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VIBRATION IN GRINDING OPERATIONS

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Abstract: *This paper deals with vibration in grinding through analyse of grinding forces. There is presented analyse of self-excited vibration. There is a formation of waviness on the surface of grinding wheel and this waviness influences waviness on the ground surface. Process of the wheel wear, cutting conditions and the type of grinder strongly affect character of self-excited vibration.*

Keywords: *grinding, vibration, waviness, cutting force*

1. INTRODUCTION

Vibration during machining is obviously vibration of low intensity and so there is no negative influence on the cutting process. On the other hand, vibration of high intensity could negatively affect some aspects of cutting process:

- formation of waviness on the machined surface and low precision of machined parts, sometimes high surface roughness,
- more intensive process of tool wear,
- negatively affects the machine life and intensive sound.

There are 2 types of vibration in grinding operations: forced and self – excited. Eccentricity and non – alignment of grinding wheel are the main reason for generation of forced vibration. Regenerative effect takes responsibility for formation of self – excited vibration. Rotary movement of grinding wheel and workpiece generates the waviness on the surface of grinding wheel and so influences formation of waviness on the ground surface [1, 2]. This kind of vibration is given by high dynamic stiffness of grinding wheel. Waviness formation must be related to grinding grain wear and increasing of grinding forces. Because of these aspects grinding process becomes unstable. Amplitude of critical frequency (frequency of self – excited vibration) is increasing and grinding wheel should be dressed.

Self - excited vibration are affected by cutting conditions, properties of grinding wheel and the next aspects [3].

This study analyse influence of cutting conditions on intensity of self – excited vibration and surface quality represented by its waviness through the measurement of grinding forces.

2. EXPERIMENTS

Experiments were carried out under the following conditions: machined material – 100Cr6 (100x85x10 mm), a_p = 0,01 to 0,04 mm, v_f = 8 m.min^{-1}, v_c = 27 m.s^{-1}, Emulzín H (2% concentration), grinding wheel Al_2O_3 (250×20×76 38A 60 JVS), surface plunge grinding, grinding machine – BPH 20. Measurement of grinding forces was carried out by dynamometer KISTLER. Signals of grinding forces were recorded after each $\boldsymbol{V_0}$ = 30 mm^3 per 1 mm grinding wheel width. Fig. 1 and 2 represent the record of grinding forces for $\boldsymbol{V_0}$ = 30 mm^3 and $\boldsymbol{V_0}$ = 1500 mm^3. This signal were analysed from the point of view of static and dynamic component of grinding force. Fig. 3 illustrates relation of grinding wheel wear and static component of grinding force F_c and F_p**.** There is visible that static component is increasing with $\boldsymbol{V_0}$ after dressing up to the $\boldsymbol{V_0}$ = 1000 mm^3 because of increasing grinding grain wear. Static components of grinding forces do not change after this point, because grinding grains are worn and their shape does not change. On the other hand, RMS values (effective value - „Root Mean Square“) of dynamic components do not change significantly after dressing up to $\boldsymbol{V_0}$ = 1000 mm^3, and there is a strong rise from this point (fig. 4). This characteristic process is visible under the different cutting condition. There is only one difference. It is the critical value of V_o. Grinding wheel should be redressed after the critical value, because grinding process becomes unstable. Fig. 5 illustrates that increasing cutting depth leads to shorter dressing intervals because of more intensive grinding grain wear given by higher mechanical and thermal load of grinding grain.

Fig. 5 illustrates that there can visible the decreasing period of RMS values of dynamic components and static components under the higher cutting depths. This should be related to breakage of grinding grains and initialisation of new grinding grains on the grinding wheel surface.

