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EFFECT OF CUTTING MATERIALS ON ROUGHNESS IN TURNING

Pavel Polák[1], Ján Žitňanský[1], Petr Dostál[2], Katarína Kollárová[3]

[1] Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic

[2] Department of Technology and Automobile Transport, Faculty of Agronomy, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

[3] Department of Science and Research, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic

Abstract

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This paper focuses on demonstrating the effect of cutting materials and the geometry of cutting blades on roughness during the turning of machined surface. Experiments have been targeted at measuring roughness when turning a sample of 11 523 steel at constant parameters of shift and depth of cut and under variable values of spindle speed. Measurements were performed by using replaceable cutting blades of different types and parameters. Results were evaluated in terms of the effect of different properties of cutting blades and variable values of spindle speed.

Keywords: machining of materials, shift, depth of cut, spindle speed, cobalt, TiCN

INTRODUCTION

The machining of materials is a working process where a workpiece obtains its required shape and dimensions by removing the material from the surface layer. The most widespread machining method is turning where material is being removed in the form of chips based on the mutual interaction of the tool and workpiece (Žitňanský *et al.*, 2014a). Based on a long-term development of cutting materials, it is not possible to expect in the near future the development of a completely new cutting material; therefore, the research of leading manufacturers of tools and cutting materials is aimed especially at improving the existing materials, specifying the optimum parameters of machining, and exactly defining the areas of their use.

In the turning process, the cutting part of the tool is exposed to high thermal load, mechanical stress, friction, vibrations and sudden thermal and mechanical shocks. It is a reason why it is paid heighten attention to structural ceramics as the potential cutting material with aimed to tribological tests (Brusilová and Gábrišová, 2014a, 2014b). Therefore, measuring and examining the behaviour of materials in such conditions and the resultant roughness of machined parts is an inseparable part of the research and development of cutting materials (Bátora and Vasilko, 2000; Geleta, 2010).

Our objective was to examine and evaluate the material roughness in turning induced by with different properties of the cutting blades used as well as monitoring the changes in these characteristics with three different values of spindle speed.

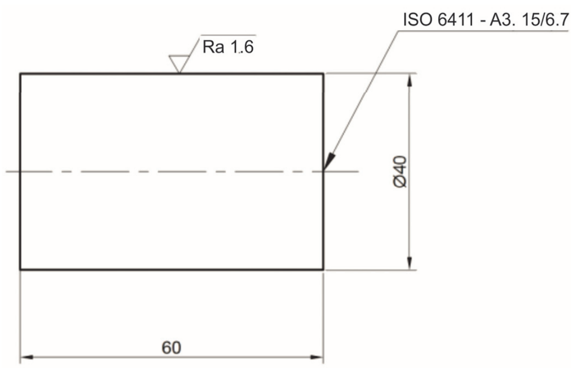
MATERIALS AND METHODS

We have focused on examining the effect of cutting material (replaceable cutting blade) and former geometry on the roughness of machined surface. To enable examining the effect of one factor only, it was necessary to ensure such measurement conditions that other factors could not influence the quantity examined (Janáč *et al.*, 2006; Polák *et al.*, 2014a). We have used the cutting blades of the same type (DNMG 150608), from different cutting materials and with several former types. When assessing the effect of cutting material, we compared

I: *Mechanical properties and chemical composition of steel 11 523*

Steel 11 523							
Chemical composition (%)						Mechanical properties	
						Yield point	Strength limit
C	Si	S	Mn	P	N	R_e (MPa)	R_m (MPa)
0.2	0.55	0.04	1.6	0.04	0.009	345	490–630

only those cutting blades the only differentiating factor of which was just the cutting material. We proceeded similarly with assessing the effect of the geometry of cutting blade former. We were also interested in how the individual cutting blades will behave under different speed; therefore, our measurements were conducted with three different speeds, i.e. n_1 = 710 rpm, n_2 = 1,400 rpm, and n_3 = 2,240 rpm. Other cutting conditions remained constant. Depth of cut was a_p = 1 mm and shift f = 0.1/mm. The experimental sample was manufactured from the 11 523 steel. The cutting blades used in our experiments are designated for machining a group of materials which this steel also belongs to.



1: *Test sample drawing*
Source: own research

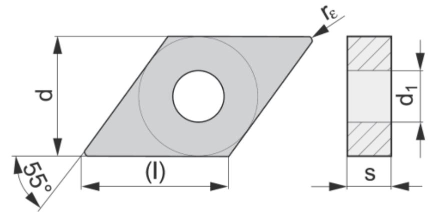
Definition of sample used. Samples of the same shape, size and material (Tab. I, Fig. 1 and Fig. 2) have been used for this experiment.

