

Researches regarding the inner turning of the Polytetrafluoroethylene at small and medium feeds

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Abstract. Experiments were made of the inner cylindrical turning of the Teflon with small and medium feeds, collecting the resulting chips. The shapes and dimensions of these chips are analyzed, explaining their correlation with the advance and with the deformation of the chips sections. The shapes of the chips resulting from considerations of the cutting process of this material are explained. From the analysis of the shapes of the chips, conclusions can be drawn regarding the deformation of the part material in the cutting area, meaning an appreciation of the machinability of the material. The quality of the chip surface indicates the marks left on the chip by the fine chip elements, some of them sticking to the resulting chip. The visualization of the aspect of the machined surface on the piece shows the lack of deposits on the edge, with small exceptions, the uniformity of the channels generated by the tip of the turning tool on the workpiece. All these considerations, as well as the final table regarding the deformation of the chip during processing, show how the Teflon behaves when turning inside with small feeds.

1. Introduction

Research on the machinability of Teflon is rare in the literature. In [1] the Ra parameter of the roughness is studied at the external cylindrical turning of a Teflon part, establishing the parameters of the cutting regime that ensures an imposed roughness. In [2], the temperature in the cutting area at the Teflon drill is measured, finding that the maximum temperature of 40 degrees appears at the cutting speed of 200 m / min. Questions and details about cutting Teflon appear on various Internet forums, and on YouTube there are videos, without comments, showing how a piece of Teflon is turned [3-6].

The shapes of the chips, as indicators of the phenomena in the cutting area, have been studied in some works, but for turning steel. Thus, in [7] the chips resulting from turning a steel are analyzed, depending on the geometric parameters of the knife, looking for the conditions in which convenient chips appear. Similar studies, but when turning an austenitic steel with high cutting speeds, are given in [8]. In [9] the 1045 steel was turned and the shapes of the chips correlated with the noises from the cutting process were studied, evaluating the chips into convenient and inconvenient.

Some approaches about plastics machining are investigated in [10].

In [11] a research about Teflon composites turning using a polycrystalline diamond tool is presented. The effect of the cutting parameters and insert radius on the cutting force and surface roughness was studied

and a predictive model have been derived. Also, in [12] a design optimization of turning parameters of Teflon cylindrical rods by using ANOVA methodology is presented.

2. Experimental data

The Teflon is a synthetic plastic, composed of carbon and fluorine, with the chemical name of Polytetrafluoroethylene; it has a low coefficient of friction, is resistant to corrosion and wear, being used in the construction of machines for bearings, gears, various bushings, gaskets, etc. For the experiment, a Teflon bush with an outer diameter of 58 mm and an inner diameter of 32 mm was turned inside. The Teflon used have hardness 6.2 HV. The cutting regime used was: $v = 50.24$ m / min, the cutting depth $a_p = 0.5$ mm, and the feed steps were: $f = 0.096$; $f = 0.208$; $f = 0.302$ mm / rot. No cutting fluid was used.

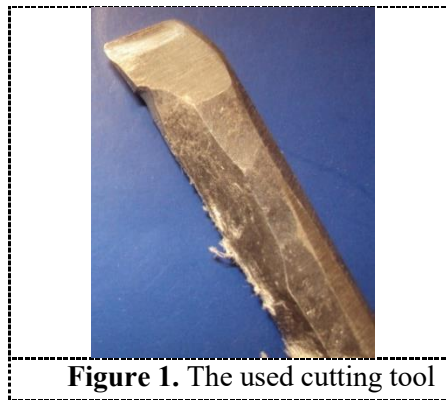


Figure 1. The used cutting tool

3. The shapes of the resulting chips

The resulting chips were studied in order to draw conclusions regarding the development of the cutting process when turning this material. All the chips are flowing, sliding slightly on the clearance face and on the channel on the cutting tool, the flow being also due to the low coefficient of friction between Teflon and the high tool steel. The chips were initially ribbon-shaped, then coiled in a ball, due to the low strength. In length the chips are not smooth, but have sinusoidal succession shapes, in different planes with variable steps and amplitudes. The color of the chips is white.