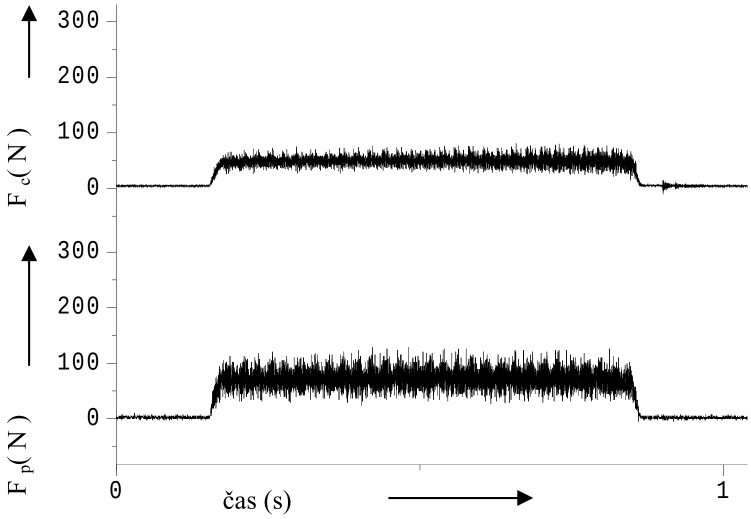


Fig.1 *Record of grinding forces F_c and F_p for V_o = 30 mm^3, a_p = 0,02 mm*

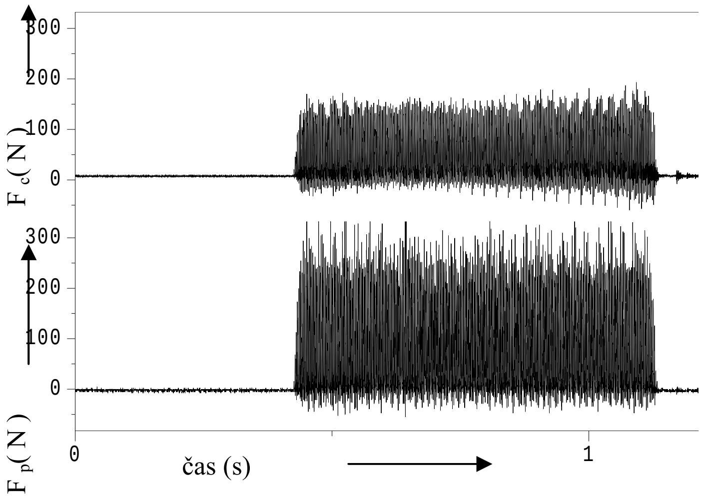


Fig.2 *Record of grinding forces F_c and F_p for V_o = 1500 mm^3, a_p = 0,02 mm*

The higher mentioned records were analysed through the FFT analyse. These analyse and character of the signal show that there is generation of waviness on the grinding wheel surface. This waviness can be located and identified through the FFT spectrums (on the fig. 6 and 7). There is no visible waviness of the grinding wheel after dressing because there is no significant amplitude if high frequency. On the other hand, there is increasing amplitude 75 N of frequency 502 Hz for V_o = 750 mm^3 because of waviness on the grinding wheel surface (fig.6). This frequency is given by revolution per second of grinding wheel (42) and number of waves generated on the grinding wheel surface (12).

This state of grinding wheel waviness must not be stable. The next process of grinding wheel wear can lead to transformation of this form – obviously decreasing of number of waves on the grinding wheel surface. This can be visible on the frequency spectrums (for example Fig. 7). Fig.7 illustrates that there is significant amplitude of lower frequency 462 Hz because of transformation 12 waves to 11 waves on the grinding wheel surface. This transformation could lead to the next decreasing of characteristic frequency and the decreasing of number of waves on the grinding wheel surface.

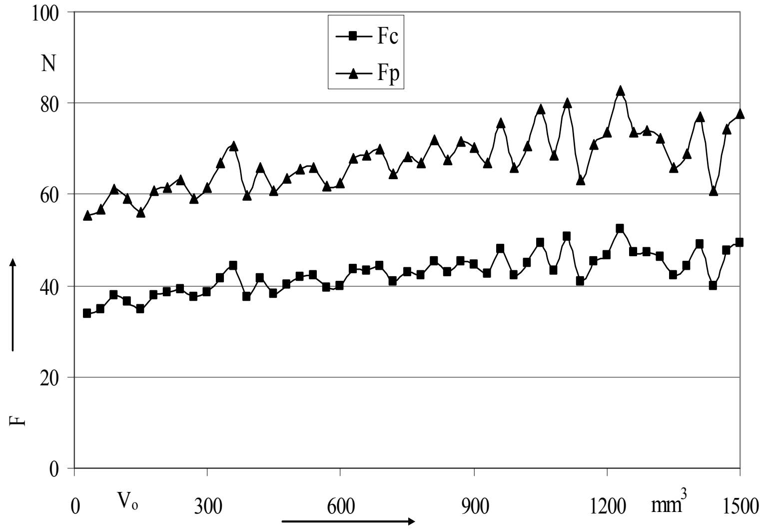


Fig.3 *Influence of grinding wheel wear on the static values F_c and F_p, a_p = 0,02 mm*

