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Analysis of tool life criterion during laminated chipboard milling

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Abstract: *Analysis of tool life criterion during laminated chipboard milling.* Direct and technological indicators of tool wear were examined during climb milling of laminated chipboard produced by three different producers. Machining was conducted with usage of CNC working center with usage of four tools, perceived in industry condition as not appropriate to the further work because of insufficient machining quality. Analysis of tool life criterion based on technological indicator was the aim of the work. Relationships between direct and technological tool wear indicators proved low and average correlations. Quality of investigated kinds of chipboards relevantly differentied between each other. Thus, there is no reason to use only one tool life criterion for wood based boards made by different producers.

Keywords: tool life criterion, milling, laminated chipboard

INTRODUCTION

Tool life criterion, it means value of tool wear indicator above which the tool is regarded as blunt, inappropriate to further work, is decisive parameter in preparing of machining process. Estimation of this parameter has relevant influence on optimal usage of the tool as well as on satisfactory machining quality [Jemielniak 2002]. Tool life criterion can be defined as permissible value of direct tool wear indicator or indirect (technological) indicator connected with quality of machined element. For example, the width of the abrasion noticed on clearance face [Salje et al. 1985; Szwajka and Górski 2006; Wilkowski and Górski 2006] or width of the wear on rake face [Stuhmeier 1989; Sokołowski 2000] were used in wood based materials milling as direct indicator. The quality of machining, in wide range, is treated as technological, indirect indicator. This type of indicators shows for instance increasing of surface roughness, deterioration of machined edges quality or increasing of dimensions deviation in compare with nominal value. The damages observed along machined edges (chips) during cutting of laminated chipboard are very undesirable consequence of edges wear. Measures which describe these changes can be assumed as indirect technological tool wear indicators. The number of chips [Boehme and Munz 1987; Lemaster et al. 2000] or maximal width of chips measured on wide surface of machined material [Pałubicki 2006; Porankiewicz 1993] belongs just to this group of indicators.

Estimation of the tool life criterion in production process is very complicated because both properties of machined material and cutting parameters (feed per tooth, cutting speed) have relevant influence on machining quality too [Cyra 1997]. Indirect indicators which, how was mentioned earlier, describe quality changes of element are a base to estimate tool life criterion in mass production Jemielniak [2002]. Analysis of the tool life criterion during permanent and direct inspection by CNC machine operator in industrial conditions was the aim of this work. Moreover, technological and the most objective direct tool wear indicators were taken into account.

MATERIALS AND METHODS

Three layers laminated chipboard from three different producers signed with following letters of alphabet („A", „B", „C") was taken to the experiment. This type of material is widely used in furniture industry. Outer layers made from melamine film distinguish by much higher density than inner layers of the board. The appearance of hard mineral contaminations is the most relevant factor which affects tool wear [Salje et al. 1985]. Specification of average densities and contents of mineral contaminations was showed in Fig.1.

Tab.1. Average density and content of mineral contaminations in researched chipboards

Producer	Average density [kg/m³]	Content of mineral contamination [%]
„A”	648	1,28
„B”	667	0,98
„C”	666	1,06

Milling was carried out on working center CNC ROVER B4.35 - BIESSE (Fig.1). Four router bits with tipped edges from polycrystalline diamond, with diameter 16 mm were used (Fig.2).

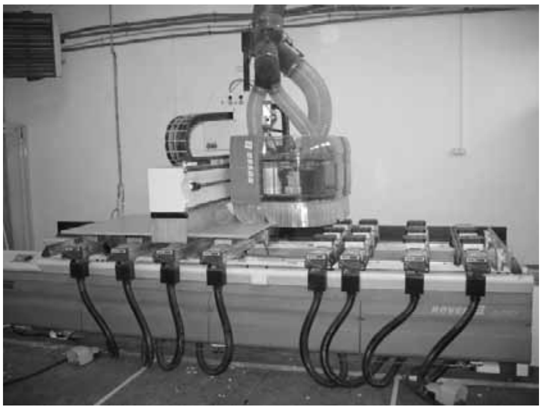

Fig.1. Working center CNC (Biesse Rover B4.350) from 2006

Fig.2. Router bit used in experiments and scheme of machining

Measurement of tool wear degree was carried out with usage of vision methods. The measurement stand consisted of digital camera Canon EOS 40D, with matrix resolution CMOS 10,1MPx (22,2x14,8mm). Objective Canon EF 100 mm f/2,8 Macro USM was used too. Four lamps F&V 85/400 WATT with color temperature 5500 K lighted the work pieces. Then, obtained in this way digital images were analyzed with usage of computer application GIMP 2.6.6.

