Evaluation of delamination in drilling medium density fibreboard

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Abstract: Drilling is a frequently practised machining process in furniture manufacture owing to the need for component assembly. The drilling of medium density fibreboard (MDF) is significantly affected by the delamination tendency of these materials under the action of cutting parameters. The aim of this article is to study the cutting parameters (cutting speed and feed rate) on delamination in MDF drilling. A plan of experiments was performed drilling with cutting parameters prefixed in two MDF panels. The objective was to establish the correlation between cutting velocity and feed rate with the delamination around the MDF blind hole. The delamination factor decreases with the increase of cutting velocity and increases with the feed rate for both materials. The drill tests showed the important role of the cutting speed on the evolution of the delamination factor as a function of the material removal rate (MRR). The advantage of using a high cutting speed in drilling these materials is clear.

Keywords: drilling, medium density fibreboard (MDF), delamination, material removal rate (MRR)

1 INTRODUCTION

Medium density fibreboard (MDF) is an industrial wood product. It is made out of wood waste fibres glued together with resin, heat, and pressure. Nowadays, MDF products are preferred over solid wood in many applications owing to certain comparative advantages. MDF is appropriate for many interior and exterior construction and engineering applications. Drilling is a frequently practised machining process in furniture manufacture owing to the need for component assembly. The drilling of metals has been studied extensively in the literature but MDF drilling has not received much attention.

Recently, various authors [**1–6**], when reporting about the machining of MDF, have shown that machinability is strongly dependent on the cutting parameters, cutting forces, cutting tool (material and geometry), and workpiece material.

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Dippon *et al.* [**1**] investigated the orthogonal cutting mechanisms of MDF. The mechanics of orthogonal cutting of MDF were modelled. Orthogonal cutting tests both perpendicular and parallel to the MDF surface were conducted. A Coulomb friction model was assumed on both the flank and rake faces. According to these authors the experimental results showed that the friction on the rake face is rather small and the pressure exerted by uncut chip on the rake face mainly dominates the force on the rake face. These results are useful in describing the mechanisms of drilling and routing when machining MDF parts.

Aguilera *et al.* [**2**] investigated the cutting parameters required for the routing process of the distinct density layers found in MDF. The relationship between surface roughness, work material density, and cutting power is discussed.

Lin *et al.* [**3**] presented a study on the machinability of MDF. The behaviour of MDF was investigated by passing a cutting tool through it at a relatively low speed. These authors confirm that unrefined particles play a major role during machining. The board densities were found to have a major

Table 1 Some mechanical and physical properties of MDF panels tested

MDF ref.	Tensile strength (N/mm^2)	Flexural strength (N/mm^2)	Elasticity modulus (N/mm^2)	Humidity (%)	Density (kg/m^3)
LAMIPAN PB (wood coating layer) and SUPERPAN DÉCOR (melamine coating layer)	> 0.35	$\geqslant 13$	$\geqslant 1600$	5–13	650–700
Norm	EN 319	EN 310	EN 310	EN 322	EN 323

