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INFLUENCE OF THE TYPE OF INSERTS ON DIMENSIONAL ACCURACY IN TURNING PROCESS

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Abstract:
This article is aimed to demonstrate the effect of cutting material and geometry of inserts chip breaker for dimensional accuracy in turning. The experiment is aimed on measuring compliance with dimensional accuracy in turning of samples from steel 11 523 at a constant feed rate and depth of cut, with varying spindle speeds. Machining was performed by using a different types of replaceable inserts. The measurement results will be evaluated in terms of the impact of different geometry characteristics and changing speeds spindle.

***Key words**: turning, dimensional accuracy, cutting edge, chip breaker*

INTRODUCTION

Machining of materials is a working process, which changes the work piece into desired dimensions and shape by removing of material from surface layer. The most common method of machining is turning. Material during turning is removed in form of chips and those are generated by the interaction between the tool and machined material [1, 2]. Based upon long-term development of cutting materials we can´t expect in near future that new cutting material will be discovered. Therefore, the research of the leading manufacturers is focused on improvement of existing cutting materials, the specification and exact determination of their optimal application.

In the process of turning the cutting edge of tool is exposed to high thermal load, mechanical stress, friction, vibrations and sudden thermal and mechanical shocks. Therefore, measurement and examination of behavior under these conditions is an inseparable part of research and development of cutting materials [5, 7].

The aim of this paper is to monitor and evaluate the dimensional accuracy in turning caused by different properties of individual inserts and monitoring of changes in these characteristics at three different values of spindle speeds [3, 4].

MATERIALS AND METHODS

We have focused on monitoring the influence of cutting material and the chip breaker geometry on dimensional accuracy of machined sample. In order to study the influence of only one factor, it was necessary to set the conditions that other factors were eliminated. These other factors could influence measured parameter. We have used one size of cutting inserts – DNMG 150608, made of different cutting materials and with different chip breaker geometry. In assessing the influence of cutting material were compared only the cutting inserts, whose only distinguishing feature was just cutting material. We have also followed in assessing the impact of inserts geometry. We were interested in behavior of inserts at different spindle speeds – at 710 rpm, 1400 rpm and 2240 rpm. Other cutting conditions remained constant – depth of cut a_p = 1 mm and feed rate f = 0.1 mm^{-1}. As the sample of the material steel 11523 was used. Inserts used in measurement are designed especially for machining this type of material.

Characteristics of used sample

For the experiment were used samples of the same shape, dimensions and material (see Table 1).

Table 1
Mechanical properties and chemical composition of steel 11 523

Steel 11 523							
Chemical composition [%]						**Mechanical properties**	
C	Si	S	Mn	P	N	**Yield point R_e [MPa]**	**Breaking strength R_m [MPa]**
0.2	0.55	0.04	1.6	0.04	0.009	345	490-630

The dimensions of the sample are shown in Figure 1. The sample was clamped by triple jaw chuck. To reduce vibrations to minimum, the sample was supported with tailstock. To do that, it was necessary to drill a centering hole.

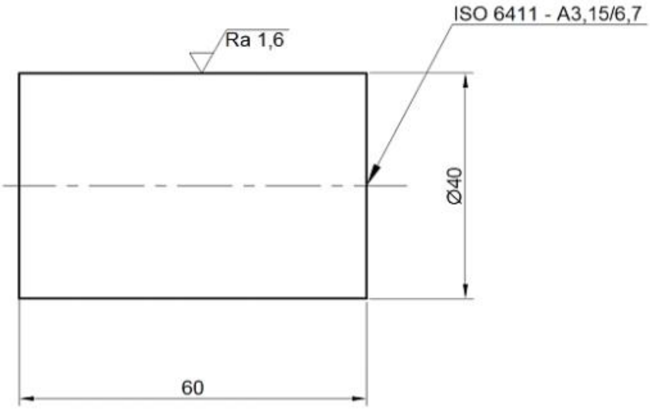

Fig. 1 Drawing of the sample

Characteristics of the tool holder

We have used tool holder (Fig. 2, Tab. 2) for external turning provided by Pramet Tools, type PDJNR 2525 M15 [6].

