Analysis of cutting forces from point of view fracture mechanics in quasi-orthogonal CNC milling and cutting by circular saw-blade. Part II

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INTRODUCTION

Milling on CNC machines is one of the most used operations today, not only in the production of furniture. Computer numerical controlled machines and their possibility of relatively easy connection with a good technological solution offer the possibility of controlling the entire production from one central computer and without the need for human intervention in production.

The aim of this part of experiment was to accurately determine the cutting forces in the conventional and climb quasi-orthogonal milling of the MDF fiberboard and artificial stone Corian.

MATERIAL AND METHODS

The machining was performed by CNC milling machine KX3.

A single-edged end mill (D = 12 mm) with interchangeable inserts was used for the experiment.

The milling was performed under the rotational speed n = 4000 min^{-1}, feed velocity was changed in the range v_f = 0,3 – 1,5 $m \cdot min^{-1}$ with the step 0,3 $m \cdot min^{-1}$.

This corresponded to the changing feed per tooth f_z and the mean uncut chip thickness h_m.

A series of 5 measurements was performed for the present cutting conditions, type of milling (climb milling and conventional milling), each feed speed and each type of material.

MDF fiberboard (e = 18 mm) and artificial stone Corian (e = 12 mm) were used for machining. The reason for choosing these materials is because their homogeneous structure and frequent use in furniture industry.

The measurement of the forces was realized by a three-axis piezoelectric dynamometer Kistler 9257B.

Fig. 1 CNC milling machine KX3

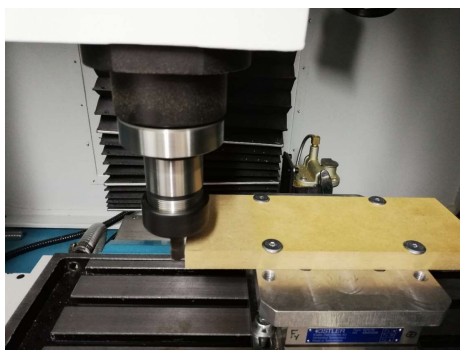

Fig. 2 Milling of MDF board

Fig. 3 Milling of artificial stone Corian

Fig. 4 Record of force measurement

RESULTS

The cutting force for the MDF board increases with increasing uncut chip thickness. The same dependence of the cutting force on the uncut chip thickness is also visible for artificial stone Corian.

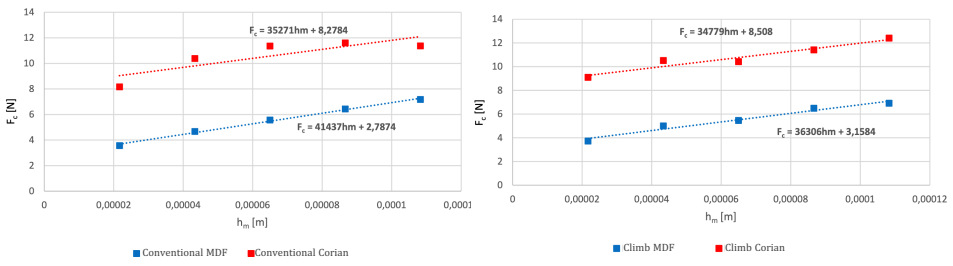

Fig. 5 Dependence of cutting force on uncut chip thickness (left: conventional milling, right: climb milling)

We can notice higher values of the cutting forces in the climb milling process. The cutting force is directed to material, reducing clamping forces while decreasing machine susceptibility to vibrations, and it is possible to increase the feed per tooth while maintaining a good quality machined surface. The cutting force of artificial stone Corian is about twice as high as the cutting force of MDF board.

On the basis of the performed experiments, the main parameters of the newly designed model (fracture toughness and shear yield stress) were calculated. These parameters were input data for the calculation of the specific cutting resistance.

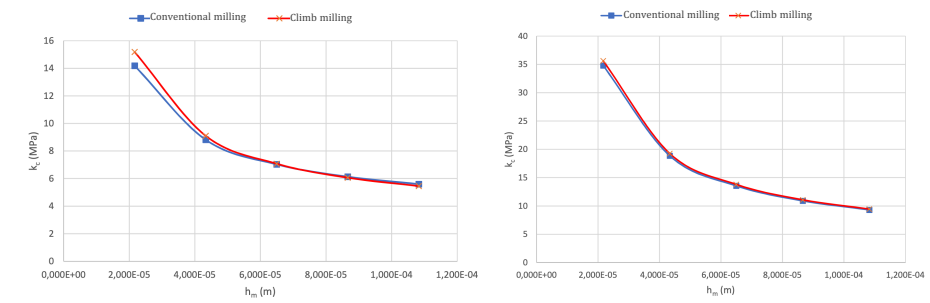

Fig. 6 Dependence of specific cutting resistance on uncut chip thickness (left: MDF board, right: artificial stone)

The various authors agree that the specific cutting resistance decreases with the increasing chip thickness. For both materials, the values of specific cutting resistance are slightly higher for climb milling than for conventional milling.

CONCLUSION

The application of the obtained results enabled to accurately determine the values of the forces working in the interaction of work-tool-depth of cut. Based on the cutting force knowledge it is possible to determine important parameters – fracture toughness and shear yield strength of the newly designed computational model for quasi- orthogonal CNC milling of MDF boards and artificial stone Corian.

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