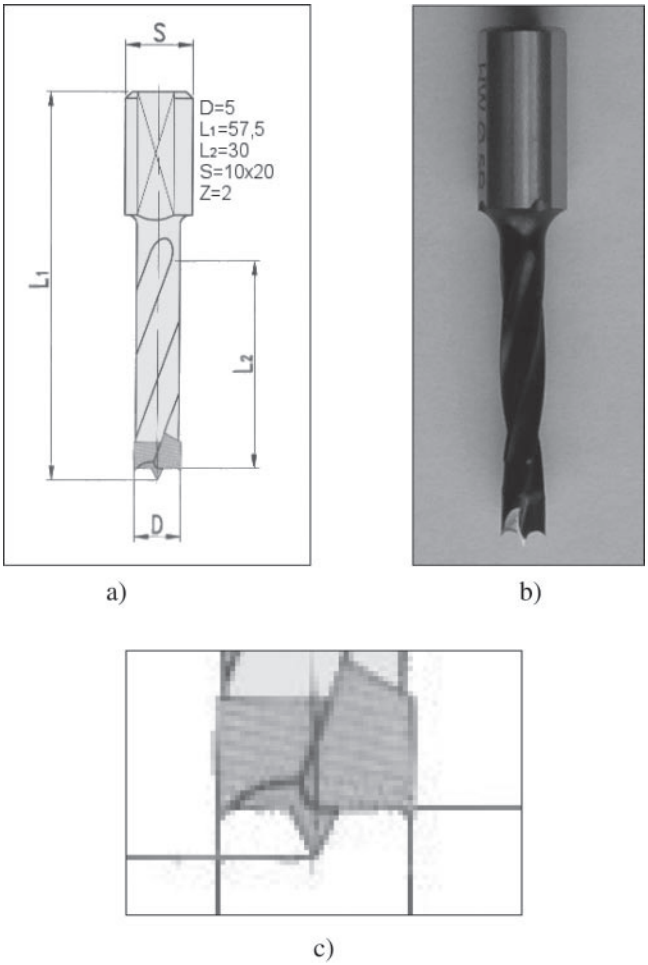


Fig. 1 Cemented carbide K10 special drill 'Brad' used in the tests: (a) dimensions of the drill; (b) special drill 'Brad'; (c) geometric detail of 'Brad' point

Table 2 Processing parameters used in drilling the MDF panels

Test	Spindle speed (r/min)	Cutting speed (m/min)	Feed rate (m/min)
1	1000	16	0.1000
2	1000	16	0.7125
3	1000	16	1.3250
4	1000	16	2.5500
5	1000	16	3.7750
6	1000	16	5.0000
7	4000	63	0.1000
8	4000	63	0.7125
9	4000	63	1.3250
10	4000	63	2.5500
11	4000	63	3.7750
12	4000	63	5.0000
13	7000	110	0.1000
14	7000	110	0.7125
15	7000	110	1.3250
16	7000	110	2.5500
17	7000	110	3.7750
18	7000	110	5.0000

influence on the machinability characteristics of the board.

Gordon and Hillery [4] presented a brief review of research on the prediction of cutting forces in cutting MDF with special emphasis on the work of Altintas and his co-workers [1, 5]. These works adapted a general mechanics and dynamics model for machining metals with helical end mills for predicting the cutting forces when machining MDF.

Subsequently, Philbin and Gordon [6] studied the application of polycrystalline diamond (PCD) in machining MDF. According to these authors the major benefit of using PCD is an extended tool life resulting from its superior properties over traditional tool materials.

Zhao and Ehmann [7] presented an original study on the development and experimental performance assessment of a new generation of spade drill bits. These authors confirm that the new spade bits present lower thrust and torque over the whole range of pragmatic operating conditions.

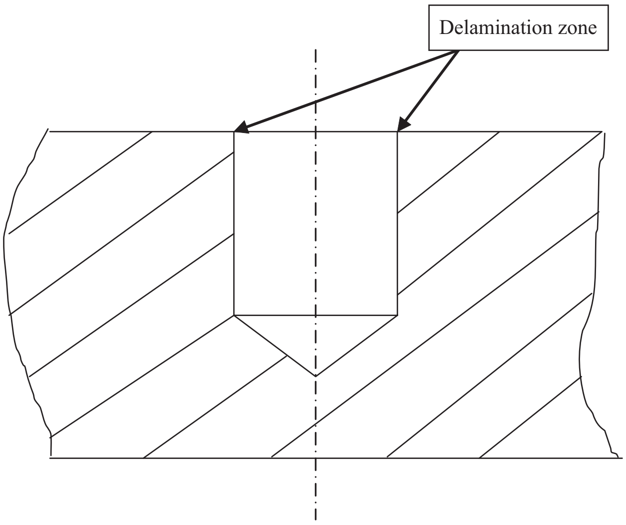
Recently, Davim *et al.* [8] presented a preliminary study on drilling two types of MDF panel. The drill tests showed the different scheme of delamination around the hole for each material (wood or melamine coating layer).