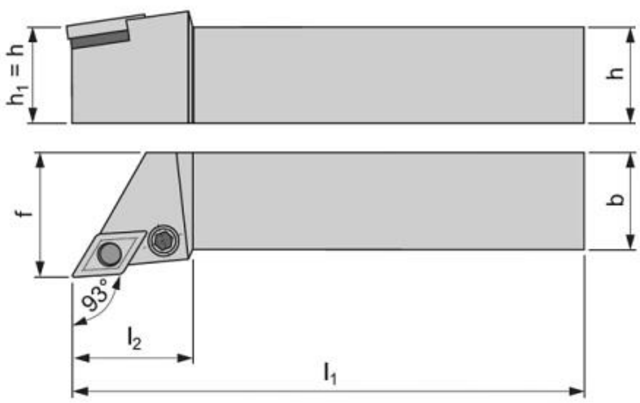

Fig. 2 Tool holder PDJNR for external turning

Characteristics of the turning inserts

We have used turning insert from manufacturer Pramet Tools, type DNMG 150608 (Fig. 3). The dimensions of the DNMG 150608 insert:
l=15.5 mm d=12.7 mm d_1=5.16 mm s=6.35 mm r_ε=0.8 mm

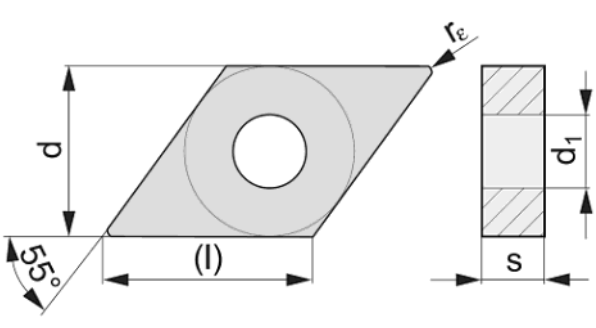

Fig. 3 Dimensions of the DNMG 150608 insert (Pramet, 2012)

Measurement of dimensional accuracy

For the control of dimensional accuracy was used digital micrometer Mitutoyo (Fig. 4), which is accurate to three hundredths of a millimeter and has a measuring range from 25 mm to 50 mm. With this digital micrometer was measured the diameter of each machined sample. Measured values were recorded into table and processed into diagram.

Fig. 4 Mitutoyo micrometer

RESULTS AND DISCUSSION

Basic samples were machined to the diameter 39 mm. For machining of individual samples was used several different grades of inserts. The difference between was only in the geometry of chip breaker and cutting material. Another influencing factor was varying spindle speed.

Experiment no.1: The influence of cutting material on dimensional accuracy

To assess the influence of cutting material on dimensional accuracy is necessary to compare the samples machined with inserts of the same geometry and dimensions. The only allowed difference is cutting material. Measured dimensional values of machined samples are in Table 3 (Fig. 5), and Table 4 (Fig. 6).

In assessing the values of dimensional accuracy after machining with inserts made from cutting materials 6610, 6615 and 6630, with geometry of chip breaker type M, we have evaluated the influence of cutting material on dimensional accuracy. In all three types of insets we have recorded positive deviations from desired value, i.e. diameters were greater than 39 mm. The highest accuracy was reached with cutting material 6615, which has a unique TiCN coating created by combination of MTCVD and PVD method, and is designed for higher cutting speeds. The second highest accuracy was achieved with material 6610, which has a strong Al_2O_3 coating created by MTCVD method and is also designed for higher cutting speeds. The lowest accuracy was achieved with cutting material 6630, which has intermediate TiCN coating created with MTCVD method and is designed for intermediate and higher cutting speeds. Based upon that we can conclude that the cutting material can affect the dimensional accuracy and an important role has type of insert coating.

