

ROUGHNESS OF MACHINED SURFACE OF HARDENED STEEL AFTER MICRO END MILLING

М. РУБИЦКІ

ШОРСТКІСТЬ ОБРОБЛЕНОЇ ПОВЕРХНІ ЗАГАРТОВАНОЇ СТАЛІ ПІСЛЯ КІНЦЕВОГО ФРЕЗЕРУВАННЯ

Робота присвячена шорсткості обробленої поверхні після циліндричного фрезерування з різними параметрами зрізання f_z і a_e . Дійсні висоти мікронерівності порівняли з розрахованими теоретично. Це дозволило виявити дійсні причини максимальних розбіжностей дійсних і розрахованих параметрів шорсткості.

Работа посвящена шероховатости обработанной поверхности после цилиндрического фрезерования с разными параметрами срезания f_z и a_e . Действительные высоты микронеровности сравнили с рассчитанными теоретически. Это позволило выявить действительные причины максимальных расхождений действительных и рассчитанных параметров шероховатости.

Work is devoted to a roughness of the processed surface after cylindrical milling with different parameters of cutting f_c and a_e . The valid heights of microroughness have compared with calculated theoretically. It has allowed to reveal the valid reasons of the maximal divergences of the valid and calculated parameters of a roughness.

1. INTRODUCTION

As it is known one of the most important factors influencing the roughness of the machined surface is feed f_z (geometric-kinematic mapping of the teeth in the work material). The increase in feed per tooth f_z leads to increased roughness of machined surface, which has been confirmed in many publications, both in relation to milling in conventional terms or in HSM terms [1,5-8]. Feed per tooth f_z , cutting speed v_c and axial depth of cut a_p and the radial depth of cut a_e , are the most common factors taken into account when developing forecasting models. However, theoretical models describing the changes in surface roughness parameters as a function of the geometric-kinematic parameters often differ significantly from the actual surface roughness, especially for small values of feed [6,7].

2. RANGE, CONDITIONS AND TECHNIQUE OF RESEARCH

The study was conducted during the up and down dry milling of samples made of hardened steel 55NiCrMoV (52 HRC) under the conditions presented in Tab. 1. Milling took place on the milling machine FND32F made of AVIA at maximum possible speed of the spindle n . Axial depth of cut a_p was chosen so as to be a complete multiple of axial pitch of the mill.

Feedrate f_z was changed in the range of 0,01-0,08 mm/tooth with a higher concentration in the small values of feeds.

Milling width a_e was varied smoothly from 0 to 2,5mm. In the range there was the certainty that the average normal feed force $F_{JN\dot{s}r}$ acting perpendicular to the

are much larger for the conditions assumed in studies of the parameter a_e impact on roughness (fig. 4).

Simultaneously, it can be seen that during up and down milling similar roughness height are obtained. This is contrary to some literature dates [8], according to which the down milling provides about 6,5 times lower roughness parameter Ra .

Significant differences in the height of roughness for these milling types occur only at the feed $f_z \geq 0,07 \text{ mm/tooth}$ (fig. 2,3). For the feed differences in cycloid tracks of the tooth in up and down milling should be taken into account [7]. These differences are taken into account by for example formula (1) [4,5], where the plus sign is inserted for up milling, while minus sign for down milling.

$$R_{z_{10}} = \frac{f_z}{8\left(\frac{D}{2} \pm \frac{f_z z}{\pi}\right)} \quad (1)$$

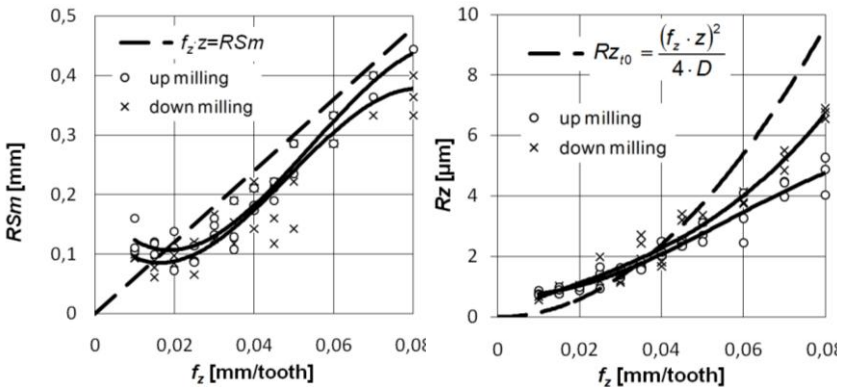


Figure 2 – Influence of feedrate f_z on parameters R_z and R_{Sm} during down and up end milling

At very low feed rates (corresponding to the thickness of cut less than the minimum one) disturbance of the tooth's mapping in the work material can be seen, due to cyclic movement of the tooth (fig. 2 for $f_z=0.01 \text{ mm/tooth}$). This phenomenon is also observed by other cutting methods such as face milling.

Figure 4 shows that in up milling for $a_e \approx 2 \text{ mm}$ mean value of normal feed force $F_{fN_{sr}}$ changing sense. Around the mean value changes value and sense instantaneous force F_{fN} [1-3].

In the vicinity of the width for up milling is a sharp increase in the amount of machined surface roughness, and about two times reduction in the roughness interval (fig. 4,5). The increase in roughness is probably caused by vibration in a direction perpendicular to the machined surface.