Direct tool wear indicator VBmax (maximal width of the wear of clearance face) was established on the ground of digital image analysis. Technological indicator signed as Lw, in other words, number of chips calculated on 1m, was obtained thanks to visual inspection of chipboard edges.

Experimental researches were conducted in industry factory JUAN in Warsaw, which produces worktops. Tools taken to experiments were used in standard production process, to different wood based materials. Feed speed and overall time of exploitation for each tool was not monitored on this stage of work. Given tool was working till the moment, when the operator removed the tool from exploitation due to bad edge condition of machined laminated chipboards. So, criterion of tool life was the value of technological tool wear indicator. Then, the tools which were called back from production were next subjected to further investigations. Laminated chipboard was climb milled according to schema showed in Fig.3, through the whole thickness with successive tool. Cutting parameters, constant for all four tools were described in Tab.2. Five inspection work pieces from laminated chipboard, with dimensions 500x50x18mm (Fig.3) was prepared for each tool. Direct tool wear indicator and technological indicator on inspection work pieces, on upper and lower edge of chipboard were obtained after machining.

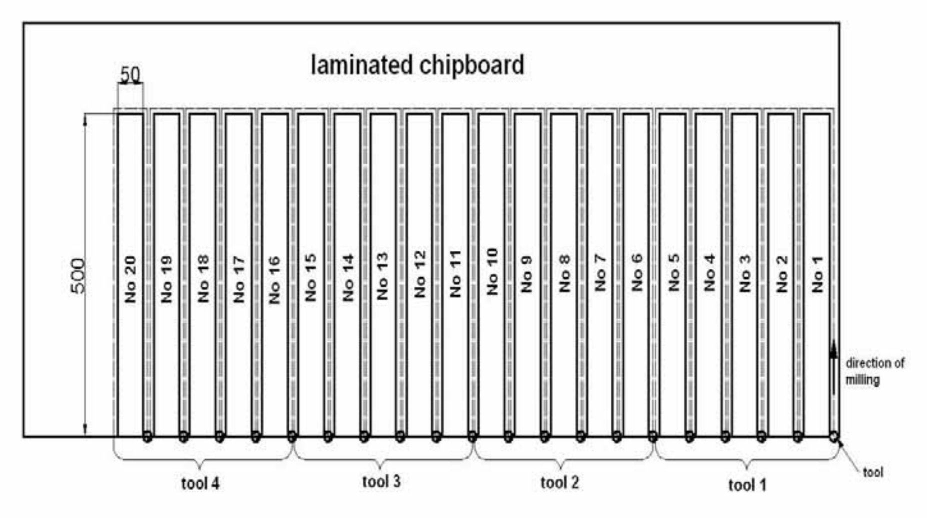

Fig.3. Milling schema of inspection work pieces with their dimensions

Tab.2. Cutting parameters during milling laminated chipboard

Parametry obróbki	
High of milled layer	h = 18 mm
Feed speed	u = 5 m/min
Rotational speed of tool	n = 16000 RPM
Number of cutting edges	z = 1 pc.
Cutting speed	v_c = 13,4 m/s
Feed per tooth	Δ_z = 0,31 mm

RESULTS AND DISCUSSION

Technological indicator obtained on ground of inspection work pieces demonstrates very high level of differentiation between particular chipboards made by these three producers. This variety of quality was observed both between work pieces machined with successive tools and even between particular edges tipped in one tool, too. Technological tool wear indicator for each investigated router bit was showed in Fig.4. The value of technological indicator in case of chipboard „C" is evidently higher than in case of chipboards from other producers. This relationship was confirmed both for particular edges and whole tool. Analysis of technological indicator (number of chips named as L_W) proved that the worst machining quality for this chipboard was obtained during milling with tool 2 and 4 (Fig.4). The influence of direct indicator on technological indicator Lw for chipboards made by different producers was showed in Fig.4. Due to figures below it can be concluded that correlations between these indicators are on average and low level (Fig.5). It means, that besides tool wear degree, another factors such as properties of machined material decided about quality. Therefore, assuming of one tool life criterion in situation when there are used materials which come from different producers is according conducted researches unreasonable.

