INFLUENCE OF CHIP THICKNESS ON VARIOUS CUTTING PARAMETERS IN MILLING OF CHIPBOARD

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Abstract

Influence of chip thickness on various cutting parameters in milling of chipboard. Report shows influence of tool wear and chip thickness on various parameters characterizing milling of chipboard. Cutting force, feed force, machined surface temperature and power consumption of cutting and feed mechanisms are presented. The correlation between chip thickness (feed rate), tool wear and force, power and temperature parameters is calculated and described.

Key words: machining *of wood products, chipboard, tool wear, milling.*

INTRODUCTION

One of the most significant problems in woodworking industry is improvement of cutting process without sacrificing the quality. In order to make a reliable system, recognizing tool wear state and possibly cut quality it is necessary to obtain database of parameters connected with tool wear. Cutting and thrust force, surface temperatures, vibration and cutting and feed power consumption should be taken into account. Overall production gain based on feed speed increase, often applied in industry, may affect products quality in means of excessive forces or increased temperature effect. Finding basic correlation between tool wear and basic cutting parameters in various materials may allow to design an universal database with neural network based system recognizing tool wear on the basis of cutting parameters. On the basis of previous work with MDF, additional tests were performed witch machining of chipboard

MATERIAL AND EXPERIMENT METHOD

As a test material, standard three-layer chipboard with average density – 680 kg/m^3, and thickness of 18 mm was used.

Test material was milled with cutter head with inserted steel knives: cutting diameter 160 mm, knives thickness – 10 mm.

Test was carried out on specially prepared joiner, equipped with piezoelectric force sensors, machined surface temperature sensor and digital wattmeter with for power measurement. Following data was collected: cutting and thrust forces, surface temperature and cutting and feed power consumption. Real-time measurement data was collected by data acquisition system. Milling parameters are presented in Table 1

Table 1. Milling parameters.

Chip thickness	0,158 mm	0,316 mm	0,474 mm	0,632 mm
Cutting speed	25m/s			
Cutting head diameter	D=160 mm			
Number of tools	z=1			
Cutting depth	h=4 mm			

Number of experimental test: 4 wear development for every material and for every milling process with the different chip thickness. As a tool wear indicator RR parameter was used – edge retraction parallel to the cutters rake face.

EXPERIMENT RESULTS AND CONCLUSIONS

Experiment results, containing correlation of cutting and thrust forces, machined surface temperature and power consumption to tool wear, with different chip thicknesses are shown on fig 1-6.

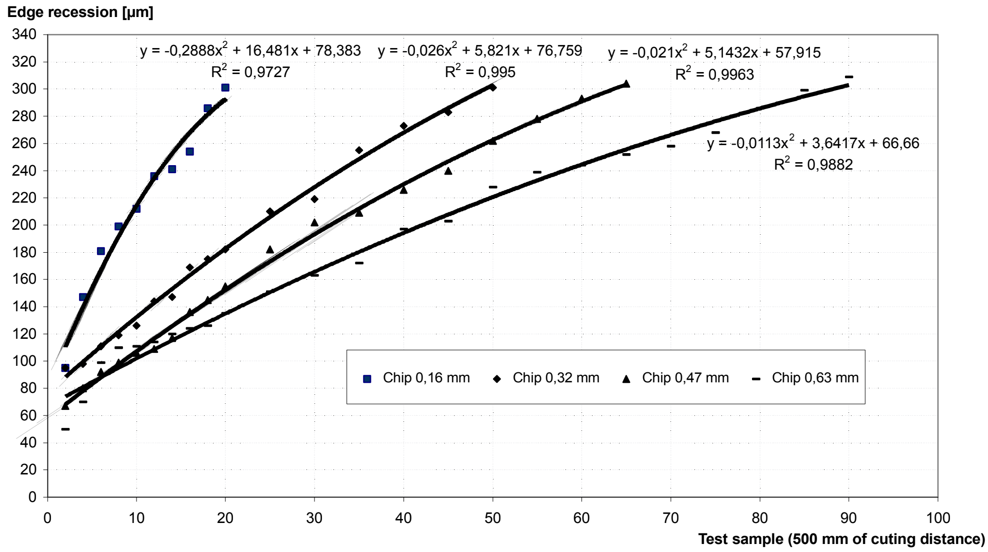

Fig.1 Correlation between the tool wear and chip thickness in milling of chipboard.

