INVESTIGATIONS ON THE IMPACT OF THE CUTTING EDGE ON WOOD-POLYMER COMPOSITE MACHINABILITY

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Abstract

The study presents research results on the workability of polyvinyl chloride and polyethylene-based WPCs containing wood meal fillers when drilled using different kinds of drill bits. The aim of the study was to determine proper machining work and thrust force during boring in selected WPC materials using drill bits of different cutting edge geometry with the aim to select drill bit geometry optimal for composite processing. The total of five drill bits was examined; three bits for metal drilling of different angle parameters, a drill bit for wood with straight head and a spur and lips as well as a drill bit for through boring in wood-based materials. Traditional drill bits for metal boring turned out to be most suitable for drilling in WPCs. The smallest thrust force was observed in the case of a drill bit for wood with straight head and a spur and lips, whereas the lowest proper machining work was recorded for the drill bit for metal. The screw bit with a conical head (here called a through bit) should not be recommended for WPC boring.

Key words: *WPC, wood-plastic composite, proper machining work, thrust force, cutting edge geometry.*

INTRODUCTION

At the present time, increasingly higher requirements are expected from wood-based materials regarding their strength, dimensional stability, resistance to moisture, biotic factors etc. Wood-plastic composites (WPC), combinations of wood and polymers, were developed with the idea of water resistance and are, at present, among the most developmental materials with great potentials due to the fact that they combine the best properties of wood and polymers. In the case of the United States of America, Canada and Japan this is a technology with an already established position both in industry and among consumers, whereas in Europe it is still considered a new area. In the USA, 400 000 tons of WPC products were manufactured in 2003 and their production has increased considerably since then [Kuciel 2007].

From the point of view of their application, the highest share is occupied by floor boards followed by construction woodwork (window profiles) as well as parts for car industry (door profiles, strips etc.).

A composite is made up of a filler of natural origin (40-65%), most frequently, it is wood or annual plants, in combination with a thermoplastic material, i.e. polyethylene, polypropylene, polyvinyl chloride and others.

Depending on the quantity of the applied wood, it is characterised by high resistance to moisture (absorbability – from several up to 10%, swelling – not more than 2%), biological and chemical degradation, atmospheric factors, it does not deform and crack in the course of utilisation and is characterised by high modulus of elasticity (3.000 – 6.000 MPa, or even up to 10.000 MPa).

Table 1 presents manufacturers of WPC products, application of their articles and composite composition.

Table 1. Companies manufacturing wood-plastic composites

Producer	Composition		Application
WERZALIT	50% shavings	50% PP	Terrace, façade, balcony boards
	60% shavings	40% PP	Windowsill, fencing boards
MOCO	60% meal	40% PP	Terraces, balconies
TECNODECK	70% wood dust	30% PE	Terraces, footbridges, floors
ETERNOIVICA	70% wood dust	30% PE	Terraces, footbridges, floors

WPC properties can be compared with polymer materials and evaluated using methods developed for them, although high levels of composite filling with wood meal warrants to compare them with properties of wood and wood-based materials of MDF type or chipboard [Gozdecki, Kociszewski, Zajchowski 2005].

Introduction of articles manufactured from wood-polymer composites makes it necessary to select appropriate tools for their processing and assembly. It is well known that when drilling using drill bits of different cutting edge geometry, the appropriate machining work can be affected not only by the angles of the main blade edge but also by the point angle, the rake of the drill, by the geometry of the drill transverse edge, value of the drill lip clearance and, most importantly, by the drill diameter. There is no information in the available literature concerning the choice of drill bits of appropriate geometrical parameters to drill in WPC materials.

RESEARCH OBJECTIVE

The aim of the investigations was to determine the optimal drill cutting edge parameters for processing WPCs, in other words, what drill bits are best to bore holes in wood-plastic composites in order to achieve minimal values of proper machining work and thrust forces.

METHODOLOGY

In order to determine the optimal drill bit geometry, it is necessary to perform measurements of machinability of a WPC material using different drill bits. To determine the proper machining work and thrust force, it is essential to fulfil the condition of maintaining equal shaving thickness which can be achieved by maintaining constant feed of the examined sample against the rotating drill bit. The description of the employed experimental stand can be found in the study by Wieloch and Pohl (1991).

