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***M. RYBICKI***, PhD. Eng.,
***M. KAWALEC***, Prof. DSc. Eng., Poznań, Poland

# FORM ERRORS AND TOPOGRAPHY AFTER FACE MILLING WITH VARIOUS MACHINING PARAMETERS

*М. РУБІЦКІ, М. КАВАЛЕЦЬ*
*ПОХИБКИ ФОРМИ І ТОПОГРАФІЯ ПІСЛЯ ФРЕЗЕРУВАННЯ З РІЗНИМИ ПАРАМЕТРАМИ МЕХАНІЧНОЇ ОБРОБКИ*
У роботі представлена оцінка впливу умов різання на шорсткість поверхні обробленої під час торцевого фрезерування загартованої сталі. Як змінні умови прийняли головним чином глибину обробки, подачу й число лез торцевої фрези. Підтверджено, що фрезерування з більшою глибиною обробки, подачею й числом ріжучих лез приводить до більших погрішностей форми обробленої поверхні. Знаходження однорідних оброблювальних слідів двоспямованих не обов'язково має свідчити про більшу площину обробленої поверхні чим в односпрямованих слідів.

В работе представлена оценка влияния условий резания на шероховатость поверхности обработанной во время торцевого фрезерования закаленной стали. В качестве переменных условий приняли главным образом глубину обработки, подачу и число лезвий торцевой фрезы. Подтверждено, что фрезерование с большей глубиной обработки, подачей и числом режущих лезвий приводит к большим погрешностям формы обработанной поверхности. Нахождение однородных обработочных следов двунаправленных не обязательно должно свидетельствовать о большей плоскости обработанной поверхности чем у однонаправленных следов.

In work the estimation of influence of conditions of cutting on a roughness of a surface of the tempered steel processed during face milling is presented. As variable conditions have accepted mainly depth of processing, submission and quantity edges of a face mill. It is confirmed, that milling with greater depth of processing, submission and quantity cutting edges leads to greater errors of the form of the processed surface. The finding homogeneous traces bidirectional not necessarily should testify to a greater plane of the processed surface than at the unidirectional traces.

## 1. INTRODUCTION

Accurate machining of hardened steel, especially turning and milling [1, 4-7], is treated recently as finish operation replacing grinding. Therefore machined surface accuracy, determined by roughness or dimensional tolerances of workpiece, has a great importance in the processes. Many results of research [2, 3, 5-7] indicate that during face milling high flatness error can be expected. The error consist of deviation $STRt_w$ and $STRt_p$ in logitudinal and transverse section respectively.

## 2. RANGE, CONDITIONS AND TECHNIQUE OF RESEARCH

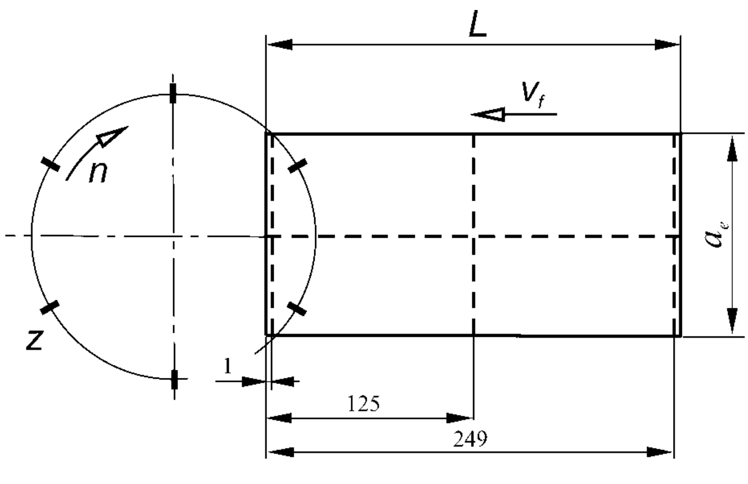
Research have been carried out on the FND32F milling machine made of AVIA. As workpiece was used slab made of the 55NiCrMoV (52±1HRC) steel with dimensions $L \times a_e$ = 250×75,3mm. Surface of the slab was milled by one, two and six wedges fixed to face mill 4.01006R323 (made of Kennametal) and diameter $D$=87 mm. For milling round wedges RNGN 120700 T01020 made of mixed ceramics, grade KY1615 (made of Kennametal) were used.