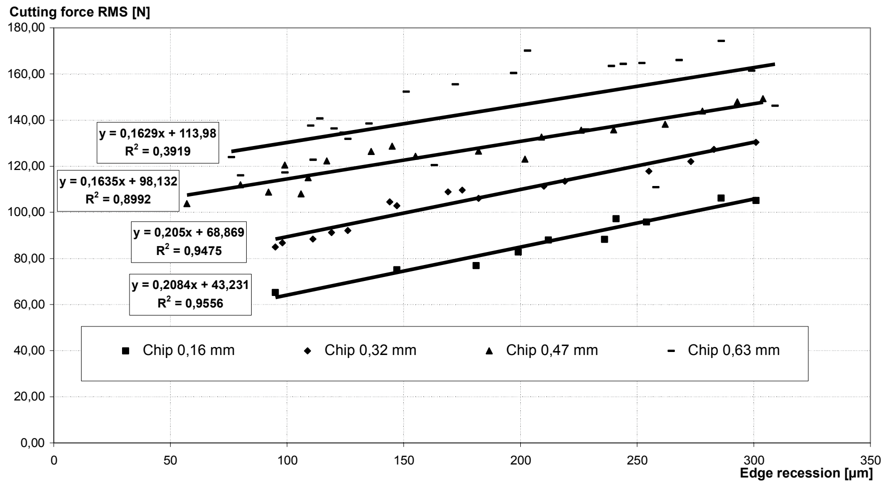

Fig.2 Correlation between cutting force and tool wear with different chip thickness in milling of chipboard.

Experiment shows, that cutting force grows linearly with tool wear - chip thickness has similar influence on forces. However, diagram shows that increasing chip thickness may lead to unexpected results - cutting force with chip 0.63 mm does not really correlate with tool wear (R^2=0,39). This may occur because of crushing process connected with excessively thick chip, or loss of machine or measurement devices constructional stiffness. Both cases will lead to poor milling quality, despite of its high efficiency.

Similar results to cutting force may be observed with thrust force. Linear growth of forces with increasing tool bluntness has good correlation up to the certain chip thickness. Beyond that point results can be unexpected, due to very low correlation between tool wear and thrust force. Despite its relatively low results, it is necessary to remember that maximal values may be very high in opposition to their root mean square calculations – caused by unstable cutting process. Dependence of thrust force on tool wear with different chip thickness is shown on fig.3.

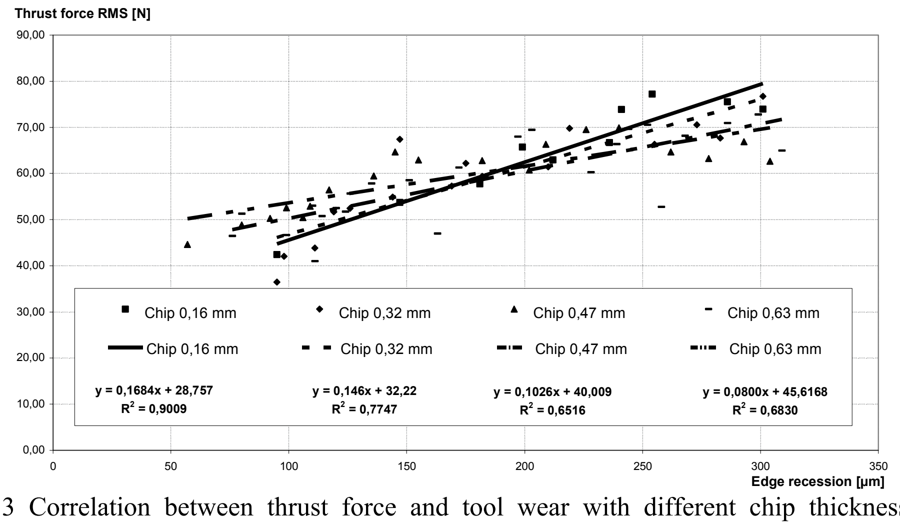

Fig.3 Correlation between thrust force and tool wear with different chip thickness in milling of chipboard.

Machined surface temperature may become very important factor in overall process quality control. Dependence of temperature on tool wear with different chip thickness is shown on fig.4.

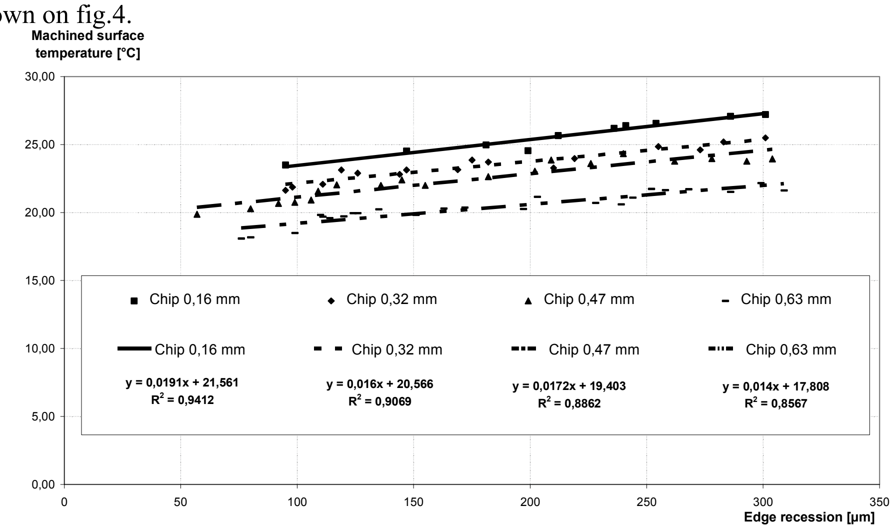

Fig.4 Correlation between machined surface temperature and tool wear with different chip thickness in milling of chipboard.

