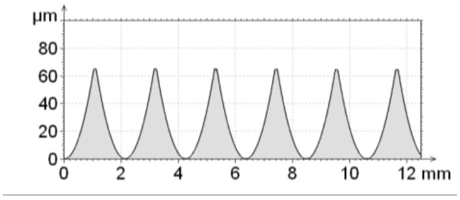
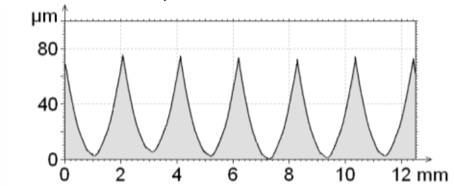
for cutting with two circular inserts are shown in Figs. 6–8.



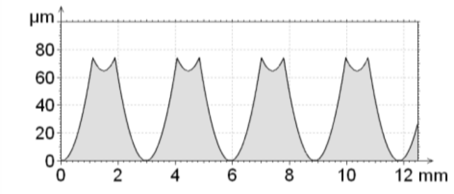
a) theoretical



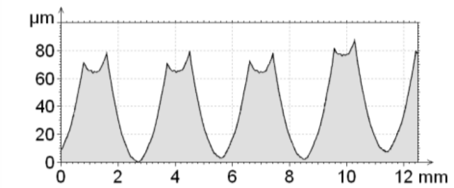
b) measured

Fig. 6

Theoretical and measured 2D profile diagrams of surfaces milled with two circular insert for f_{z3}



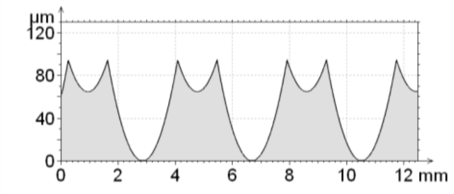
a) theoretical



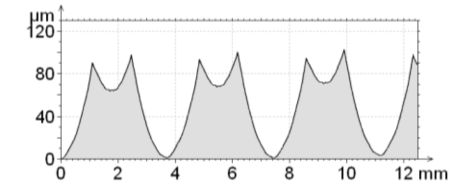
b) measured

Fig. 7

Theoretical and measured 2D profile diagrams of surfaces milled with two circular insert for fz4



a) theoretical



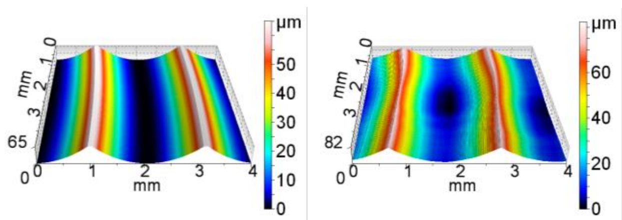
b) measured

Fig. 8

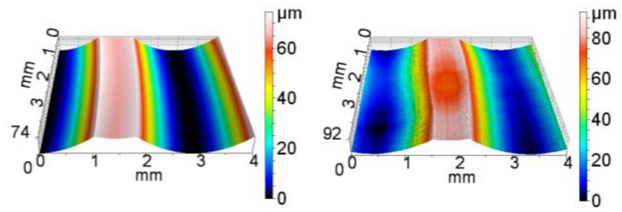
Theoretical and measured 2D profile diagrams of surfaces milled with two circular insert for fz5

As was mentioned before, the two circular inserts were located in the milling head with a difference between them of e_{ax} = 65 µm value. The topography of the cut surface was changed by this fact. Roughness values were increased with the same feed per edge values. The reason for this is that the insert which is located farther away from the surface is not working at low feed values because of the axial setting error, while at higher feeds it still removes a smaller chip cross section. Practically, the chip removal was performed by this insert only with feed per tooth values set at f_z = 1.48 and 1.98 mm. The developed CAD model was extended to be able to determine theoretical roughness values of resulting topographies in such cases. The simulated theoretical and the measured three-dimensional surfaces are summarized in Fig. 9 when cutting with two circular inserts with setting errors.

