[1.]Slavica PRVULOVIC, [2.]Predrag MOSORINSKI, [1.]Dragisa TOLMAC, [1.]Ivan PALINKAS

CHIP SHAPE AS MACHINABILITY PARAMETER IN THERMOPLASTIC TURNING

[1.]University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, SERBIA
[2.]Technical School, Zrenjanin, SERBIA

Abstract: Chip shape, as a parameter of machinability, can be one of the most important parameters during certain machining processes. Different shapes of chip in steel machining can be obtain by removing chip to outside of machining zone, different geometry of cutting tool, defining chip breaker on tool face and similar. Problem appears with materials that have much lower mechanical properties comparing to steel. This includes almost all non-metals, and the most prominent among them are thermoplastic materials. The paper discusses the possibility of obtaining the chip shape that would be the most acceptable for easy removal from the cutting zone when processing thermoplastic materials. It is considered that with adequate choice of cutting regime parameters, it could be obtained the ideal chip shape, with small length and low percentage of twisting, which is confirmed by experiment.
Keywords: thermoplastic materials, regime of cutting, chip, machining

INTRODUCTION

Chip shape, as a parameter of machinability, can be one of the most important parameters during certain machining processes. Different shapes of chip in steel machining can be obtain by removing chip to outside of machining zone, different geometry of cutting tool, defining chip breaker on tool face and similar [1 - 3]. Problem appears with materials that have much lower mechanical properties comparing to steel. This includes almost all non-metals, and the most prominent among them are thermoplastic materials.

A special problem is to get acceptable chip shape for easy removal from cutting zone when machining thermoplastic materials. Thermoplastic materials have high toughness but low hardness and strength, and with that kind of material the most common is striped and long chip shape that wound around the cutting zone on coupled elements, i.e. tool and workpiece. That kind of chip is hard to remove from cutting zone, and piling it around the cutting edge of tool increase the temperature on face of tool and increase surface pressure on contact surface between tool and workpiece. The question arises as to whether the adequate choice of cutting regime parameters can lead to most acceptable chip shape, with small length and low percentage of twisting. In this paper the researches on subject and results of measurement are presented.

The wide application of thermoplastic materials is conditioned by the possibility to recycle, low cost, machining with small resistance force and low machining temperature, resistance to external influences and many other acceptable properties [4].

Many contemporary researchers of today are dealing with the problem of testing the characteristic values of the machining process, such as cutting force, the shape of chip, the temperature in the cutting zone [5 - 8], and many have made a full contribution with similar research in their time.

MATERIAL AND METHODS

In the experiment, a CNC machine with the following technical characteristics was used (Table 1).

Table 1. Technical characteristics of the EMCO F5 CNC

Name	Unit of measure	Value
The power of the EM	W	440
Travel over X axis	mm	150
Travel over Z axis	mm	300
Machine accuracy	mm	0.01
Feed rate	(mm / min)	5 - 400
Main spindle speed	rpm	50 - 3000
Connector	RS 232	

The values of the input parameters of the turning cutting regime are given in Table 2, and the measurement method used in the experiment is based on eight measurements by variation of the given variable parameters of the turning cutting regime in Table 3.

Table 2. Value of input parameters

	min	max
a_p (mm)	1.5	2
v_f (mm/min)	80	300
n (rpm)	600	1200

where: a_p (mm) – cutting depth, v_f (mm / min) – federate, n (rpm) - main spindle speed

Table 3. Experiment plan

		Measurements			
		1	2	3	4
a_p	(mm)	2	2	2	2
v_f	(mm/min)	80	80	300	300
n	(rpm)	600	1200	600	1200
		Measurements			
		5	6	7	8
a_p	(mm)	1,5	1,5	1,5	1,5
v_f	(mm/min)	80	80	300	300
n	(rpm)	600	1200	600	1200

Tool used in the experiment is made of HM (hard metal) with a handle of HSS (high speed steel). The HM turning insert is hard solder connected to the handle of the tool. The workpiece material is PTFE (polytetrafluoroethylene). Other technical characteristics of the tool are given in Table 4.

Table 4. Characteristic sizes of rotary knife

Characteristic value	mark	Dimension
Tool handle	DIN 4976	1010 P10
Turning insert	SPGN	12 07 08
Side cutting edge angle	κ	45^0
Auxiliary side cutting edge angle	κ_1	45^0
Back rake angle	γ	10^0
End relief angle	α	11^0
Angle of the patch surface	λ	4^0
Nose radius	r (mm)	0,8

RESULTS AND DISCUSSION

In the experimental measurement 1, an unfavorable chip shape was obtained, which was striped and twisted in a narrow space (figure 1).

Figure 1. Measurement 1:
(a_p=2 mm; v_f=80 mm/min; n=600 rpm)

Such chip is twisting directly to the cutting edge of the tool and burdens the tool with additional surface pressures, causes the appearance of vibration during machining and prevents the cooling and lubricating agent from entering the immediate cutting zone. In order to successfully remove the chip from the cutting zone, it is necessary to construct special forms of chip breaker, which would increase the production costs.

By changing one of the parameters of the cutting regime (experimental measurement 2), in this case main spindle speed n, a more favorable chip shape is obtained compared to the previous one (figure 2). The chip in this case is straight shape, partially ragged and with a much smaller length. This shape is highly desirable in machining because it is easily removed from cutting zone and does not affect on the appearance of vibrations that impair the quality of the machined surface.