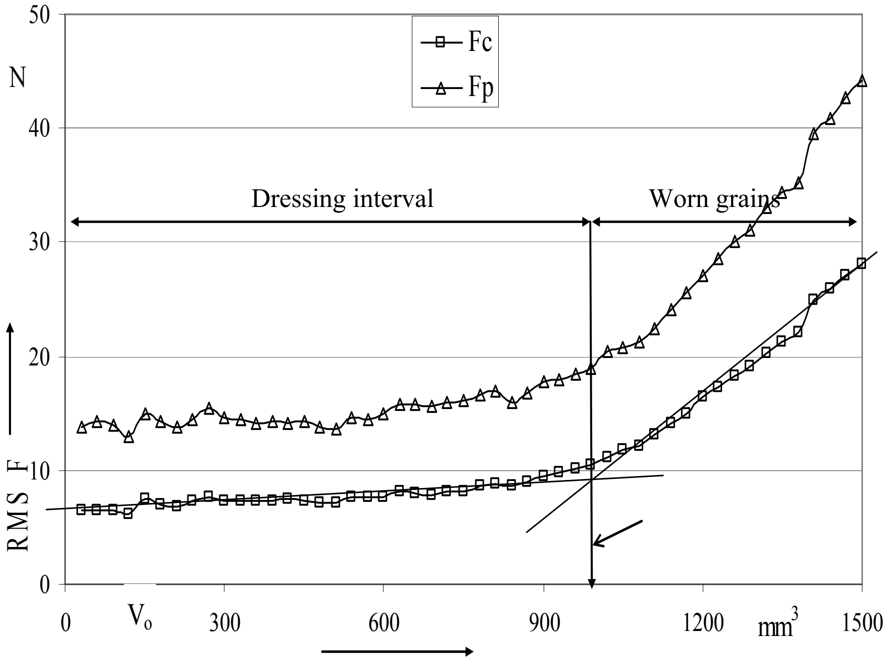


Fig.4 *Influence of grinding wheel wear on RMS values of F_c and F_p, a_p = 0,02 mm*

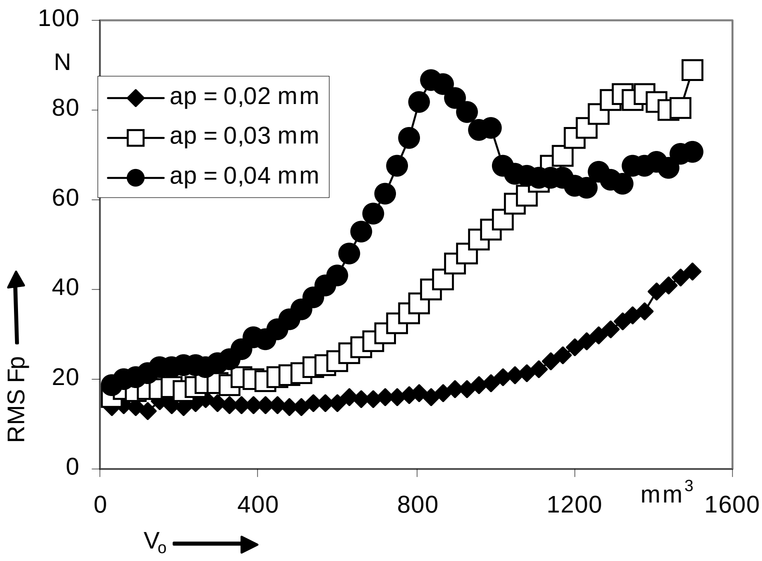
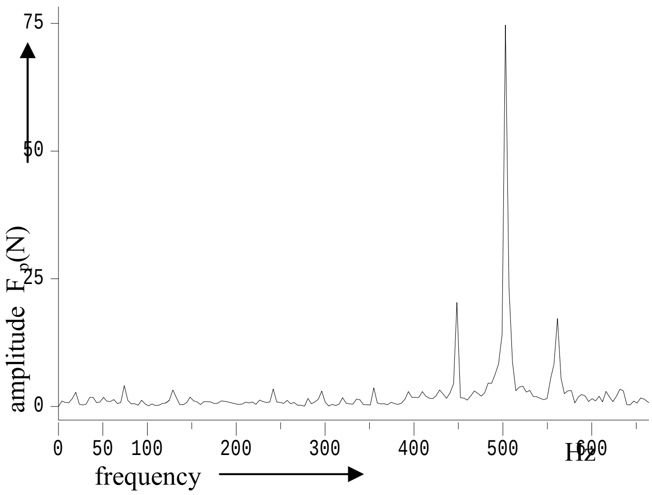
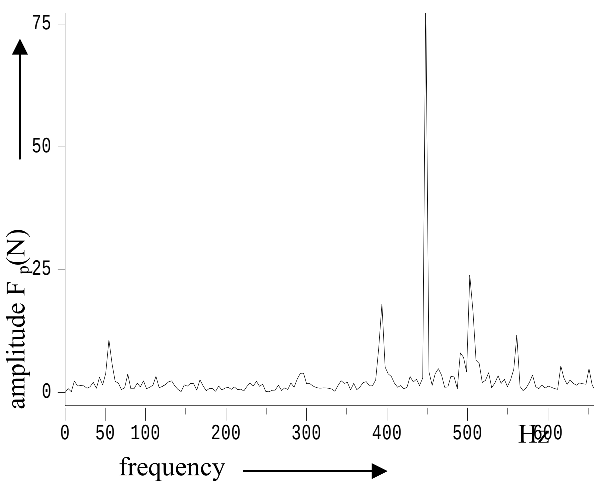