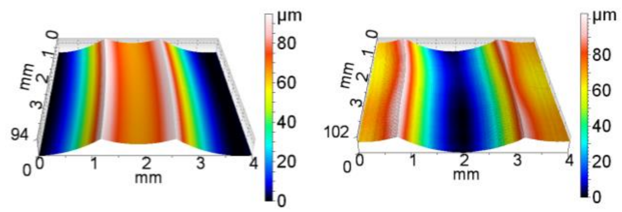
Theoretical **Measured**



a) f_{z3}



b) f_{z4}



c) f_{z5}

Fig. 9

Theoretical and measured 3D surface diagrams of surfaces milled with two circular inserts

Finally, theoretical and real roughness values are compared, as well as their changing character as a function of the feed. It can be concluded that the theoretical roughness values determined by the model show good agreement with the measured values both in their character of change and in the values themselves. It can be stated from Figs. 10 and 11 that the accuracy of the values by the model is sufficient to predict the actual roughness.

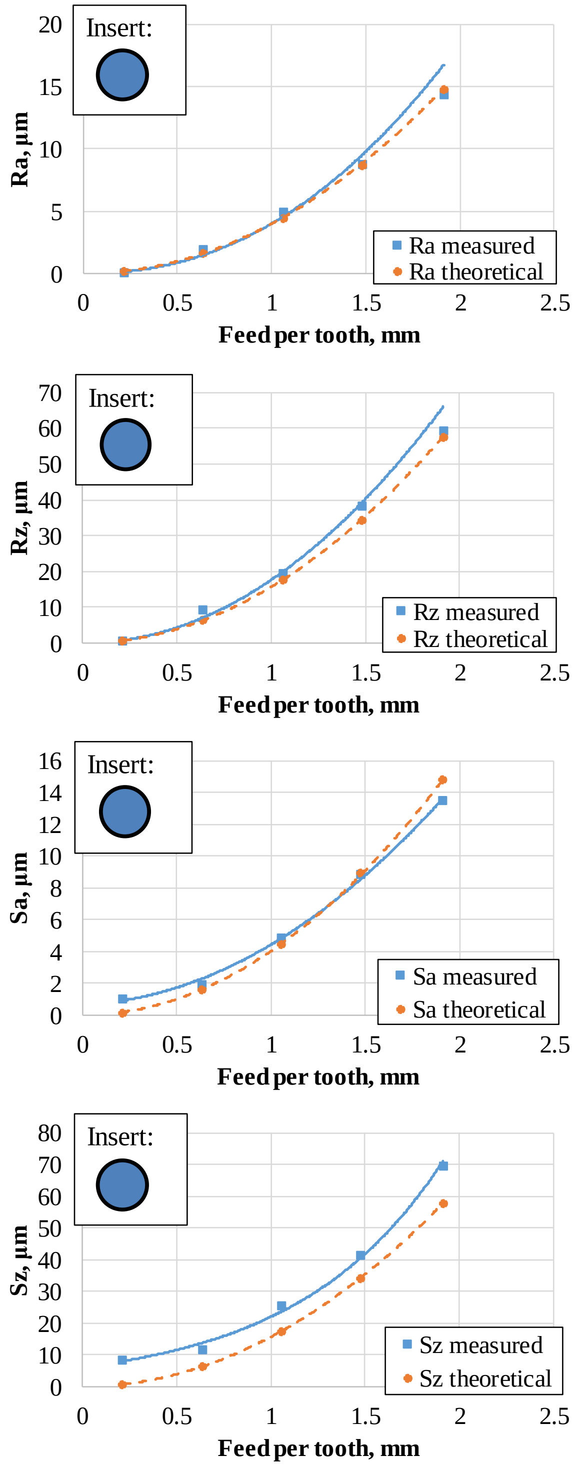


Fig. 10
Changing of roughness characteristics of surfaces milled by one circular insert as a function of feed

The relation between theoretical and real surface roughness characteristics can be seen from the comparison graphs in Figs. 10 and 11.