Investigations were carried out on the following two types of WPC materials:

- WPC (PVC): 50% wood meal + 50% polyvinyl chloride of $\rho = 1350$ kg/m^3 density,
- WPC (PE): 50% wood meal + 50% polyethylene of $\rho = 1350$ kg/m^3 density,

for the following five drill bits of 8 mm diameter:

1. Screw bit No. 1 for metals from HSS steel (Fig. 1),
2. Screw bit No. 2 for metals from HSS steel (Fig. 1),
3. Screw bit No. 3 for metals from HSS steel (Fig. 1),
4. Screw bit No. 4 with straight head and a spur and lips further called 'wood drill bit' (Fig. 2),
5. Uneven screw bit No. 5 with a cone head further called a drill bit for through boring in wood-based materials (Fig. 3).

Angle parameters of individual drill bits are shown in Table 2.

Table 2. Angle parameters of experimental drill bits

Drill bit	Drill bit angle parameters			
	Ψ	α	β	γ
Nr 1. – for metals	112,20	5,40	61,15	23,05
Nr 2. - for metals	114,00	23,30	58,00	8,30
Nr 3. - for metals	161,00	16,00	49,20	24,40
Nr 4. – for wood		18,78	46,55	24,67
Nr 5. – through bit	64,19	41,39	38,35	10,26

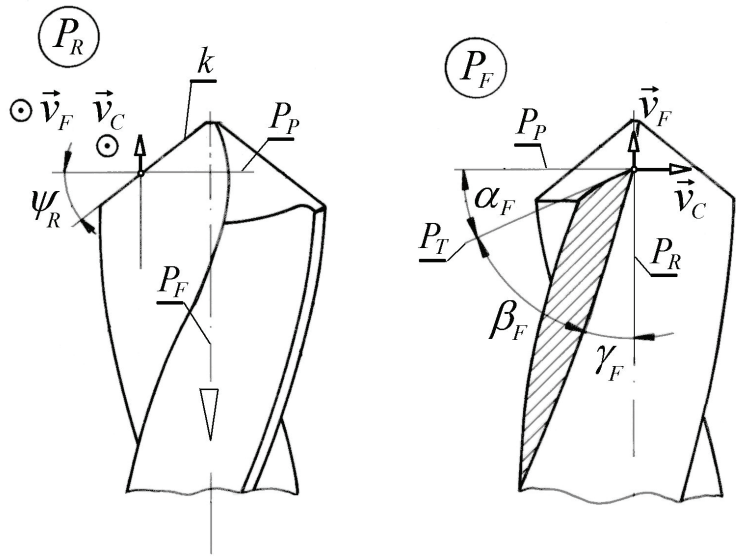

Figure 1. Screw drill bit for metals.

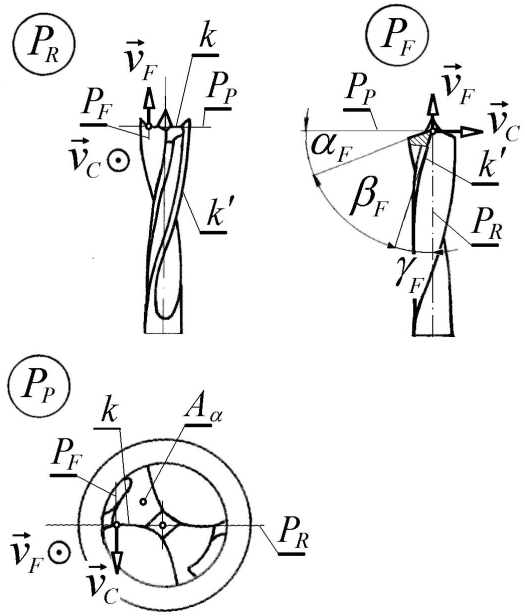

Figure 2. Screw with straight head and a spur and lips

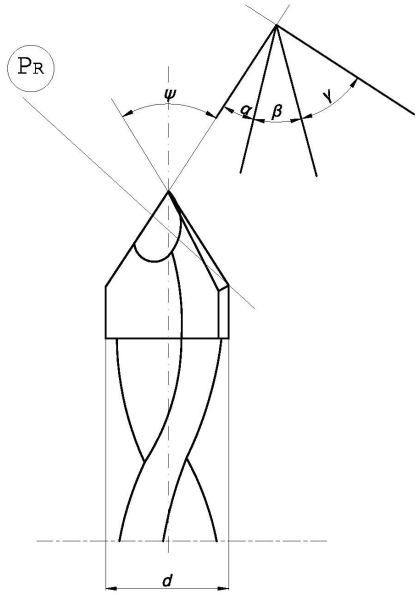

Figure 3. Uneven screw bit with a cone head.