Machined surface temperature, as shown on fig 4 is not critical parameter when it comes to choosing the right chip thickness for the operation, with provided quality requirements. It is shown that despite linear growth of temperature with tool wear, measured values do not exceed 30 degrees centigrade, which value is not dangerous to material in any means. Increasing chip thickness lowers the surface temperature, due to shorter cutting path with thicker chip (less cuts to achieve equal amount of material removed).

Figures 5 and 6 show feed and cutting power dependency on tool wear.

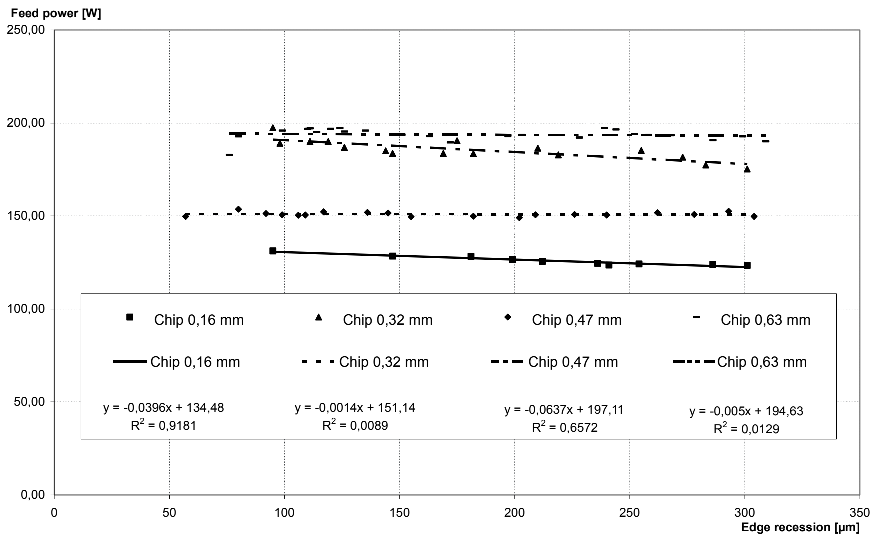

Fig.5 Correlation between feed power and tool wear with different chip thickness in milling of chipboard.

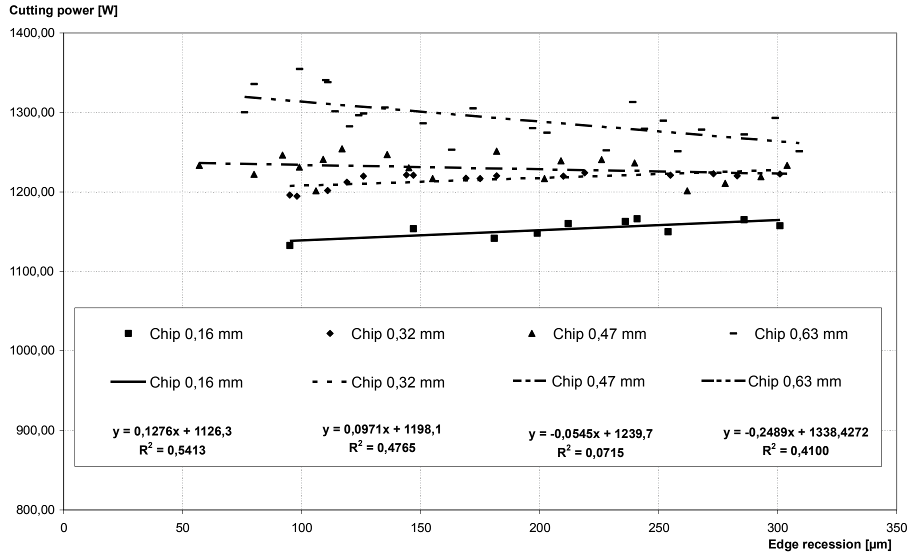

Fig.6 Correlation between cutting power and tool wear with different chip thickness in milling of chipboard.

As can be seen on presented figures, with low sensitivity on tool bluntness, power consumption is the most obvious indicator of excessive chip thickness. Excessive change in chip thickness will lead to drastically increased power required by feed and cutting motors. Especially feed power, due to almost 100% growth when machine is overloaded. Unfortunately, very low regression values means sophisticated equipment with time delay neural networks or fuzzy logic will be required to successfully trace changes.

CONCLUSION

Basing on the above experiment, following conclusions may be withdrawn :
Limited increase of chip thickness may be the very suitable method of increasing overall production efficiency, not causing any important changes to cutting parameters. However, excessive chip thickness (or feed speed) may lead to unexpected results, especially in means of product quality – large cutting and thrust forces and increased power consumption may lead to lowered product quality, as well as excessive machinery wear. Therefore, in production practice, test cuts should be made to determine maximum safety and quality wise set of cutting parameters. If possible, some sort of diagnostic system based especially on cutting force parameters (best regression values) should be applied to safely operate and not to overload machinery.

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