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Influence of cutting speed on tool life during of laminated particleboard drilling

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Abstract: *Influence of cutting speed on tool life during of laminated particleboard drilling.* Relationships between cutting speed and durability of cutting tool was examined in this work. Researches were based on holes drilling with five tools (diameter 10 mm) made from HSS, in laminated chipboard. Each drill was working with different cutting speed, while feed per rotation was constant. One of the direct tool wear indicators called VBmax which shows maximal width of abrasion on clearance face of edge,was chosen. Results revealed that tool wear drops with increasing of cutting speed. This relationship was assigned in logarythmic scale in order to estimate Taylor exponent.

Keywords: tool life, drilling, cutting speed, laminated particleboard

INTRODUCTION

Following in course of time process of tool wearing which has the huge consequence in decreasing of cutting edge properties, is one of the relevant subject in machining science. Tool wear is a result of its mechanical, thermal, chemical and electrical influence on machined material. Clearance surface in cutting of wood based materials is the strongest subjected to this process. There is observed widely abrasion due to existence of hard mineral contaminations in material, glue, and friction of wood fibers [Pahlitzsh and Sommer 1966]. Wear on rake face is definitely smaller because on this side of edge is shaped only chip [Porankiewicz 2003]. Raised content of glue and mineral contaminations in outer layers of wood based materials is a reason of much more intensively edge wearing (even many times) [Sheikh-Ahmad and McKenzie 1997]. Literature unmistakably states that process of wearing has not linear character. This relationship shows Lorentz curve. It can be distinguished three stages of edge wearing. First part, when it comes to run in of the edge has quite violent course. Next stage of working period of tool correspond to relatively low intensity of wearing and it is the longest. Tool wear raised quite fast in the latest period of tool life. Exploitation of the tool is at the time unreasonably since this moment due to very high probability of catastrophic tool wear or even damage of machine [Dmochowski and Uzarowicz 1984].

Producers of the woodworking tools define their maximal admissible working parameters. However, these values don't correspond to optimal values for given machined material. It concerns cutting speed too. Stefaniak [1970] noticed unexpected increment of tool wear for cutting speed 50m/s. Porankiewicz [2003] proved according conducted researches, increasing of tool wearing during milling of chipboards with growth of cutting speed in range of 19-75m/s. However, Salje et al. [1985] noticed during chipboard milling, certain range (60-95m/s) of cutting speed when the speed of tool wear decreases. So literature indicates that cutting speed significantly influences on durability of edge. User must in this situation search for compromise between efficiency and constant costs of tool exploitation.

Estimation of cutting speed influence on durability of cutting edges during drilling in laminated wood based materials was the aim of work. Tool life was expressed by number of drilled holes. Tool wear indicator which amount 0,7mm, was assumed as tool life criterion.

MATERIALS AND METHODS

Researches were conducted in Department of Wood Machining WTD SGGW by usage of working center CNC Busellato JET 130. Five blind drills with center spike and cutters produced by LEITZ were taken to the experiments. Parameters of the tool were respectively: diameter of the working part 10mm, length of the working part 80mm, two cutting edges made from HSS. Optimal cutting parameters for these drills in case of wood base boards machining according to producer were following: feed speed u=2m/min, rotational speed of spindle n=4500RPM, cutting speed v=2,36m/s, feed per revolution Δ=0,33mm. Drilling was carried out in laminated chipboard (three layers) widely used in furniture production, marked as U511 SM from KRONOPOL firm. Drilling was realized in pieces 1200x350x18mm, 15 holes in each row. Depth of holes amounted 10mm (Fig.1). Experiment consisted of 5 cycles (one cycle – machining with usage of one tool) for different rotational speeds of spindle (one tool – one rotational spindle speed) with constant feed per revolution Δ=0,33mm. Tab.1 shows cutting parameters which were used for particular tools.

