THE INFLUENCE OF MICROGEOMETRY OF CUTTING TOOL ON DYNAMIC LOAD OF SYSTEM

Tomáš ZLÁMAL, Jana PETRŮ, Šárka MALOTOVÁ, Robert ČEP, Jiří HAJNYŠ

VŠB - Technical University of Ostrava, Ostrava, Czech Republic, EU
tomas.zlamal@vsb.cz, jana.petru@vsb.cz, sarka.malotova@vsb.cz, robert.cep@vsb.cz, jiri.hajnys@vsb.cz

Abstract

The contribution deals with the determination of the influence of the microgeometry of the cutting tool on the progress and size of the dynamic load of the system in the machining process. The experimental part was realized in conditions of longitudinal turning of aluminum alloy EN AW 2014. For machining alloys were suggested replaceable cutting inserts with pre-set microgeometry edge with mark CCGT 120408-AL and cutting conditions. By means of the mechanical adjustment of the microgeometry of brushing, the rounded edge was achieved for radius 0-5 µm, 10-15 µm and 20-25 µm for tested inserts. During the experimental activity of machining aluminum alloy, the dynamic load of the system was measured and evaluating for the effect of the individual parts of the cutting forces using the stationary piezoelectric dynamometer Kistler. The resulting cutting force was determined with respect to the radius of the rounded edge and the value of the feed of the cutting tool.

Keywords: Aluminum alloy, turning, cutting edge, cutting forces, microgeometry

1. INTRODUCTION

The producers of cutting tools still contend with the issue of microgeometry of cutting edge. During machining process cutting tool and its cutting part are exhibited strong mechanic and thermal loading. Choice of suitable microgeometry of cutting tool it is possible to achieve decrease of the wear of cutting edge and thereby increase of durability of cutting tool. The cutting edge before the adjustment contents many defaults, such as microcracks, burrs, fragments and overpacks. With the use technologies, e.g. grinding, brushing or tow wearing is achieved required of the shape and edge radius. It is a process of the transformation of geometry of cutting edge into shrinked or rounded shape, which is characterized by parameters S_a, S_γ, which describe the sharp or obtuse run of the contour to the rake or flank face respectively. Then symmetry factor K, which define to describe of the contour generated by the cutting edge rounding process. And last, edge radius r_n define size of rounded cutting edge after cutting preparation. They are described in publication of the authors Denkena, B. et al. [1]. Resulting edge radius is dependent on the machined material, choice of cutting material and cutting conditions. The microgeometry of cutting tool eliminate the defects caused during machining process and has the positive influence on size of cutting forces, distribution of the heat, chip forming residual stress into surface and subsurface layers and on the stability of the whole process [2,3,4].

2. THE INFLUENCE OF MICROGEOMETRY AND GEOMETRY OF CUTTING EDGE ON THE DYNAMIC LOAD OF SYSTEM DURING TURNING

In machining material, there is created tenseness caused by the cutting wedge, when is getting into the workpiece. In this moment it comes about plastic and then elastic deformation and demonstration of force relations. The ratio of cutting forces is given especially by selected technology and geometry of cutting tool. The main cutting force F_c has usually the highest significance [5,6].

The geometric parameters of the cutting edge have a great influence on the cutting forces. For machining forces, the limiting effect is primarily the rake angle. This angle has a higher influence on passive and feed force. These cutting forces will increase with increasing rake angle. Finally, the angle of cutting edge and the edge radius of the cutting edge affect the size and distribution of cutting forces. The increasing feed force F_f and the decreasing passive force F_p with increasing angle κ_r are determined by the rotation of their resultant F_{fp}. The positive geometry of the cutting tool in combination with the straight face ensures lower cutting forces and heat generation and generally better chip forming. The disadvantage of this geometry is its lower strength. The cutting forces are shown in **Figure 1**. [6]

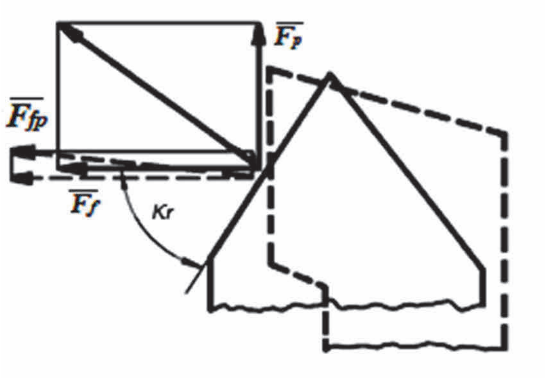


Figure 1 The influence of angle κ_r on distribution of cutting forces [6]

From the point of microgeometry view of cutting tool, there are sharp-edge, rounded and chamfered edge. The shape radius edge provides low cutting forces, decrease danger of creation of build-up edge. Despite, the machining process could be unstable, and the cutting edge can be damage and durability of cutting tool is shorter [7,8].

