TOOL WEAR DIAGNOSTICS IN MILLING OF SELECTED WOOD SPECIES. LARCH WOOD.

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Abstract
Tool wear diagnostics in milling of selected wood species. Larch wood. Report shows influence of tool wear on selected parameters characterizing milling of larch wood. Cutting force, feed force, machined surface temperature and power consumption of cutting and feed mechanisms are presented. The correlation between tool wear and force, power and temperature parameters is calculated and described.

Key words: *machining of wood , larch, tool wear, milling*

INTRODUCTION

In woodworking industry, maintaining sufficient quality with improvement of cutting process speed, connected with economic calculation, is one of the most significant problems. Required cut quality can be maintained by constant diagnostic of tool wear, which when comes to rotating tools is simply impossible to do. Knowing however influence of tool wear on some selected phenomena connected with cutting process, such as forces, surface temperatures and like may allow to sufficiently determine time when tool is due to be replaced/sharpened. Material such as wood due to inconsistent density and unpredictable machining behavior are especially hard to manage technologically. It is necessary to develop basis of tool wear state recognition system, which would enable more optimal utilization of tools, machinery and raw material. System recognizing tool wear requires sufficient database of parameters connected with tool wear. Unfortunately even basic specification on different wood species containing cutting and thrust force, surface temperatures, vibration and cutting and feed power consumption changing with tool wear are simply unavailable. Finding basic correlation between tool wear and basic cutting parameters in various materials may allow to design an universal database with neural network or fuzzy logic based system recognizing tool wear on the basis of cutting parameters.

MATERIAL AND EXPERIMENT METHOD

As a test material, larch boards were used. Larch samples density was 526 kg/m^3. Larch wood density ranges from 400 kg/m^3 to 820 kg/m^3 with average of 550 kg/m^3.

Test material was milled with cutter head with inserted steel knives: cutting diameter 160 mm, knives thickness – 8 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. 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 spindle torque to tool wear, on fig 1-6. Due to the amount of data, only meaningful dependencies and summary will be presented

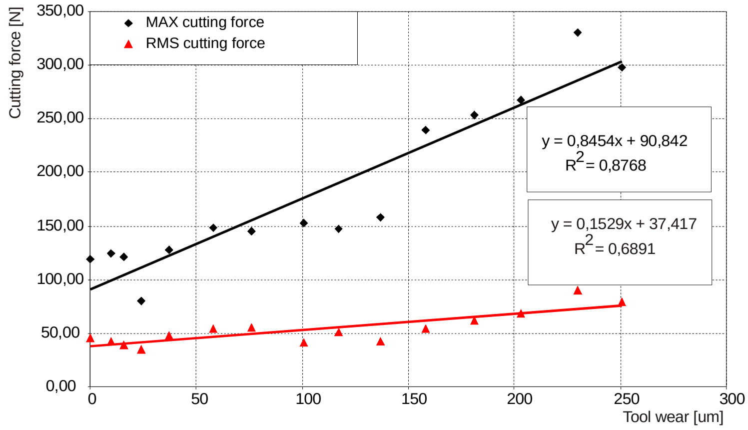

Fig.1 Correlation between the tool wear and cutting force in milling of larch wood

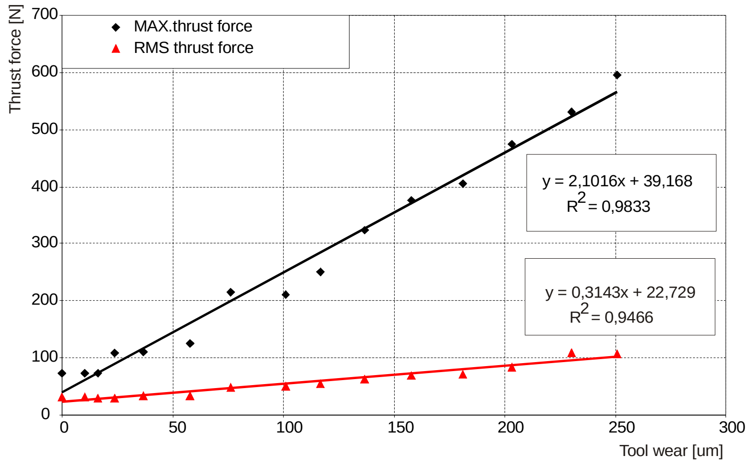

Fig.2 Correlation between the tool wear and thrust (normal) force in milling of larch wood

Experiment shows, that maximal and average (root mean square) cutting force grows linearly with tool wear. Maximal from 100 up to 300 N and RMS from around 40 to 80N. Cutting forces correlate really well with tool wear (R^2=0,7-0,9). It is necessary to remark that such correlation in non-homogenous material may be regarded as high.

Similar results to cutting force may be observed with thrust force. Linear growth of Maximal and RMS forces with increasing tool wear reaches from 80 up to 600N and 50 to 100N respectfully. Correlation of normal force and tool wear is even higher than in cutting forces, with R^2 reaching 0,98 and 0,95 for maximal and rms values. 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.