Table 2
Parameters of tool holder PDJNR 2525 M15

$h = h_1$	b	f	l_1	$l_2$max	rake angle γ_o	back-slope angle λ_s	weight m
25 mm	25 mm	32 mm	150 mm	40 mm	- 6°	- 6°	0.68 kg

Table 3
Comparison of measured diameters machined with M geometry inserts

Insert DNMG 150608		Diameter (mm) Spindle speed (min^{-1})		
Geometry	**Grade**	**710**	**1400**	**2240**
M	6610	39.083	39.072	39.065
M	6615	39.012	39.011	39.007
M	6630	39.084	39.073	39.072

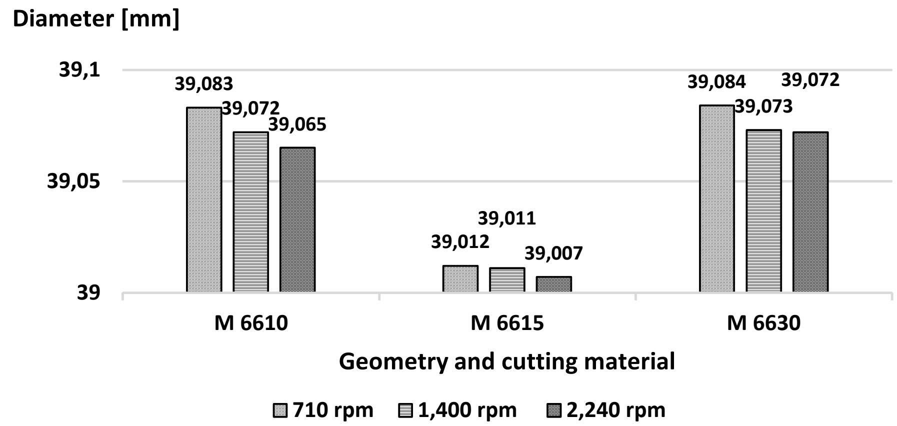

Fig. 5 The influence of cutting material on dimensional accuracy, geometry M

Table 4
Comparison of measured diameters machined with R geometry inserts

Insert DNMG 150608		Diameter (mm) Spindle speed (min^{-1})		
Geometry	**Grade**	**710**	**1400**	**2240**
R	9230	38.974	38.978	38.990
R	6630	39.077	39.074	39.011
R	6640	38.974	38.978	38.990