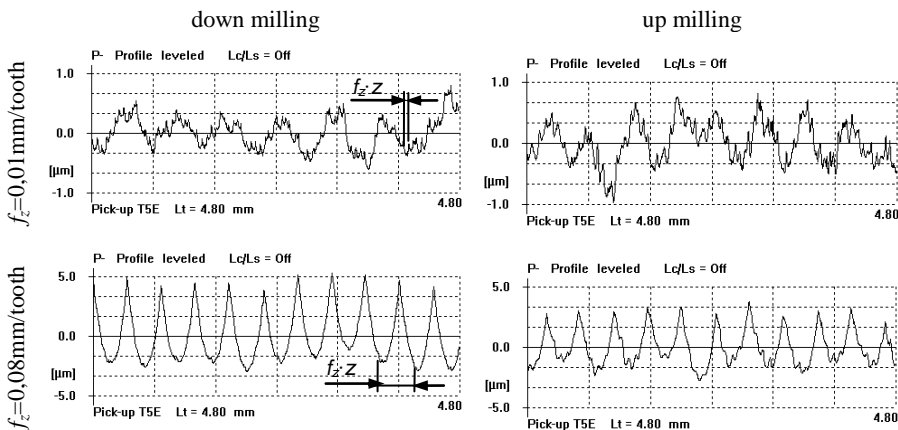


Figure 3 – Primary profiles obtained after down and up end milling with various feedrates f_z

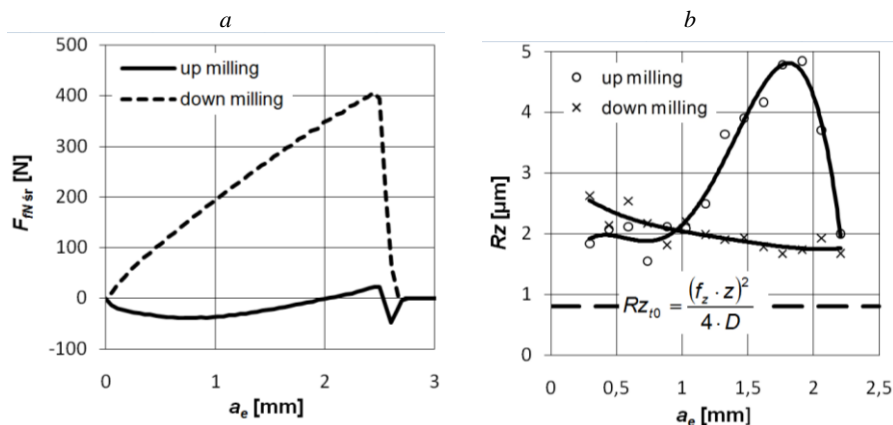


Figure 4 – Influence of milling width a_e on mean value of normal feed force $F_{fm\ sr}$ a) and roughness parameter Rz b) during down and up end milling

4. CONCLUSIONS

Calculation of surface roughness in end milling is a very difficult task. Frequently in the calculation of the theoretical surface roughness is assumed that the cutter diameter maps per revolution of the mill. Such mapping is the result of radial run the cutter tooth. Calculation of the theoretical roughness in this way includes large errors, which further increase when:

- feed f_z is very large and it cannot be assumed that in the work material is mapping diameter of the mill but epicycloids of different shape for up and down milling;

- feed f_z is very small, and disturbance of theoretical mapping occurs, due to cyclic movement of the tooth relative to the machined surface;
- up milling with width a_e , at which the mean normal feed force $F_{fN} \dot{s}_r \approx 0$, and there are changes in the value and sense of the instantaneous force F_{fN} .

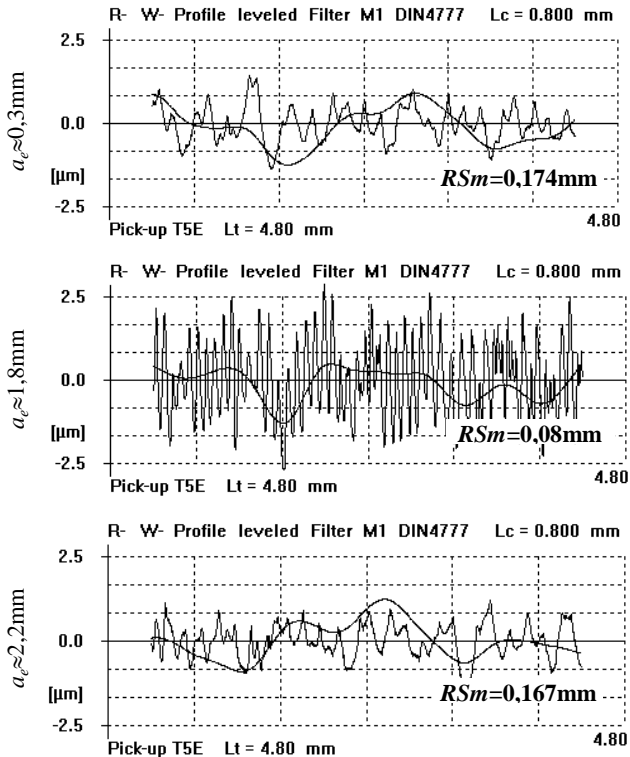


Figure 5 – Roughness R- and waviness W- profiles obtained after up end milling with various milling widths a_e

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