3. EXPERIMENTAL ACTIVITY

Experimental activity deals with turning of aluminum alloy marked EN AW-2014. Exchangeable cutting inserts marked CCGT 120408-AL, which are shown in **Figure 2,** and they were chosen for machining aluminum alloy. These inserts have positive geometry suitable for machining of non-ferrous materials. [9] The geometry of cutting inserts was repaired by mechanical method uses nylon cylindrical brushes with a circular cross-section of fibres to modify the tool edge. Osborn brushes with a SiC abrasive (120µm grain size) were used for rounding the cutting edge with this method. By cutting edge preparation were obtained cutting edge radius in range 0-5 µm, 10-15 µm and 20-25 µm.

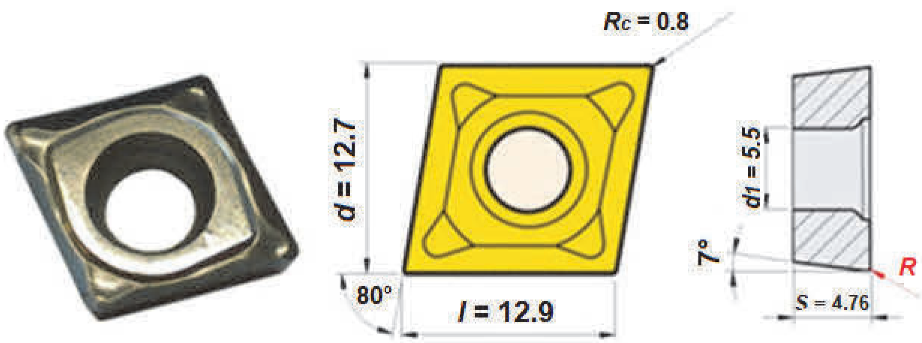
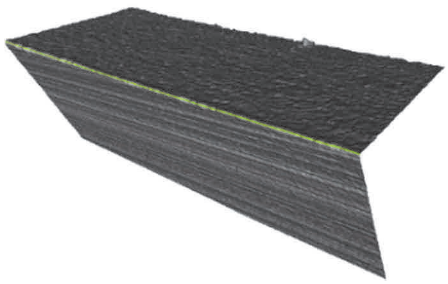
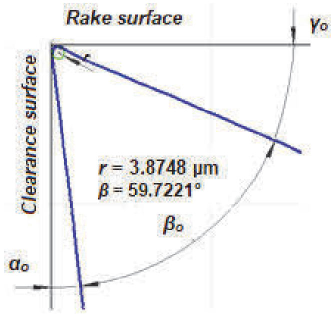
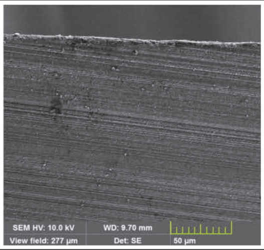
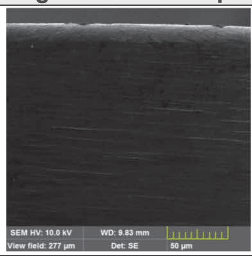
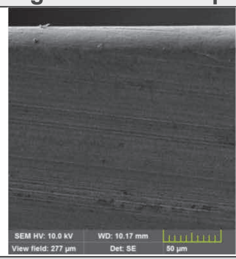


Figure 2 Use cutting insert CCGT 120408-AL [10]

The cutting edge radius 0-5 µm is considered as a very sharp cutting edge, which avoids creation of build-up edge and decrease of size of cutting forces. Disadvantage of this cutting edge is relatively low strength and chipping while machining. The optical microscope Alicona Infinite Focus G5 was used for getting information about cutting tools geometry, roughness of surface and factor *K* of symmetry. Additionally the magnified images of cutting tool edge were taken by EDX microscopy. The real measured values of cutting edge are shown in **Table 1.**