The size of the sample used is illustrated in Fig. 1. The sample was fixed using a three-jaw chuck. As it was needed to avoid noise generation, it was necessary to support the sample with a headstock, with drilling a centring hole.

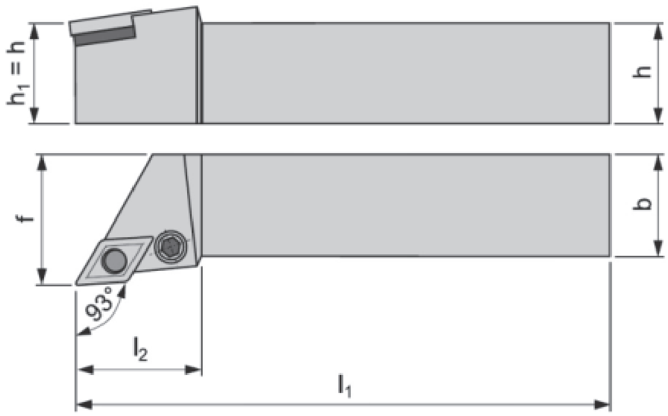
Definition of holder used. The tool holder (Tab. II, Fig. 2) for external turning by the Pramet Tools, s. r. o. company, designated as PDJNR 2525 M15.

Definition of cutting blades used. There were used replaceable cutting blades by Pramet Tools, s. r. o., designated as DNMG 150608.

The size of the cutting blade DNMG 150608 (Fig. 3): l = 15.5 mm, d = 12.7 mm, d_1 = 5.16 mm, s = 6.35 mm, r_ε = 0.8 mm.



3: *Replaceable cutting blade DNMG 150608 size (Pramet Tools, s. r. o., 2012)*



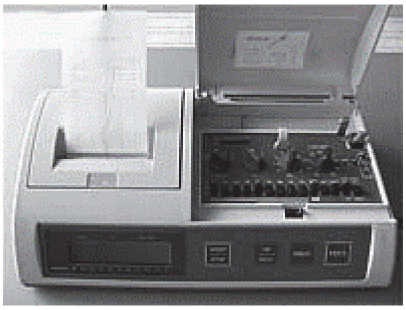
2: *PDJNR knife for external turning (Pramet Tools, s. r. o., 2012)*

II: *Parameters of the holder PDJNR 2525 M15*

$h = h_1$	b	f	l_1	l_{2max}	Rake angle γ_0	Angle of cutting edge λ_s	Weight (kg)
25 mm	25 mm	32 mm	150 mm	40 mm	–6°	–6°	0.68

The following materials of cutting blades have been used in experiments: functionally gradient substrate with a relatively low cobalt content, unique dual coating applied by the combination of MTCVD and PVD methods with a bearing layer of TiCN, with finishing to coarse-grained turning. This material is used for machining the materials of groups P and K and is conditionally applicable also to the M group.

Roughness measurement. The roughness of machined surface was measured using the roughness meter Surftest 301 by Mitutoyo (Kawasaki, Japan) (Fig. 4). We focused on measuring the mean arithmetic deviation of profile R_a, which represents the arithmetic average of absolute values of profile deviations within the range of basic length.



4: *Roughness meter Surftest 301 by Mitutoyo*

RESULTS AND DISCUSSION

Definition of measurements. Surface roughness represents deviations of the actual surface from the nominal surface in the field of surface microgeometry. It is assessed on surface sections, i.e. in the direction of tool motion, or in the direction perpendicular to this motion. In most of machining technologies, transversal roughness is higher than longitudinal; therefore, it is considered as a basis of evaluation (Polák *et al.*, 2014b; Žitňanský *et al.*, 2014b; Polák *et al.*, 2014c). In our experiments, we proceeded according to this method.

Experiment No. 1: Effect of cutting material type on surface roughness R_a. To enable assessing the effect of cutting material on surface roughness reached, it is necessary that compared measured roughness values of these surfaces, which were machined by cutting blades of the same size and geometry, differ in cutting material only. To evaluate the effect of cutting material, we used cutting blades with the same former type and different cutting materials (Tabs. III, IV).

Experiment No. 2: Effect of former type on surface roughness R_a. To assess the effect of former type on surface roughness, we have compared the roughness of surfaces machined with three blades of the same cutting material 6630 and with three different formers of type M, R, and SI (Tab. V).