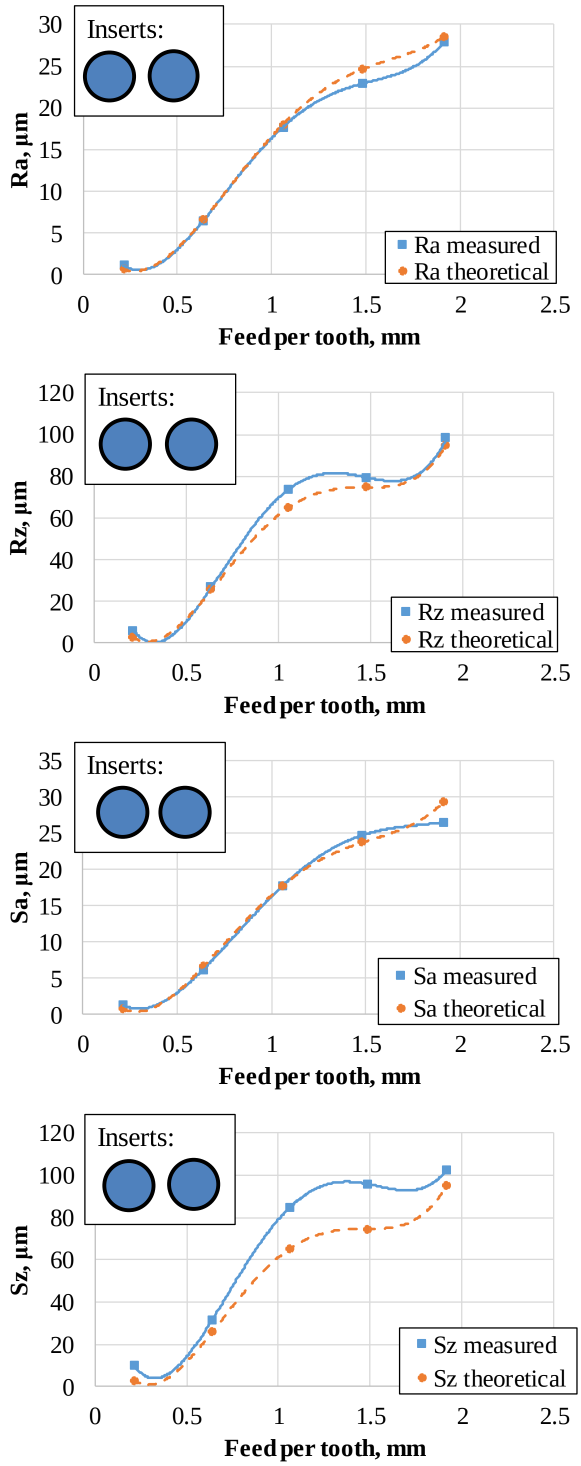


Fig. 11
Changing of roughness characteristics of surfaces milled by two circular inserts as a function of feed

The good agreement also applies to the two inserts that have setting errors to each other (Fig. 11).

5 Discussion

The automation of production, the spreading of flexible manufacturing systems and the proliferation of computer technology allows technological processes and their products to be planned with ever growing accuracy. The accurate planning of the topography of generated surfaces of parts facilitates even better compliance with functional requirements of surfaces in the final machining of parts, which can significantly extend their lifespan. Analysis of the changing of micro-geometrical properties and surface roughness values of face milled surface topographies as a function of technological data has long been an important direction of research.

Part production in which the allowance is essentially removed in one cut is becoming more common; therefore, choosing the feed value is becoming more important. Increasing the feed increases the machining productivity, but at the same time the roughness also increases. Thus, the research is aimed at using only one cut on a part with increased feed, thus achieving higher productivity while keeping the increase in roughness under control (it must be in accordance with prescriptions for the surface). This is extremely important in finishing operations where the formation of surfaces providing functional properties is done. The simultaneous effort to produce the blanks with as minimal an allowance as possible and to remove the allowance in one cut makes it even more important to analyze the effects of the feed.

6. Conclusions

The effect of changing feed on the roughness characteristics of face-milled surfaces was introduced in the paper. In addition to the data obtained during cutting experiments their theoretical values under identical conditions were also defined. A CAD model was applied for the latter. Both the theoretical 2D and 2D roughness profiles exhibit good correlation with cut surface profiles calculated with the introduced method, which was elaborated for the determination of theoretical values. The model is suitable for the determination of 2D and 3D theoretical values of roughness parameters. In case of a nearly ten-fold change in a_p/f_z values, the theoretical roughness values and their change followed the real roughness values with good correlation. In addition, experiments with two inserts introduced to show the effect of the setting error confirmed the applicability of the method. The overall conclusion is that the method is well suited for the estimation of expected roughness values.

Acknowledgements

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