Table 1 Used cutting edge

					
Edge radius 0-5 µm		**Edge radius 10-15 µm**		**Edge radius 20-25 µm**	
					
r_n = 3.6 µm		r_n = 13.8 µm		r_n = 23.1 µm	
α_o = 7.02°	K = 0.65	α_o = 6.98°	K = 1.20	α_o = 6.94°	K = 1.31
β_o = 59.72°	R_a = 0.73 µm	β_o = 61.36°	R_a = 0.17 µm	β_o = 59.99°	R_a = 0.28 µm
γ_o = 23.25°	R_z = 3.66 µm	γ_o = 21.65°	R_z = 1.06 µm	γ_o = 23.06°	R_z = 1.01 µm

Cutting parameters were determined for safety machining non-ferrous materials and their alloys. The turning of aluminum alloy was realized in constant cutting velocity v_c = 1000 m·min^{-1} and depth of cut a_p = 2 mm. Variable parameter was value of feed f, which was selected 0.2 mm and 0.4 mm. The dynamometer KISTLER 919AA was used for determination of the influence of microgeometry of cutting tools on dynamic load machine system. The value of cutting force can change during machining therefore the measured results were statistically evaluated.

4. EVALUATION OF THE RESULTS

In **Figure 3**, there are shown the results of cutting forces for different cutting edge radius and for the both feeds. The measuring of cutting forces was in interval where the start and end of the machining were not considered.

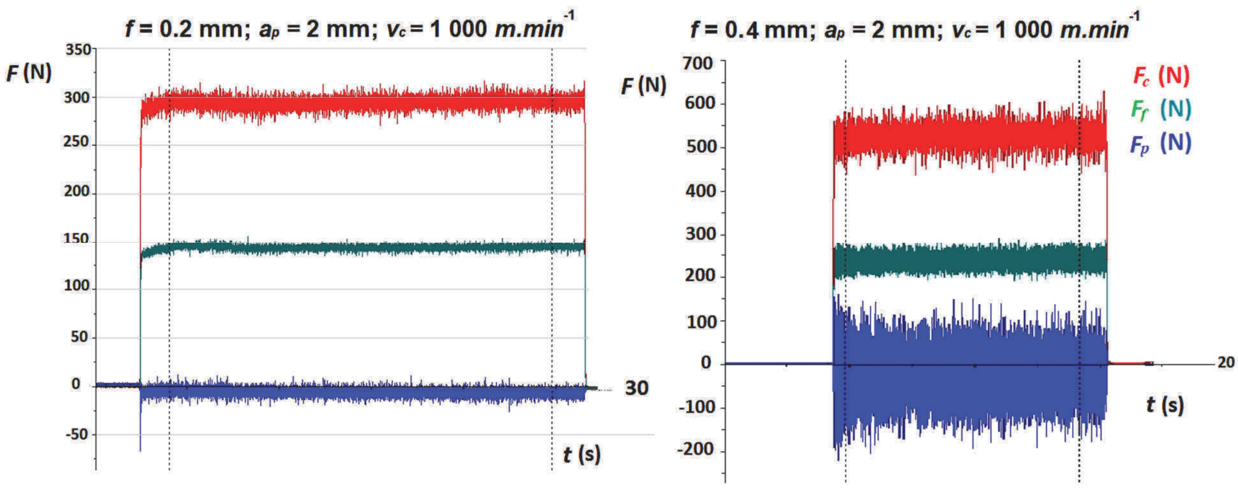


Figure 3 Records of cutting forces for the both feeds

Ten values were selected from the interval where the process was stable and there was minimum deviation. In **Figure 4**, it can be seen that with the increasing edge radius of cutting tool, size of cutting forces increase considerably. Even though the size of edge radius differs in tens of micrometres, the resulting values between forces reached a difference of up to 40 N.