The current article presents some delamination aspects of drilling MDF as a function of cutting parameters as well the relationship between the delamination factor and the material removal rate.

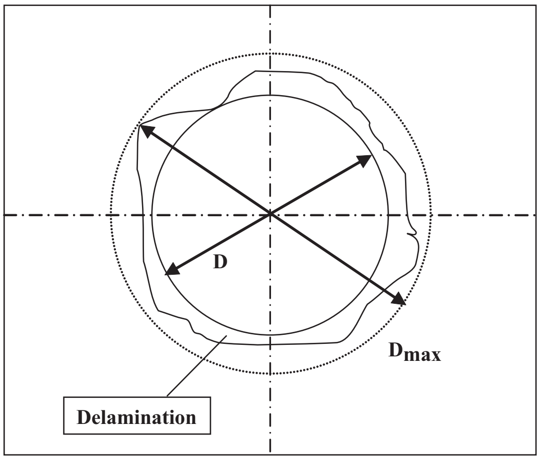
2 EXPERIMENTAL DETAILS

Two types of MDF panel, coated LAMIPAN PB (veneer layer) and SUPERPAN DÉCOR (melamine layer) with 16 mm of thickness, were tested. Some mechanical and physical properties of the MDF panels are described in Table 1.

The experiments were carried out on a *VCE500 MIKRON* Vertical Machining Centre with 11 kW



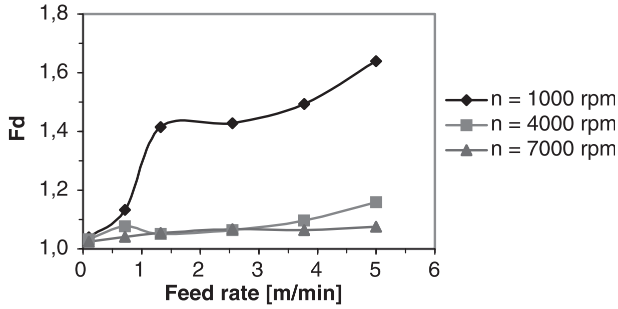
(a)



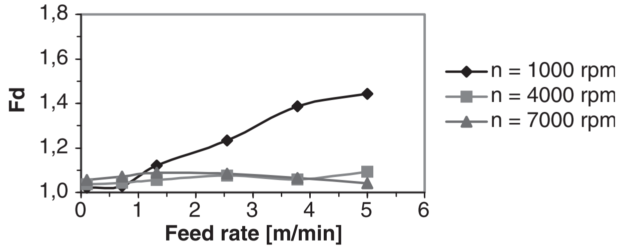
(b)

(c)

Fig. 2 Delamination factor: (a) delamination zone in the blind hole; (b) scheme for measuring the using toolmaker's microscope; (c) example of delamination in the MDF panel



(a)



(b)

Fig. 3 Delamination factor as a function of feed rate for different spindle speeds: (a) LAMIPAN PB; (b) SUPERPAN DÉCOR

spindle power and a maximum spindle speed of 7500 r/min.

The experiments were carried out on MDF panels using cemented carbide special drills 'Brad', grade K10, with 5 mm of diameter, as shown in Fig. 1.

Table 2 shows the cutting parameters used for drilling MDF panels tests. All tests reported in Table 2 were repeated. The blind holes present a depth of 12 mm.

The delamination around the entrance of the blind holes was measured with a toolmaker's microscope with 30 × magnification and 1 μm resolution. The delamination factor (F_d) is defined as the ratio of the maximum diameter (D_{max}) of the damage zone to the hole diameter (D) (Fig. 2).

3 RESULTS AND DISCUSSION

The results of drilling tests allowed the evaluation of delamination around the blind holes for two types of MDF panel: coated LAMIPAN PB (veneer layer) and SUPERPAN DÉCOR (melamine layer).