The measurements of the machining moment and thrust force during drilling were repeated ten times, while the measurement results of the machining moment were converted into values of proper machining work according to the following formula [Pohl, Biniek 2002]:

$$k = \frac{8Fl}{ud^2}[MPa]$$

where:
d – drill bit diameter (d = 8 mm),
F – measured value of the force [N],
l – length of are (l = 107 mm),
u – feed per rotation (u = 0.10 mm/rot.).

RESEARCH RESULTS

Figure 4 presents measurement results of proper machining work of PVC and PE-based WPC materials during drilling with different drill bits.

Figure 5 presents graphically collated research results of thrust forces during the drilling of the examined composite materials using different drill bits.

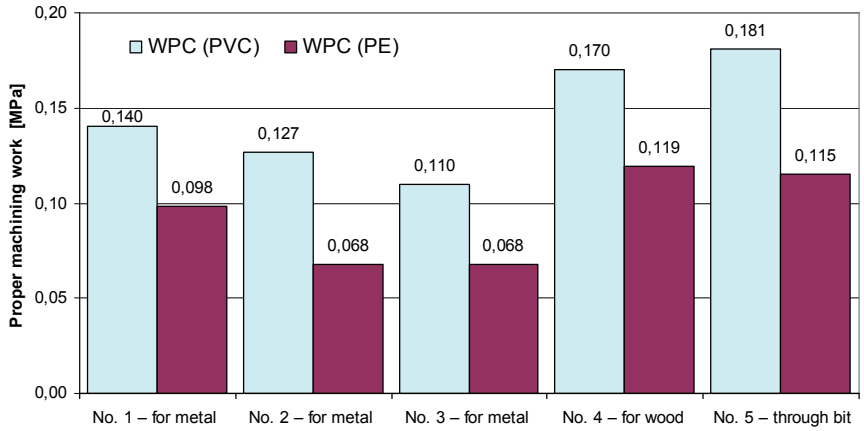

Figure 4. Proper machining work of PVC and PE-based WPC materials during drilling with different drill bits.

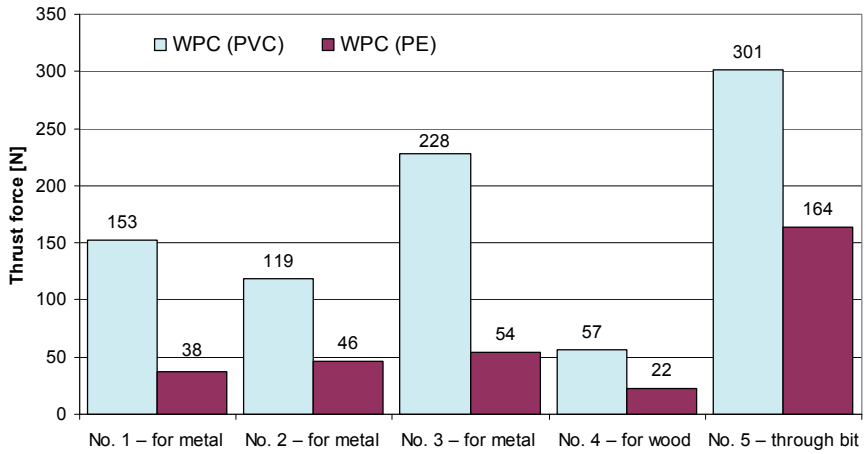

Figure 5. Thrust forces of PVC and PE-based WPC materials during drilling with different drill bits.

CONCLUSIONS

It can be concluded, on the basis of the above-presented results, that PVC-based WPCs are more difficult to work. In general, they are characterised by higher machining work as well as a considerably higher thrust force during machining using all drill bits.

Adopting proper machining work as a criterion, traditional drill bits for metal are more suitable for boring in WPCs than drill bits for boring wood and wood-based materials.

The drill bit for metal No. 2 was characterised by the lowest proper machining work during drilling but thrust forces developing during boring WPCs (PVC) significantly exceeded the remaining metal bits (No. 1 and 2) as well as the drill bit for wood (No. 4).

The screw bit No. 4 with straight head and a spur and lips also known as a wood drill bit was characterised by the lowest feed forces.

The screw bit with a conical head (here called a through bit, No.5), whose main application is boring in wood-based materials (chipboards and MDF), when used to drill WPCs was characterised by high proper machining works and thrust force values and, consequently, is not recommended for WPC boring.

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