Table 1 – Range of research

| No. | $a_p$ [mm] | $f_z$ [mm/tooth] ($v_f$ [mm/min]) | n [rev/min] ($v_c$ [m/min]) | $z$ ($z_c$) |
|---|---|---|---|---|
| 1 | 0,05 | 0,15 (168) | 1120 (306) | 1 (0,33) |
| 2 | 0,20 | | | |
| 3 | | 0,15 (504) | | 3 (1) |
| 4 | 0,50 | 0,15 (639) | 710 (194) | 6 (2) |
| 5 | | 0,08 (341) | | |

Machining conditions is presented in tab. 1. In passes done by the face mill with six wedges rotational speed was decreased due to power of machine tool. In each of conditions 1-5 three passes were done, after which machined surface profiles have been registered.

For recording of machined surface profiles incremental length gauge MT12B with resolution 0,0005 mm and ball-shaped contact tip was used. Values $STRt_w$ and $STRt_p$ of deviations were given as a distance between maximal and minimal position of approximated profiles points measured relative to movement path of the gauge. The profiles recording was done in section presented in fig. 1 Scatter of measured quantities $STRt_w$ and $STRt_p$ was characterized in figures as a maximum range.




– – places of the profiles recording

Figure 1 – Recording places of profiles in longitudinal and transverse sections

3. RESULTS AND ANALYSIS OF RESEARCH

From figures 2 and 3 follows that both deviations $STRt_w$ in longitudinal sections and $STRt_p$ in transverse sections increases with increasing of the mill load (rise of the $a_p$, $f_z$ and $z_c$).

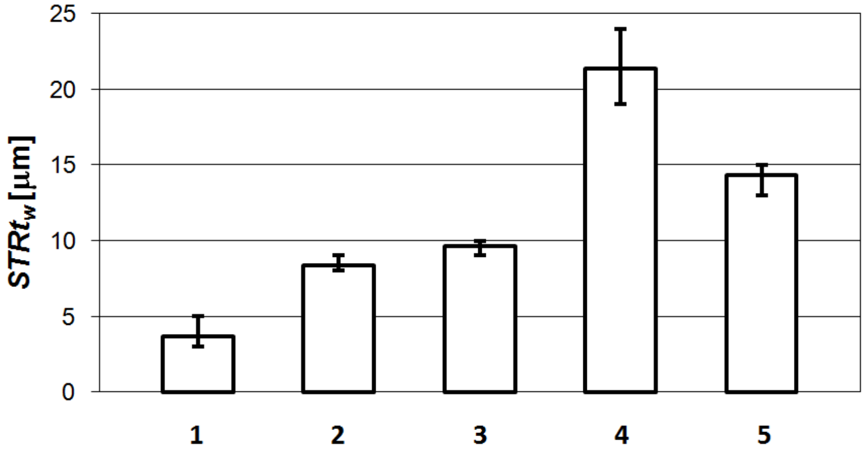



Figure 2 – Influence of face milling conditions (1-5 according to tab. 1) on deviation $STRt_w$ in middle longitudinal section

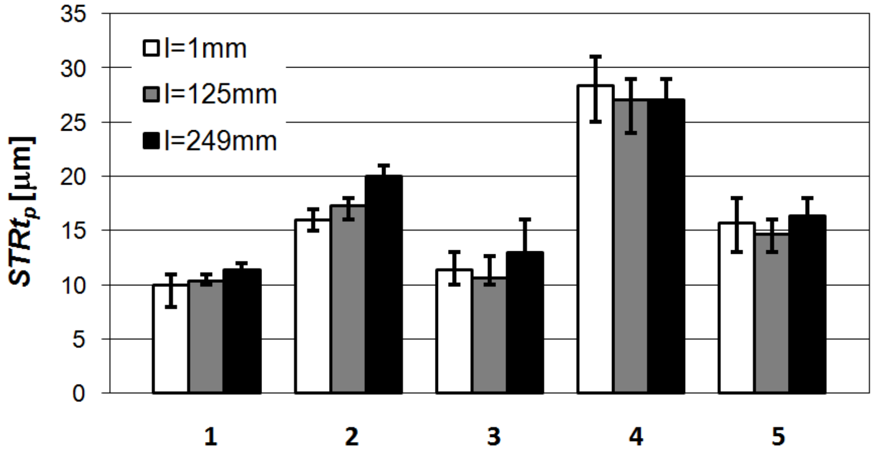



Figure 3 – Influence of face milling conditions (1-5 according to tab. 1) on deviation $STRt_p$ in transverse section measured in various milling lengths $l$

