Advanced tool materials and their influence on the parameters of CNC machining of wood-based materials (PART II)

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GOAL OF THE PROJECT

The goal of the project is to quantify machining parameters of tools designed for CNC machining of commonly used wood-based materials. In particular, to analyze the machining process focusing on the cutting forces and energy consumption during machining and to create a methodology for choosing the appropriate tool coating and cutting conditions depending on the machined material.

Fig. 1 Goal and methodology

THEORETICAL BACKGROUND, HYPOTHESIS

During the wood machining, the main problem is generally a high proportion of friction during chip formation, which leads to excessive heating of the tool.

In the surface layers of the tool, the temperature while wood is being machined can be up to 850 °C.

A common solution to reduce the coefficient of friction is to apply a suitable tool coating, which has a positive effect on both the friction of the tool against the material and the easier chip evacuation from the cut.

There is a wide range of hard coatings mostly based on carbides and nitrides on the market, which are deposited in a microscopic layer to the surface of the tool. The main advantage of tool coatings is the possibility of application practically on any substrate of any shape of an already finished tool.

This can be done by two basic methods, i.e. the chemical deposition (CVD) and newer physical deposition (PVD).

Both methods have many other variants depending on the coating material. CVD and PVD coating are also often used methods to deposit a thin layer of carbon in its hardest sp3 structure, so called Diamond-like Carbon (DLC).

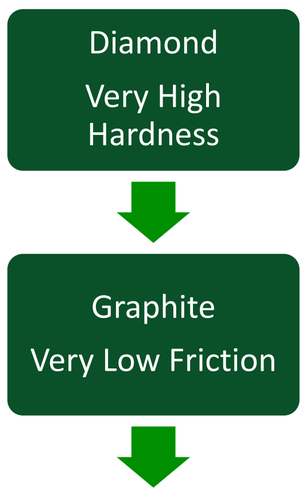

Fig. 2 Description of DLC

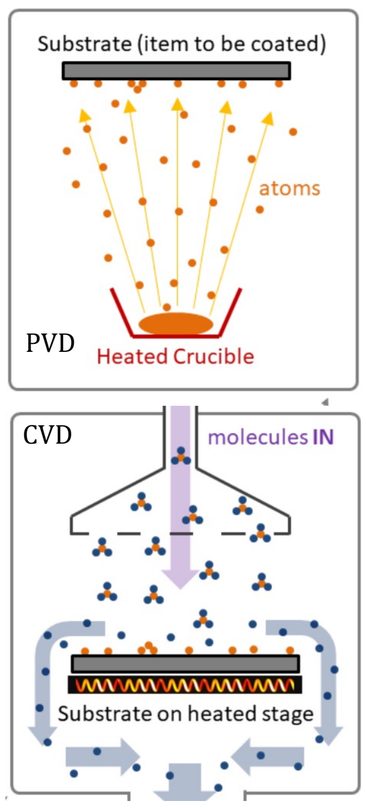

Fig. 3 Principle of PVD/CVD

DLC coatings, appear to be a possible universal solution for machining wood-based materials. However, it is necessary to prove this hypothesis by comparing the cutting parameters of different tool materials on different machined materials.

MATERIAL AND METHODS

Standard CNC milling machine Morbidelli m100 (SCM Group, Italy)

Medium density fiberboard (MDF) proportions: 500 x 500 x 18 mm (L x W x T), density: 684 kg×m^{-3}, moisture: 3 % at 25° C.

Five Hard metal tools with different surface modification: reference tool without coating., Triple Si, DLC and Hyperlox. Coatings were applied onto special designed 10 mm router bits with one straight edge manufactured by long term partner Vydona.

Fig. 4 CNC milling machine; Medium density fiberboard; Measuring chain

Cutting speed v_c: 8; 10; 12 m·s^{-1}

Feed speed v_f: 6; 8; 10 m·min^{-1}

Feed per tooth f_z: 0.1; 0.15; 0.2; 0.25; 0.3 mm

Depth of cut e: 1 mm

Type of milling: conventional and climb milling

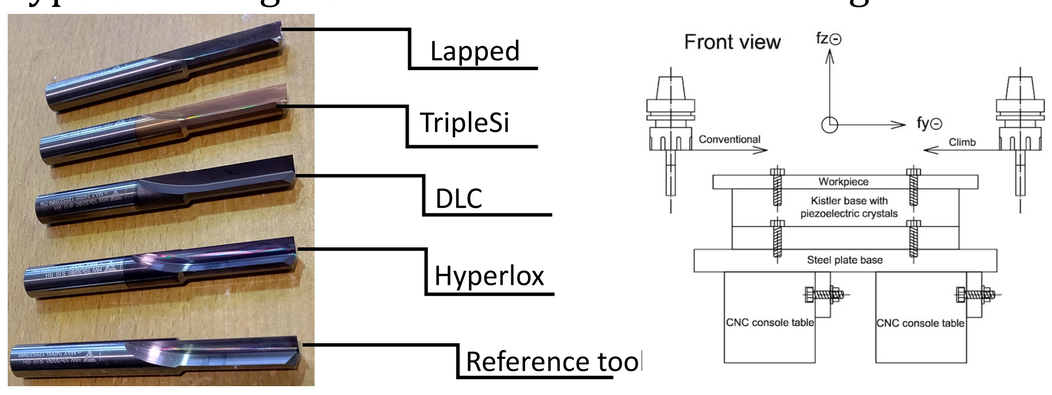

Fig. 5 Tools with different type of coatings; Scheme of dynamometer Kistler

The cutting forces measurement was carried out on the three-axis piezoelectric dynamometer 9257B Kistler.

The sampling frequency of the measurement data recording was set to 4,000 Hz due to the possibility analyze the dynamic course of forces on the cutting edge. It was subsequently processed and further evaluated in DynoWare and MS Excel.

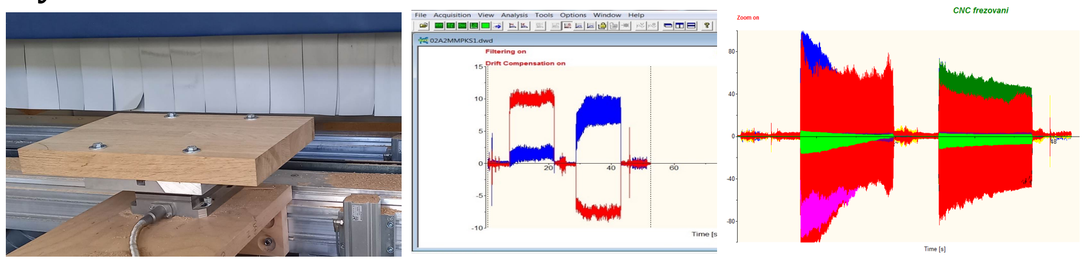

Fig. 6 Dynamometer Kistler; Record of cutting forces

CONCLUSION

The presented methodology can be, after slight adaptations, applied for wide range of materials during processing on other machines with similar cutting kinematics, such as circular saw blades, circular cutter, etc. The model is available not only for woodworking engineers dealing with woodworking processes, but also for the designers when designing new cylindrical cutter or milling machines.

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