Machined surface temperature may become very important factor in overall process quality control. Parameter has good diagnostic properties and can be measured relatively easy and cheaply in comparison to forces.. Dependence of temperature on tool wear in milling of larch wood is shown on fig.3.

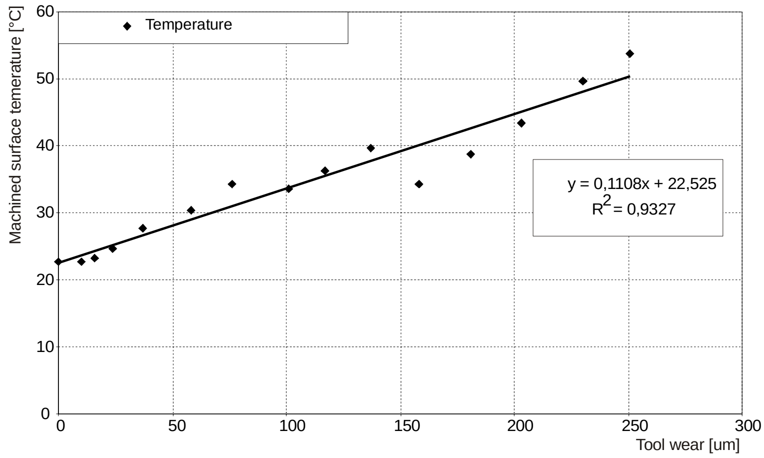

Fig.3 Correlation between machined surface temperature and tool wear in milling of larch wood

Machined surface temperature, as shown on fig 3 may be the right parameter describing actual tool wear. It is shown that linear growth of temperature with measured values growing from 22 to 55 degrees centigrade and good correlation R^2=0,93 refers very well to actual tool wear.Obviously temperatures of 50 degrees are not dangerous to material in any means.

Due to the limited space cutting power consumption, feed power consumption and spindle torque will not be presented on separate diagram, due to poor gain with increasing tool wear. Total measured parameters change with increasing tool wear is presented on fig 4.

As can be seen on presented figures, parameters such as cutting power, feed power and spindle torque show low sensitivity on changing tool wear. Low changes come from relatively high nominal power of motors and obviously high stiffness of working spindle

Basing on the above experiment, one may notice that basically forces, especially thrust (normal) ones seem to be the best indicator of tool wear in milling of larch. Significant growth of from 700% to 100% depending on the force type may easily diagnose tool state with great accuracy. Another significant parameter to be watched is surface temperature of milled material, with growth of over 100% from sharp to blunt state good correlation and relatively easy measurement may become the main factor in systems diagnosing tool state during milling of wood. Power consumption and spindle torque widely used as a tool state indicator in metal milling seem to be completely inappropriate in milling of wood.

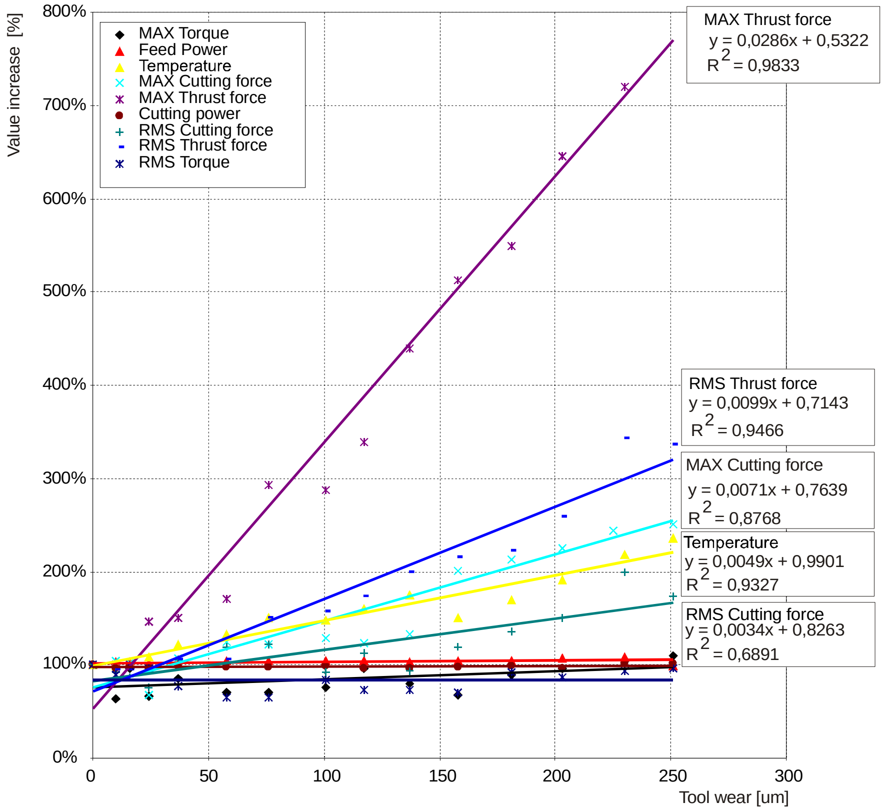

Fig. 4 Correlation between all measured parameters and tool wear in milling of larch wood

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