III: *Comparison of roughness values measured when using replaceable cutting blades with the former of M type*

Cutting blade DNMG 150608		Roughness R_a (µm)		
		Rpm		
Former	**Material**	**710**	**1,400**	**2,240**
M	**6610**	2.33	1.15	1.11
M	**6615**	2.30	1.11	1.04
M	**6630**	2.76	1.07	0.82

IV: *Comparison of roughness values measured when using replaceable cutting blades with the former of R type*

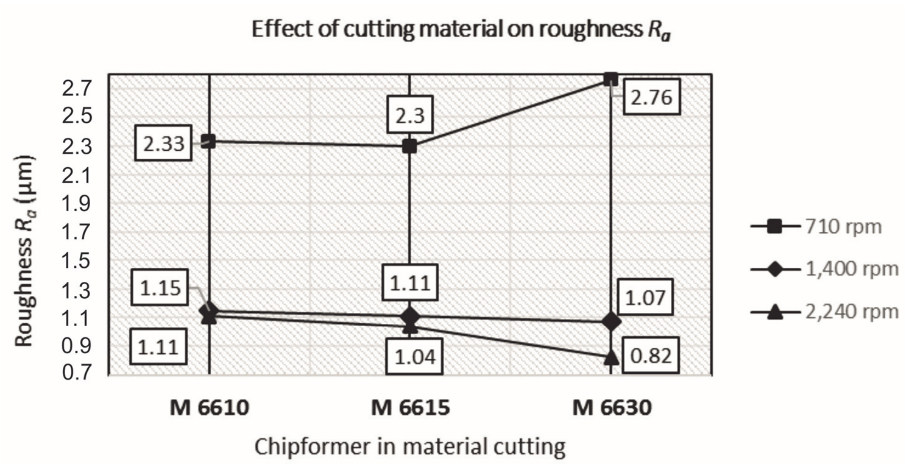
Cutting blade DNMG 150608		Roughness R_a (µm)		
		Rpm		
Former	**Material**	**710**	**1,400**	**2,240**
R	**9230**	2.31	1.41	1.13
R	**6630**	2.42	0.85	0.74
R	**6640**	2.33	1.22	0.79

V: *Comparison of roughness values measured when using replaceable cutting blades of material 6630*

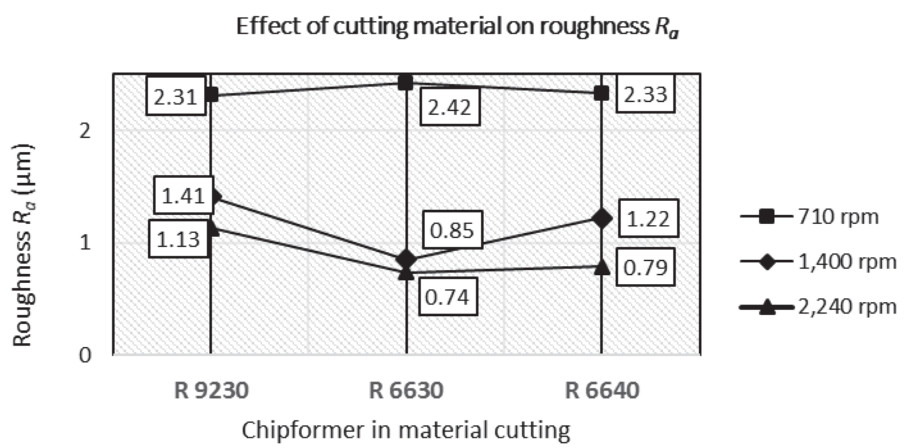
Cutting blade DNMG 150608		Roughness R_a (µm)		
		Rpm		
Former	**Material**	**710**	**1,400**	**2,240**
M	**6630**	2.76	1.07	0.82
R	**6630**	2.42	0.85	0.74
SI	**6630**	2.76	1.07	0.82

VI: *Measured values of roughness R_a*

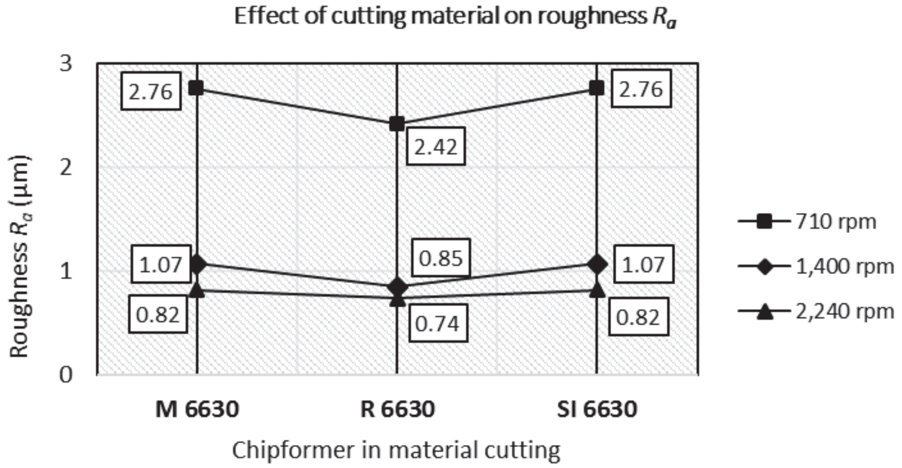
Cutting blade DNMG 150608		Roughness Ra (µm)		
		Rpm		
Former	**Material**	**710**	**1,400**	**2,240**
M	**6610**	2.33	1.15	1.11
M	**6615**	2.30	1.11	1.04
M	**6630**	2.76	1.07	0.82
R	**6630**	2.42	0.85	0.74
R	**6640**	2.33	1.22	0.79
R	**9230**	2.31	1.41	1.13
RM	**9210**	1.69	1.51	0.74
F	**9230**	2.39	2.08	1.83
SI	**6630**	1.79	0.95	0.95