Fig.5 *Influence of grinding wheel wear on RMS values of F_p*



Obr.6 *Frequency spectrum for F_p, V_o = 750 mm, a_p = 0,02mm*



Obr.7 *Frequency spectrum for F_p, V_o = 1500 mm, a_p = 0,02mm*

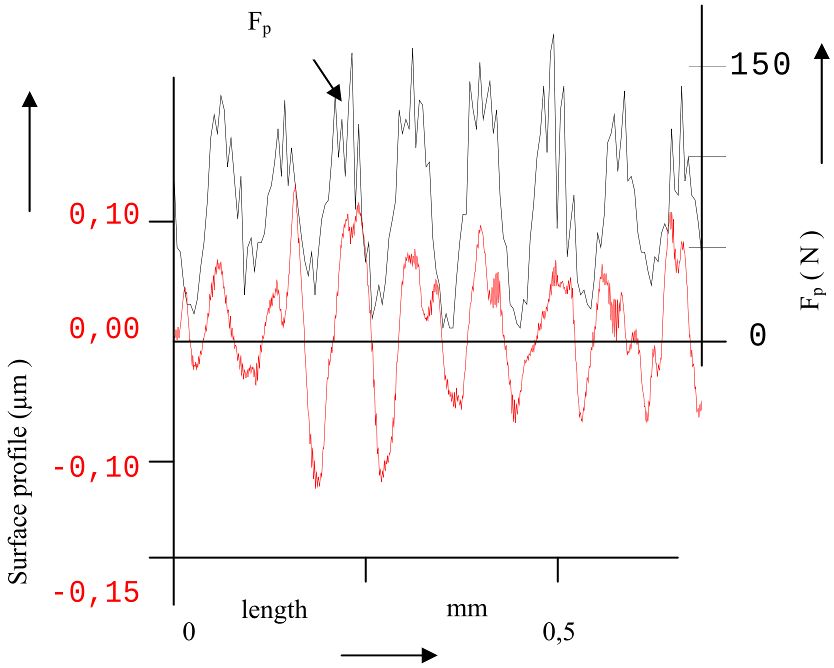


Fig.8 *Correlation of ground surface and course of* F_p*,* a_p *= 0,02mm*

3. CONCLUSION

Fig.8 illustrates that waviness of grinding wheel influences generation of waviness on the ground surface. The next, there is visible the phase shift between waviness on the grinding wheel surface and waviness on the ground surface. This is given by self – excited vibration in the tangential direction, because of the rotary movement of the grinding wheel. The frequency of the self – excited vibration should be high from the point of view of amplitude. Increasing of frequency leads to decreasing of amplitude vibration.

These results enable to set up strategy of dressing of grinding wheels (dressing intervals). The next, these experiments and analyse of recorded signals could be a suitable technique for identification of grinding wheel cutting abilities.

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