In experimental measurements under 3, a continuous chip shape was obtained that has mostly twisted around the workpiece rather than tools (figure 3). In comparison with the experimental measurement 1, this kind of chip less burdens the coupled elements of machining and does not lead to additional vibration of the tools. This kind of chip can be shortened by the previous application of a series of transversal machining, ie by more precise design of the technological machining process.

Figure 2. Measurement 2:
(a_p=2 mm; v_f=80 mm/min; n=1200 rpm)

Figure 3. Measurement 3:
(a_p=2 mm; v_f=300 mm/min; n=600 rpm)

The chip shape in the experimental measurement 4 is a long and continuous chip without visible deformations and ragged edges (figure 4). This shape is very unfavorable and it was obtained using the maximum values of all three parameters of the cutting regime. In this case, the circle is twisted around the tool and around the workpiece, further burdening the entire tribological system with visible distortion of the quality of the machined surface.

Figure 4. Measurement 4:
(a_p=2 mm; v_f=300 mm/min; n=1200 rpm)

The circle in the experimental measurement 5 has similar characteristics as in the measurement 4, but in this case the obtained chip shape is achieved using the minimum values of all three parameters of the machining cutting regime (figure 5). The conclusion is that a linear reduction in the value of the parameters of the machining cutting regime can also result in an unfavorable chip shape, and that the parameters of the machining regime according to the nonlinear principle should be varied in order to achieve a more favorable shape.

Figure 5. Measurement 5:
(a_p=1,5 mm; v_f=80 mm/min; n=600 rpm)

The experimental results of the measurement in the sixth test confirm this thesis (figure 6). In this experimental measurement, a short chip is obtained that can easily be removed from the cutting zone, with very small vibrations of the coupled system (tool-processing-clamping accessories) and similar characteristics as in experimental measurement 2.

Figure 6. Measurement 6:
(a_p=1,5 mm; v_f=80 mm/min; n=1200 rpm)

In the experimental measurement 7, the chip shape was similar to that in experimental measurement 1 with all the negative characteristics (figure 7). The chip shape in the experimental measurement 8 (figure 8) is somewhat more favorable in relation to measurements 4 and 5, which can be concluded that the most unfavorable shapes are obtained in the given measurements. The chip in experimental measurement 8 is striped, but not continuous. At a certain length, the chip breaks and thus more easily go out of the cutting zone. A partial conclusion is that by reducing the machining depth, while retaining the maximum values, the remaining two parameters of the cutting regimen can be obtained more favorable chip shape.

Figure 7. Measurement 7:
(a_p=1,5 mm; v_f=300 mm/min; n=600 rpm)

Figure 8. Measurement 8:
(a_p=1,5 mm; v_f=300 mm/min; n=1200 rpm)

CONCLUSIONS

Chip is a good indication of the machinability of certain materials, especially materials with higher toughness and less hardness and strength. The expected chip shape in the machining of thermoplastic materials is almost always spiral with a large length and without visible broken segments in the operation of the chips breaking. The chip brakers almost have no effect on the shape and length of the chips in these materials.

Experimental data in this paper show that the production of small and shredded chips can be achieved by adequate selection of parameters of the cutting regime, primarily by the main spindle speed (n [rpm]) and step size (f [mm / 0]), i.e. feedrate (v_f [mm / min]). By increasing the speed and at the same time by reducing the step size (experimental measurements 2 and 6), the required chip shape is obtained which is most easily removed from the cutting zone.

The cutting depth for these two experimental measurements is different and it is not a decisive factor for the given material. This assumption complies with experiments of world famous tool manufacturer Sandvik-Koromant, which confirmed assumption that with variation of step size and spindle speed, independently from machining depth, can be influenced on shortening overall length of chip.

Note

This paper is based on the paper presented at 7th International Conference Industrial Engineering and Environmental

Protection 2017 – IIZS 2017, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin", in Zrenjanin, SERBIA, 12 – 13 October 2017.

References

[1] Ekinović, S. (2001): Obrada rezanjem, Dom štampe, Zenica, BiH, ISBN: 9958-617-15-3, 136 str.
[2] Kalajdžić, M. (2008): Tehnologija mašinogradnje, Univerzitet u Beogradu, Mašinski fakultet u Beogradu, Srbija, 419 str.
[3] Kalajdžić, M., Tanović, Lj., Babić, B., Glavonjić, M., Miljković, Z., Puzović, R., Kokotović, B., Popović, M., Živanović, S., Tošić, D., Vasić, I. (2012): Tehnologija obrade rezanjem. Priručnik, Univerzitet u Beogradu, Mašinski fakultet, ISBN 978-86-7083-623-5, 453.
[4] Callister, W.D.,Jr. (2007): Material Science and Engineering, University of Utah, seventh edition, USA.
[5] Haijin, W., Jie, S., Dandan, Z., Kai, G., Jianfeng, L. (2016): The effect of cutting temperature in milling of carbon fiber reinforced polymer composites, Applied Science and Manufacturing, Vol. 91, Part , pp. 380 - 387.
[6] Kara, F., Aslantas, K., Cicek, A. (2016): Prediction of cutting iemperature in orthogonal machinining of AISI 316L using artifical neural network, Applied Soft Computing, Vol.38, pp. 67 – 74.
[7] Grzesik,W. (2008): Advanced Machining Processes of Metallic Materials, p.462

ACTA TECHNICA CORVINIENSIS BULLETIN OF ENGINEERING
ISSN: 2067-3809