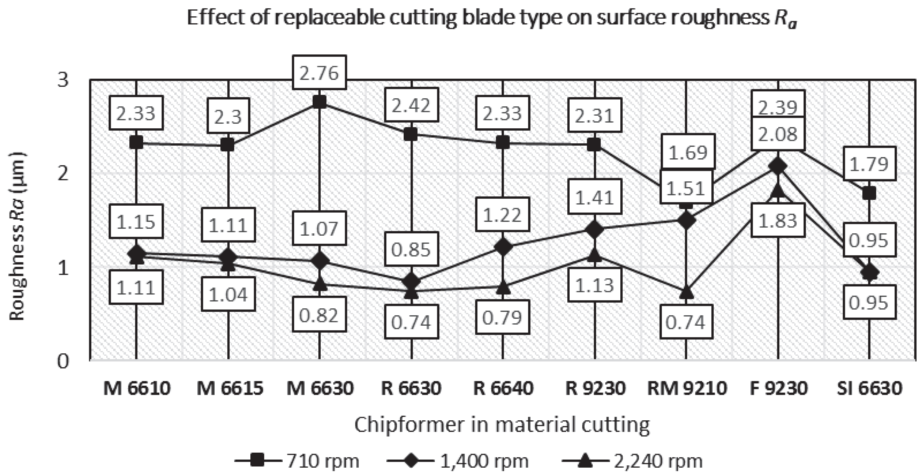
5: *Effect of cutting material on surface roughness R_a when using replaceable cutting blades with the former of M type*
Source: own research



6: *Effect of cutting material on surface roughness R_a when using replaceable cutting blades with the former of R type*
Source: own research



7: *Effect of former type on surface roughness R_a when using replaceable cutting blades of material 6630*
Source: own research



8: *Effect of the type of replaceable cutting blade on surface roughness R_a*
Source: own research

CONCLUSION

Experiments were performed using different types of replaceable cutting blades, made of different material types and different former types. The measured values of individual types of cutting blades are shown in Tab. VI.

The results were obtained in turning the same samples of steel 11 523. In each cutting blade, there were changed three values of spindle speed, i.e. $n_1 = 710$ rpm, $n_2 = 1{,}400$ rpm, and $n_3 = 2{,}240$ rpm, whereby we observed how roughness values will change at individual speeds. Other cutting conditions remained constant, i.e. depth of cut $a_p = 1$ mm and shift f = 0.1/mm. The effect of cutting material and former type on measured quantity was also evaluated.

Based on the results obtained, it is possible to state that the roughness of machined surface generally decreases with increasing speed. When the speed increases from n_1 to n_2, there can be seen a strong decline in roughness. At n_1, the measured values of roughness R_a ranged from 1.69 µm to 2.76 µm. At n_2, roughness R_a ranged from 0.85 µm to 2.08 µm. When speed increased to n_3, roughness decreased only moderately, ranging from 0.74 µm to 1.83 µm.

In some blades, there can be seen clear variations in measured roughness values when speed is changed. In the blade with the former R from material 6630, there was measured the lowest roughness at the speed n_2 and n_3; however, this blade provided the second highest roughness at the speed n_1. The blade with the former RM from material 9210 provided the lowest roughness at the speed n_1, the second lowest roughness at the speed n_3; however, the second highest roughness was observed at the speed n_2. The blade with the former F from material 9230 reached the highest roughness at the speed n_2 and n_3 and the third highest roughness at the speed n_1.

When comparing the blades with the same former, there were moderate differences in measured values; therefore, it can be stated that cutting material has an effect on surface roughness. When comparing the blades of the same material with different formers, the greatest differences can be seen at the speed n_1; at the speed n_2 and n_3, differences in measured roughness are significantly lower. Based on this fact, it may be stated that also former type has an effect on the resultant surface roughness of machined material.

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Contact information

Pavel Polák: pavel.polak@uniag.sk
Ján Žitňanský: jan.zitnansky@uniag.sk
Petr Dostál: petr.dostal@mendelu.cz
Katarína Kollárová: acta.tf@gmail.com