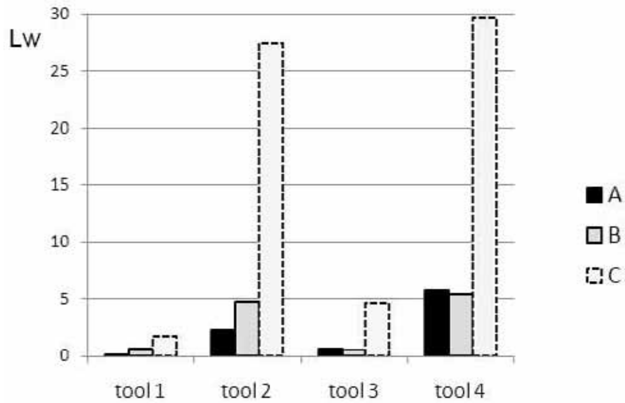

Fig.4. Dependency of chip number Lw [pc./m] on used tool and kind of chipboard

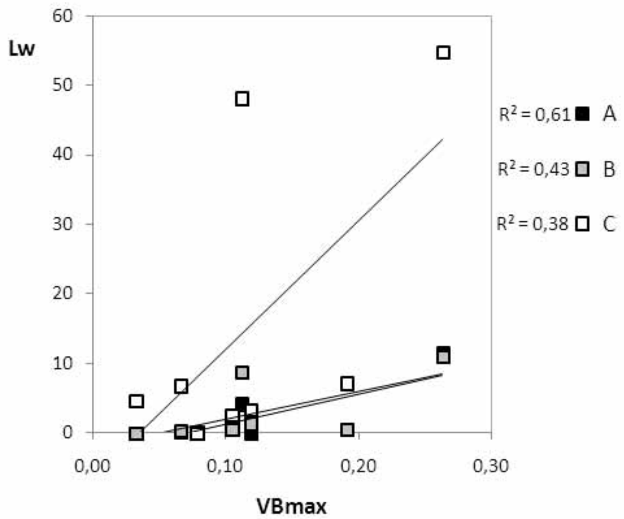

Fig.5. Dependency of chips number Lw [pc./m] on tool wear indicator VBmax [mm] for particular kinds of chipboards

CONCLUSION

Obtained results allow to formulate following conclusions:

1. Technological indicators estimated after milling of chipboards made by different producers differentiated significantly between each other. The differences achieved even several hundred percent.
2. Dependences between direct and technological tool wear indicators showed average and low level of correlations. This fact indicates on existing influence of another factories such as properties of machined material.
3. Usage of one tool life criterion based on technological factors which would describe machining quality of the wood based materials from different producers is unreasonable.
4. Tool life criterion based on direct indicators is recommended in scientific researches.

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Streszczenie: *Analiza kryterium trwałości ostrza podczas frezowania płyty wiórowej laminowanej.* W pracy badano bezpośrednie i technologiczne wskaźniki zużycia narzędzia podczas przeciwbieżnego frezowania płyty wiórowej laminowanej trzech producentów. Skrawanie prowadzono na centrum obróbczym CNC z użyciem czterech narzędzi zakwalifikowanych w warunkach przemysłowych jako narzędzia nie nadające się do dalszej eksploatacji z powodu złej jakości obróbki. Celem pracy była analiza kryterium trwałości ostrza opartego na wskaźnikach technologicznych. Zależności między bezpośrednim i technologicznym wskaźnikiem zużycia ostrza wykazują korelacje średnie i niskie. Jakość obróbki badanych grup płyt różniła się istotnie między sobą. Nieuzasadnione zatem jest stosowanie jednego kryterium trwałości ostrza dla płyt drewnopochodnych wykonanych przez różnych producentów.

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