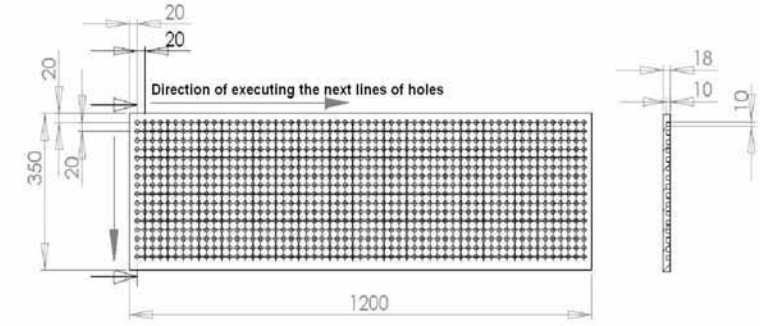

Fig.1. Schema of piece with cutting direction of successive hole rows

Tab. 1. Cutting parameters for particular tools

Index of tool	1	2	3	4	5
Cutting speed: v_c [m/s]	1,57	3,14	4,71	6,28	7,85
Feed speed: u [m/min]	1	2	3	4	5
Rotational spindle speed: n[RPM]	3000	6000	9000	12000	15000

Laboratory stand to edges wear measurement consisted of digital camera Canon 40D with matrix which has resolution 10,1mpx, equipped with macro objective Canon 100mm. Lamps giving constant light with power 80W each (4 pc) were used to take the photos. Graphical processing of images was made in application GIMP 2.6. The number of pixels (elementary unit of raster images) which fell on 1mm was fixed by usage of sidle caliper photo, in order to calibrate analyzed images. Tool wear degree was assessed on base of direct measurement of VBmax indicator in sight view on clearance face of edge. This value describes maximal abrasion measured in relation to the corner. Graphical illustration was showed in Fig.2. The tool was taken away from machine after each series of holes to make photos and next to amylase digital images. This procedure allowed to asses tool wear indicator VBmax. Cycles of wearing were conducted till the moment when value of direct tool wear indicator achieved assumed earlier limit 0,7mm.

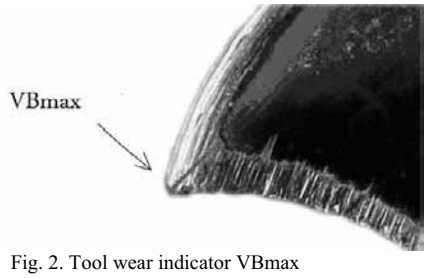

Fig. 2. Tool wear indicator VBmax

RESULTS AND DISCUSSION

Relationship between number of drilled holes and direct tool wear indicator VBmax was showed in Fig.3. Mentioned above indicator achieved higher values at higher cutting speeds. Initially, this relationships fluctuates when the tool runs in (up to 150 holes). It could be possible that value of VBmax might be lower for higher cutting speeds. This phenomena is caused by unexpected crumbling of edges what means jumping changes of tool wear indicator in first stage of tool exploitation.

The relationship between number of holes and cutting speed in linear scale is monotonic hyperbolical function (Fig.4). This relationship is in logarithmic scale rectilinear (Fig.5). Value m is called Taylor exponent and corresponds to angle tangent of line established by the points in logarithmic reference system (Fig.5). In drilling investigations concern laminated chipboard, Taylor exponent amounted 1,36. Mentioned above relationships are valid only for certain, fixed in given conditions, range of cutting speed, for this experiment in range <1,57m/s ; 7,85m/s>.