3.1 Feed $f = 0.096$ mm / rot

In figure 2 the aspect of the chips obtained at $f = 0.096$ mm / rot is presented.



Figure 2. The chips at $f = 0.096$

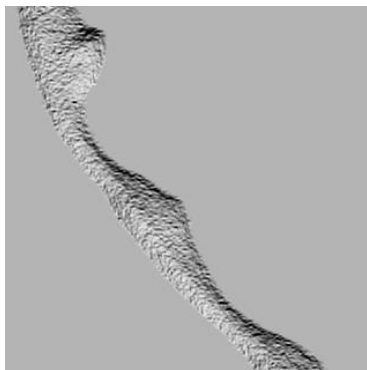


Figure 3. The thickness of the chip

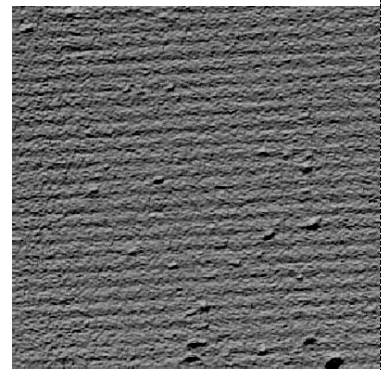


Figure 4. Processed surface

The image also shows a bold, considered a scale standard (images change their size when typing); the bold has a length of 28 mm and a diameter of 0.76 mm.

The thickness of the chip can be seen in figure 3.

A variable thickness is observed, but here also intervenes the twisted shape of the chip.

In figure 4 the aspect of the processed surface with this feed is shown.

There are quite clear the traces of the tip of the cutting tool, but also some agglomerations of chips, which shows that deformations of the initial chip appear in the cutting area. Because the image scale changes when editing, an approximation of the sizes can be done by evaluating the distance between the channels, equal to the size of the feed.

3.2 Feed $f = 0.209 \text{ mm / rot}$

The resulting chips are given in figure 5. Here, too, the chips are coiled because of their low resistance to bending, not remaining rigid.

Figure 6 shows the variation of the chip width and figure 7 shows the chipped surface. Longitudinal channels are also observed, caused by the non-uniformity of the main edge. The size of the image can be assessed by the size of the chip width, measured and given in Table 1 below.

Here, too, small agglomerations of chips can be seen on the surface of the piece (figure 7).



Figure 5. The shapes of chips

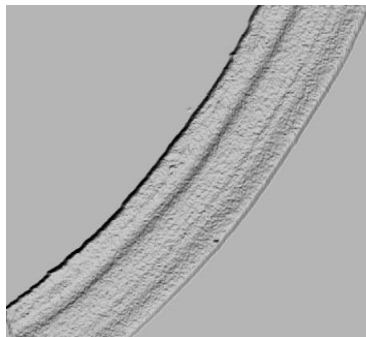


Figure 6. The chip's width

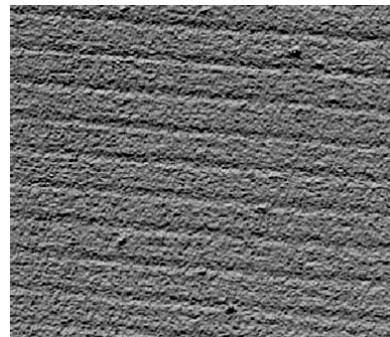


Figure 7. Processed surface

3.3 Feed $f = 0.302 \text{ mm / rot}$

For this sample, the images of figures 8, 9, 10 were obtained. In this case the chips are thicker than in the previous samples, so that less deformed shapes appear.