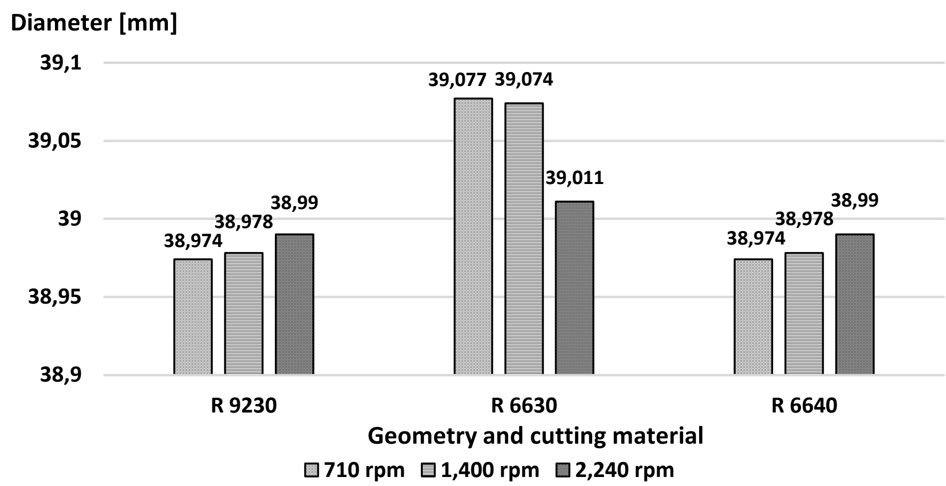

Fig. 6 The influence of cutting material on dimensional accuracy, geometry M

There are obvious differences in dimensional accuracy when we compare the values of diameters machined with R geometry insert grade 664, 6630 and 9230. The insert from grade 6640 was the only one that machined with negative deviance from required diameter at each spindle speed. Closest to the desired diameter was insert from grade 6630, but only at n_3 spindle speed. At spindle speed n2 it was the most inaccurate and at n1 the second inaccurate insert. The most inaccurate insert at n2 spindle speed was the one from grade 9230. We can propose the influence of cutting material on the change of machining accuracy, but there are important differences when the spindle speed changes. But this could be caused by the toughness of the machine and its set.

Experiment no.2: The influence of chip breaker geometry on dimensional accuracy

In the evaluation of the chip breaker's geometry influence on dimensional accuracy we have compared inserts from grade 6630 with three different geometries – M, R and SI (Table 5, Fig. 7).

Outstanding deviation from required diameter occurred after machining with SI chip breaker. The values were extremely under 39 mm. It could by caused by different geometry of cutting edge in comparison with other inserts. This insert has rounded cutting edge not reinforced with bevel and is designed to finishing and semi-finishing. The most accurate was insert with R chip breaker at the highest spindle speed.

Table 5
Comparison of surface roughness after machining with 6630 grade inserts

Insert DNMG 150608		Diameter (mm) Spindle speed (min^{-1})		
Geometry	Grade	Geometry	Material	Geometry
M	6630	39.084	39.073	39.072
R	6630	39.077	39.074	39.011
SI	6630	38.852	38.863	38.870

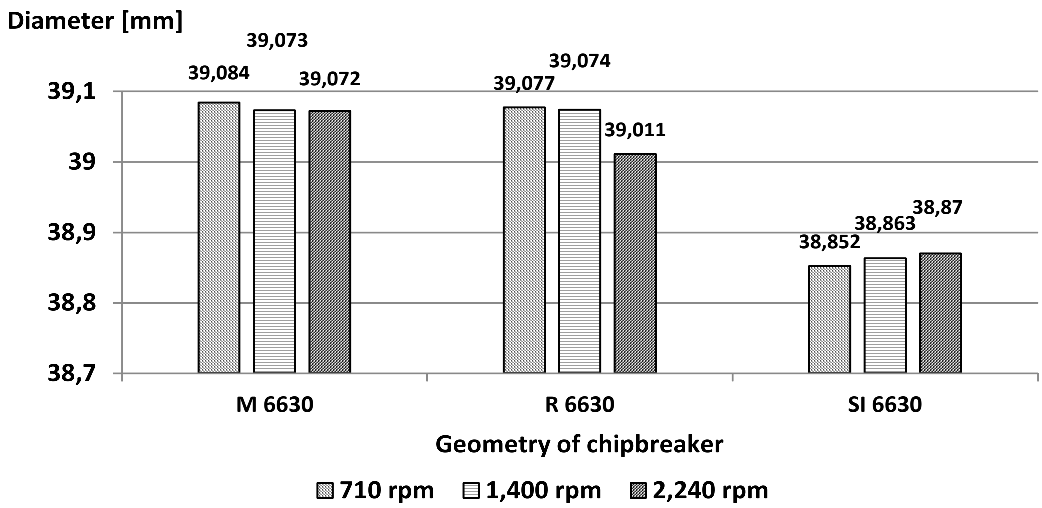

Fig. 7 The influence of chip breaker's geometry on dimensional accuracy

Based on that, we could suppose that best use of this insert is at higher speeds. At n_2 spindle speed this insert machined with highest positive deviation, and at n_1 speed it provided the most accurate machining from all. In pursuance of the differences between measured values we can conclude, that the geometry of chip breaker has an influence on dimensional accuracy in turning.