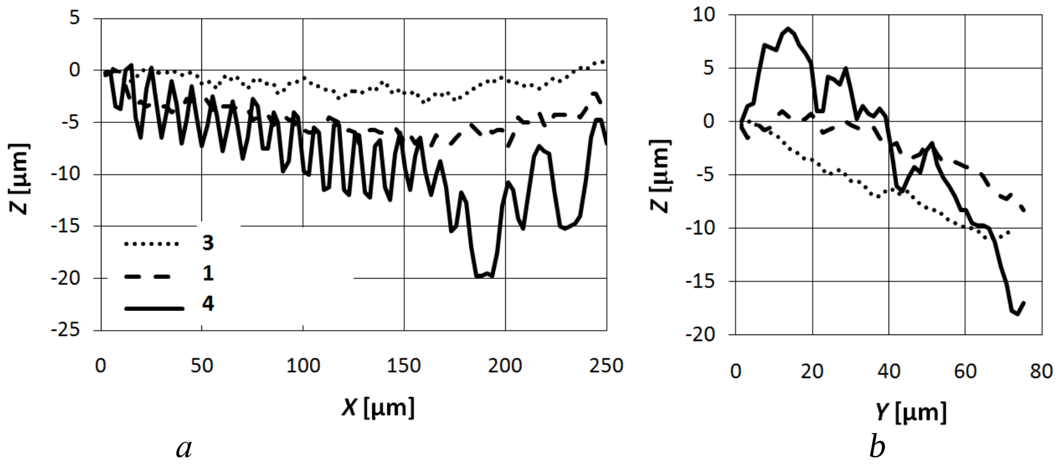



Figure 4 – Influence of face milling conditions (1-5 according to tab. 1) on profiles of machined surface in middle longitudinal a) and transverse b) sections

Many literature sources [6, 7] indicate that in order to obtain flat surface after face milling axis of the mill must be set perpendicular to feed direction. In the conditions whole machined surface has homogenous bi-directional lays. From fig. 4 and 5 follows that it can not to be true. Static tilt of face mill axis is changing due to machining forces. As given in [5], when thrust force is higher back of the mill goes down and bi-directional lays can forms. Repeated cutting of machined surface by back of the mill occurred for some of the passes in conditions 2 and 3 as well as for all passes in conditions 4 and 5 (fig. 5). It caused arising of lesser concave profile in transverse section (fig. 4).

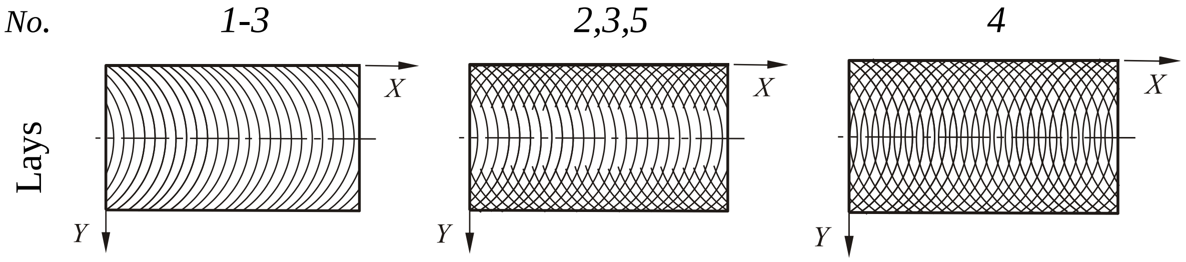



Figure 5 – Lays obtained in applied face milling conditions (1-5 according to tab. 1)

## 4. CONCLUSIONS

When milling with higher depth of cut $a_p$, feedrate $f_z$ and number of wedges $z_c$ higher form errors of machined surface (deviations $STRt_w$ and $STRt_p$) are obtained. Occurance of homogenous bi-directional lays can not testify higher flatness of machined surface than for uni-directional lays.

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