Figure 8. The shapes of chips

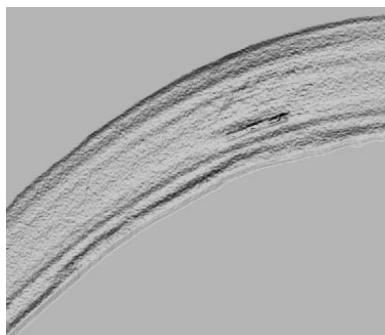


Figure 9. The chip's width

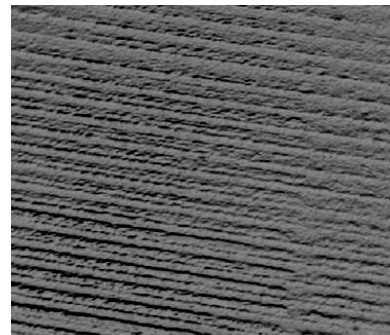


Figure 10. The surface of the part

Here also channels can be observed on the width of the chip, but they are quite uniform.

No chip agglomerations appear on the surface of the part, but the depths of the channels are not uniform, of the chip from the part breaking.

The images in figure 2, 5, 8 seem similar, but they are different not only in the shape in which they coiled, but also in size, the lengths of some bent areas being different from one case to another, so that on a large scale, compared to the bold used as a coefficient of scale, have significant differences.

4. The dimensions of the chips

The theoretical section of the chip in this operation is given in figure 11, where the theoretical section of the chip appears, the plan approach angle k_r and the corner angle of the chip α .

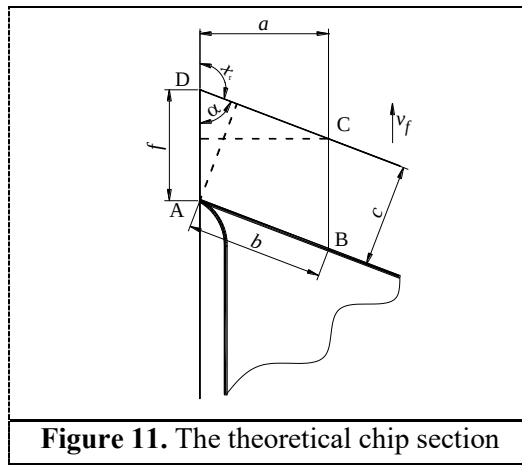


Figure 11. The theoretical chip section

The following relationships are written:

$$\alpha = \pi - k_r \quad (1)$$

$$a = b \sin \alpha \quad (2)$$

$$c = f \sin \alpha \quad (3)$$

Having $a = 0.5 \text{ mm}$ and $k_r = 110^\circ$, the result is $b = 0.532 \text{ mm} = \text{constant}$. The thicknesses and widths of the obtained chips were measured (c and b_l), the results being given in table 1. In the table also appear the coefficients of chip thickness, k_a and chip width, k_b :

$$k_a = a/c; k_b = b_l/b \quad (4)$$

Table 1. Chip section results

f [mm]	c [mm]	a_l [mm]	b_l [mm]	k_a [mm]	k_b [mm]
0.096	0.09021	0.08	0.78	0.8868151	1.466165
0.209	0.1963957	0.15	0.89	0.7637642	1.672932
0.302	0.2837871	0.19	0.91	0.6695161	1.710526

The followings are noted:

- the thickness c of the theoretical chip increases linearly with the feed;
- the thickness of the chip a_1 and its width b_1 increase as the feed increases; this is explained by shortening the length of the chip and thickening its section; therefore, the real chip is plastically deformed, differing from the theoretical one;
- the coefficient k_a decreases at the beginning, then, increasing the feed, it increases.

5. Conclusions

The shapes and dimensions of the chips resulted after Teflon inner turned were studied.

Flowing chips were obtained, long, coiled, and by increasing the feed the sections are enlarged, becoming more resistant, they no longer formed straight ribbons, but they coiled in the form of circular arches.

The thickness of the chips is uneven, but the widths are quite uniform, with some irregularities on one edge. Traces of the tip of the knife can be clearly seen on the processed surfaces, but also rare piles of chip elements.

Measurements have shown that the chips become thicker and wider as the feed rate increases. All this shows that in the cutting process of this material there are remarkable plastic deformations in the cutting area as when turning steels.

References

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