surface roughness obtained by grinding.

Surface roughness obtained for the left flank along the direction of the generators was measured over a distance of 12.5 mm (Fig.14.) and perpendicular to the generators over a distance of 4 mm (Fig.15).

For the left flank of the worm, roughness Ra obtained in both directions is higher compared to that obtained from the right flank from here we can draw the conclusion that the sense of displacement of the frontal-cylindrical milling tool at finishing the left flank must be changed to obtain a roughness comparable to that of the right flank.

ISO 4287			
Amplitude parameters - Roughness profile			
Ra	3.21	µm	*Gaussian filter, 2.5 mm*
Ra	2.33	µm	*Gaussian filter, 0.8 mm*
Rz	17.2	µm	*Gaussian filter, 2.5 mm*
Rz	11.9	µm	*Gaussian filter, 0.8 mm*
Amplitude parameters - Waviness profile			
Wt	19.2	µm	*Gaussian filter, 2.5 mm*
ISO 12085			
Roughness motif parameters			
R	7.18	µm	*A = 0.5 mm, B = 2.5 mm*
Other 2D Parameters			
Roughness profile parameters			
Rmax	21.4	µm	*Gaussian filter, 2.5 mm*

Fig.14. Roughness of the left flank obtained along the generators

ISO 4287			
Amplitude parameters - Roughness profile			
Ra	*****	µm	*Gaussian filter, 2.5 mm*
Ra	3.61	µm	*Gaussian filter, 0.8 mm*
Rz	*****	µm	*Gaussian filter, 2.5 mm*
Rz	15.5	µm	*Gaussian filter, 0.8 mm*
Amplitude parameters - Waviness profile			
Wt	*****	µm	*Gaussian filter, 2.5 mm*
ISO 12085			
Roughness motif parameters			
R	8.97	µm	*A = 0.5 mm, B = 2.5 mm*
Other 2D Parameters			
Roughness profile parameters			
Rmax	*****	µm	*Gaussian filter, 2.5 mm*

Fig.15. Roughness of the left flank obtained perpendicular to the generators

4. Conclusions

Roughness control of the archimedian worm's flanks finished through milling with frontal-cylindrical milling tool on NC machine has highlighted the following main aspects:

- The cylindrical archimedian worms can be processed by milling with frontal-cylindrical milling cutter eccentric positioned and inclined with an angle by the normal plane on the symmetry axis of semi-product in the normal technological conditions;
- Surface roughness obtained on both sides is sensible different, on the flank on which the processing is done in contra advance its values are comparable to those obtained by grinding (Ra 0.6 µm) but on flank which milling is done for the purposes of the advance value is much higher (Ra 3.6 µm);
- Equalization of surface roughness for both flanks of the worm requires designing a work program on NC machine that determines the tool to work against the advance on both flanks.

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