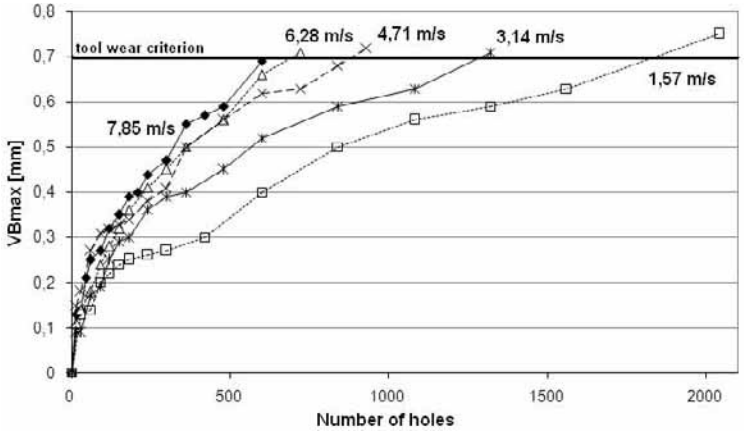

Fig.3. Curves of tool wear (dependency of indicator VBmax on number of drilled holes), it was graphically marked criterion of tool wear VBmax=0, 7mm

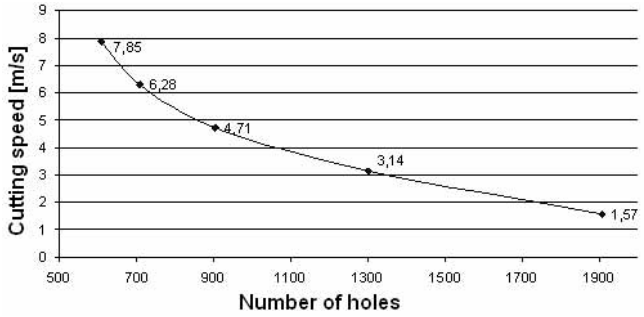

Fig.4. Number of holes made up to limit value of VBmax = 0,7mm for particular cutting speeds

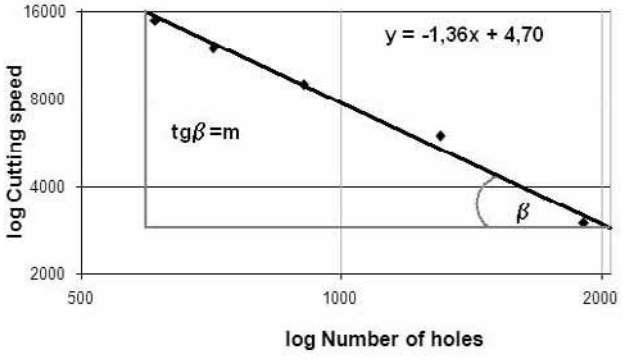

Fig.5. Dependence of tool life on cutting speed in logarithmic scale

CONCLUSION

Obtained results allow to formulate following conclusions:

1. Growth of cutting speed in range 1,57 m/s do 7,85 m/s make tool life even three times shorter.
2. With increasing of cutting speed increases the value of direct tool wear indicator VBmax.
3. With increasing of drilled holes number increases value of direct tool wear indicator VBmax. This relationship has logarithmic character.
4. Usage of tool life criterion based on direct indicator VBmax is recommended in scientific researches concern drilling wood based materials.

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Streszczenie: *Wpływ prędkości skrawania na trwałość ostrza podczas wiercenia płyt drewnopochodnych laminowanych.* W niniejszej pracy zbadano zależność pomiędzy prędkością skrawania a trwałością ostrza skrawającego. Badania opierały się na wierceniu otworów pięcioma narzędziami ze stali szybkotnącej o średnicy 10mm w płycie wiórowej laminowanej. Każde narzędzie pracowało z różną prędkością skrawania, posuw na obrót był wielkością stałą. Analizowano wielkości wskaźnika bezpośredniego zużycia ostrza VBmax określającego maksymalną szerokość starcia na powierzchni przyłożenia ostrza. Uzyskane wyniki pozwoliły stwierdzić, że trwałość ostrza maleje wraz ze wzrostem prędkości skrawania. Wyznaczono charakter tej zależności z określeniem wartości wykładnika Taylora.

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