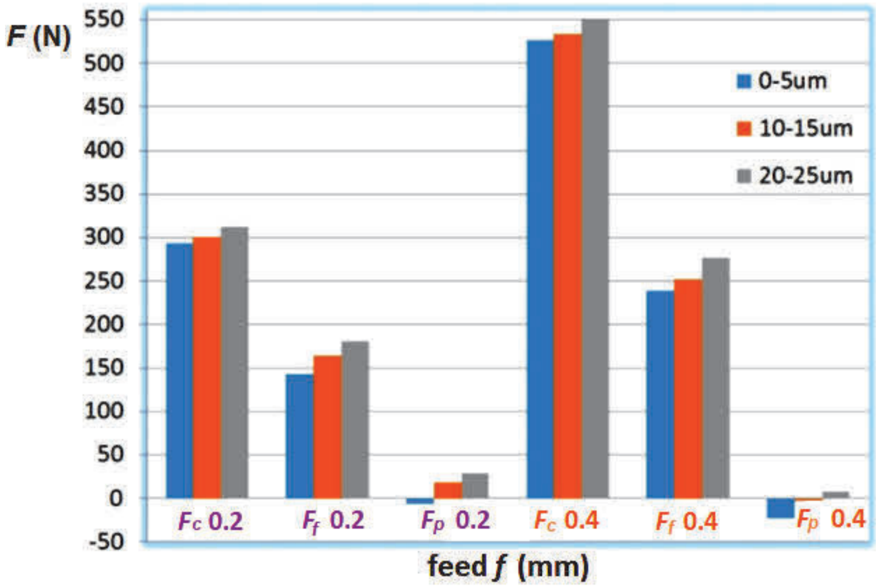


Figure 4 The comparison of feed rates with different edge radius

The same statement was confirmed for the second case. From the statistically processed values of the cutting forces, it can be seen that the double value of the feed of cutting tool has a significant influence on the cutting forces with regards to edge radius of cutting edge. The main cutting force F_c and feed force F_f achieved twofold values in comparison with lower feed 0.2 mm. The passive force F_p hadn't such influence on machining. During machining by cutting tool with the sharp edge the passive force was measured negative. It was influence by angle κ_r (95°). The vibration amplitude for passive force was measured during machining with higher feed.

The size of edge radius of cutting edge has the influence on chip forming tool, as see in **Figure 5.** In condition of sharp radius edge, the chip was curled coiled small radius and it was not winded up on cutting tool. The cutting tool with the biggest edge radius formed continuous chip, which was winded up on cutting tool. The chip forming was accompanied by dynamic process.

Figure 5 Chip forming r_n = 0-5 μm and r_n = 20-25 μm

5. CONCLUSION

Experimental activity focused on the influence of microgeometry of cutting tool during machining of aluminum alloy EN AW-2014 with regards on dynamic load of system. The exchangeable cutting inserts marked CCGT 120408-AL are suitable for machining of non-ferrous materials and their alloys. The sharp geometry is recommended for machining of aluminum alloys due to avoid of creation of build-up edge and decrease of wear of the cutting tool. The sharp edge ensures low cutting forces. The cutting edges of the inserts were modified by mechanical method brushing to value of radius edge 0-5; 10-15 and 20-25 μm.

For safe turning were proposed cutting parameters. The inserts were tested in constant cutting velocity and depth of cut. The variable parameter was feed of cutting tool. Stationary dynamometer KISTLER was clamped on cutting tool throughout of machining. The evaluated parameters were main cutting force F_c, feed force F_f, passive force F_p and force F.

The results from measurement confirmed that the sharp edge radius 0-5 μm ensures low cutting forces. Especially, for the main cutting force F_c and feed force F_f, the differences were about 40 N for different edge radius. The passive force F_p that causes the bend of the workpiece, it achieved small negative values. It was caused by combination of angle κ_r, sharp geometry with big rake angle and present of the bevel. The sharp cutting edge will have the positive influence on strengthening or else residual stress for materials, which are susceptible to deformation strengthening, e.g. nickel alloys or stainless steel. Due to higher value of the feed (feed rate of cutting tool) was caused twofold increase of cutting forces, especially main cutting force and feed force.

Suitably chosen geometry and microgeometry of cutting tool with combination of cutting parameters and machined material has significant positive influence on whole process machining. It is supported correct chip forming, size of cutting forces, increase of durability of cutting tools, quality of machined surface etc. Preparing of microgeometry of cutting tool has irreplaceable place in the field of machining.

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