Figure 3 shows the evolution of the delamination factor as a function of the feed rate for different spindle speeds for both materials. From Fig. 3 it is clear that the delamination factor increases with the feed rate, and decreases with the spindle speed. According to the graphs, it is evident that for the range of 1000 r/min the SUPERPAN DÉCOR presents a lower delamination factor than the LAMINAPAN PB, but for the range of 4000 and 7000 r/min presents

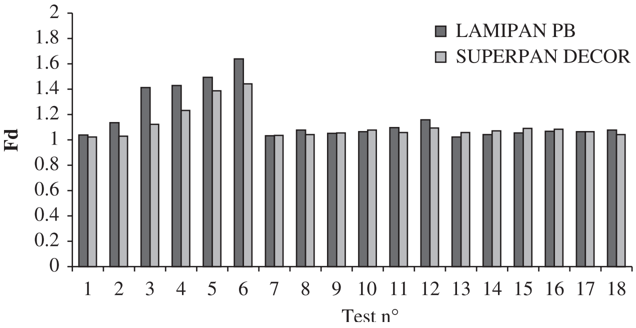
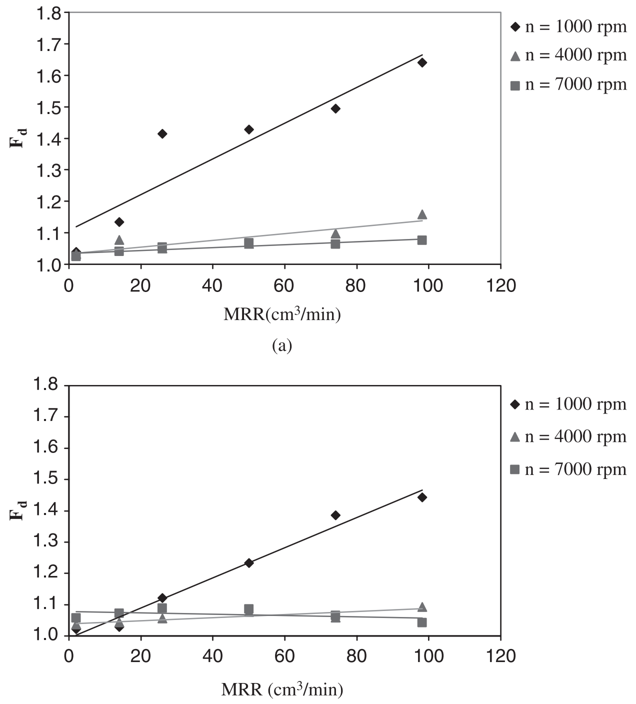


Fig. 4 Delamination factor for both materials



(b)

Fig. 5 Evolution of the delamination factor as a function of MRR for different spindle speed of (a) LAMINAPAN PB; (b) SUPERPAN DÉCOR

a similar delamination factor under the same cutting conditions (cutting speed and feed rate). Figure 4 compared the delamination factor for both materials for all completed tests and confirmed this analysis.

In Fig. 5 the evolution of the delamination factor as a function of the material removal rate (MRR) can be seen for different spindle speeds for both materials. In Fig. 3 the delamination factor clearly decreases with the spindle speed. The advantages of the cutting speed are evident in reducing the delamination factor for both materials. In general the delamination factor is inferior: 1.1 for a spindle speed 4000∼7000 r/min. Also, the material of the coated layer (veneer or melamine) determined the values of the delamination factor observed.

4 CONCLUSIONS

The following conclusions may be drawn from drilling MDF, based on the experimental results presented.

1. The delamination factor decreases with an increase of cutting speed and feed rate for both materials.
2. The SUPERPAN DÉCOR presents less delamination factor than the LAMINAPAN PB, under the same cutting parameters (cutting speed and feed rate).
3. The drill tests showed the important role of the cutting speed on the evolution of the delamination factor as a function of MRR. The advantage of the use of a high cutting speed in drilling these materials is clear.

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