CONCLUSION

Measured results have been obtained in turning identical samples from steel 11523. Each insert has machined at three values of spindle speed – n_1 = 710 min^{-1}, n_2 = 1400 min^{-1} and n_3 = 2240 min^{-1} (Table 6, Fig. 8). We have focused on the variation of dimensional accuracy at these different values of spindle speed. Other machining parameters remained constant – depth of cut a_p = 1 mm and feed f = 0.1 mm^{-1}. In evaluating the results, we have also focused on the assessment of the impact of cutting material and geometry of chip breaker the measured value.

The highest dimensional accuracy was measured after machining with M-6615 insert. After machining with R-9230, M-6610, M-6630 and F-9230 inserts we had measured positive deviations from required diameter. After machining with R-6640, SI-6630 and RM-9210 we had measured the diameters under 39 mm, what means negative deviation from required diameter. We have observed and confirmed that the geometry of chipbreaker and cutting material have the influence on the dimensional accuracy of machining. However, when assessing the results we must not forget to take into account other important influencing factors that could not be eliminated in our measurements, which are mainly stiffness and condition of used lathe, the accuracy of the measurement devices and the human factor.

Table 6
Summary of the measured results

Insert DNMG 150608		Diameter (mm) Spindle speed (min^{-1})		
Geometry	Grade	710	1400	2240
M	6610	39.083	39.072	39.065
M	6615	39.012	39.011	39.007
M	6630	39.084	39.073	39.072
R	6630	39.077	39.074	39.011
R	6640	38.974	38.978	38.990
R	9230	39.086	39.067	39.066
RM	9210	38.869	38.870	38.873
F	9230	39.134	39.108	39.095
SI	6630	38.852	38.863	38.870

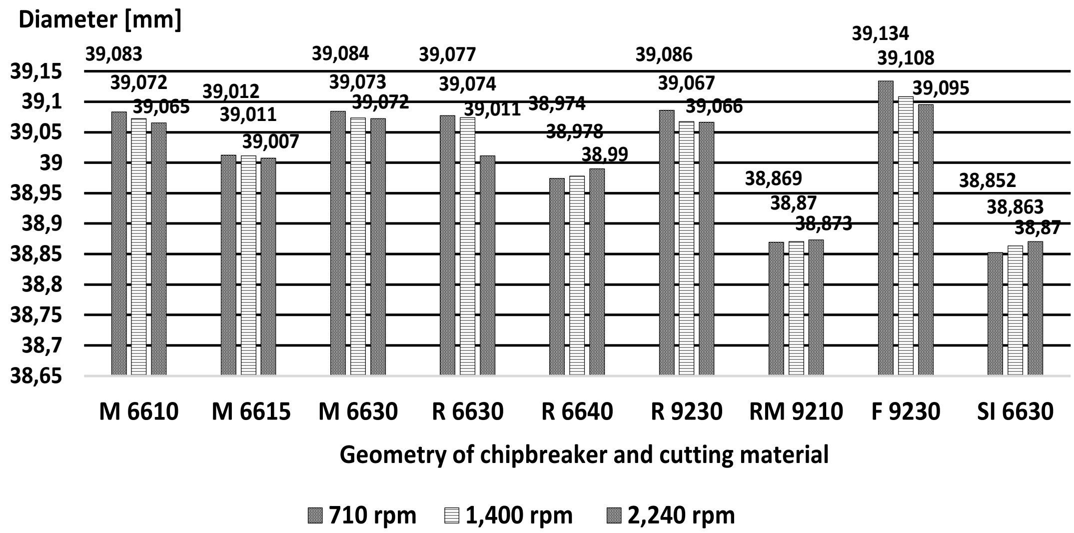

Fig. 8 The influence of the type of insert on dimensional accurancy

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