ONLINE ISSN 2069-7430
ISSN-L 1841-4737

PRO LIGNO
www.proligno.ro

Vol. 13 N° 4 2017
pp. 174-180

STUDY REGARDING THE INFLUENCE OF THE TOOL GEOMETRY AND FEED RATE ON THE DRILLING QUALITY OF MDF PANELS

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Abstract:
Wood based panel such as medium density fibreboards (MDF) are extensively used in the furniture industry. The most common machining process used for joining is drilling. In order to achieve a good surface quality and minimize the delamination, two of the main parameters must be taken into consideration while drilling: the tip angle of the drill bit and the feed speed. The objective of this study is to analyze the influence of the tip angle of the drill bit and the feed speed on the processing quality evaluated by the size of delaminations at the entrance side and the exit side of the drill bit for two types of drills: flat and twist (helical) drills. To assess the defect, a non-dimensional parameter was used: the delamination factor. The results showed that, in general, the combination of small tip angle with low feed rate minimizes the delamination at drilling.

Key words: *drilling; delamination; MDF.*

INTRODUCTION

Drilling is one of the most usual and frequent type of processing in the wood industry with the most common application in the furniture industry. This has developed along years into a massive production of furniture, where one of the main raw material is fibreboard, mainly medium density fibreboard (according to FAOSTAT, the worldwide fibreboard production in 2016 was of app. 119 mil.m3).

The operation of free drilling, which is common for on-line processes, raises a surface defect noticed, at the medium density fibreboards, to occur around the drilled holes. Delamination is a processing defect which consists of a local detachment of the coating layer engaging chips/particles pull-offs from the fibreboard surface. This phenomenon can occur during drilling at the entrance side as well as at the exit side (for drilled through holes). Its magnitude depends on the processing parameters and can be used as an indicator of the drilling quality (Davim et al. 2008).

Some long ago, Radu (1967), in his extensive study on drilling with twist drills, referred to the quality of drilling the particleboards in terms of visual qualifications of the surface in the neighborhood of the processed holes. Parameters, as tool feed speed and tool geometry, were amongst the ones investigated, but the qualifications were limited to subjective qualitative assessments as: “good”, “weak”, “slight increase”, “slight decrease”.

More recently, the delamination caused by drilling the wood based panels, especially medium density fiberboards (MDF), was quantitatively assessed by using a parameter called delamination factor, Fd. Hence, Davim et al. (2008) investigated the relationships and parametric interaction between the feed rate and the cutting speed on the Fd at entry and exit side of the holes in drilling the MDF. Two types of MDF panels, melamine coated and veneered, were tested using cemented carbide (K20) drills. The Fd decreased with the increase of the cutting speed and increased with the feed rate for both materials. Palanikumar et al. (2009), Prakash et al. (2009) studied the performance characteristics given by Fd in drilling operations of MDF boards using carbide tools. The machining parameters considered were: the spindle speed, the feed rate and the drill diameter. They found that Fd decreases with the increase of the cutting speed and increases with the feed rate and drill diameter. Prakash and Palanikumar (2011) investigated the influence, at MDF, of the spindle speed, feed rate and drill diameter on the surface roughness of the processed hole. The experimental result revealed that the most significant drilling parameter for the surface roughness was the feed rate followed by the cutting speed. Valarmathi et al. (2013) analyzed the influence of cutting parameters in a systematic approach on delamination in drilling of prelaminated MDF wood panels with High Speed Steel (HSS) twist drills of different diameters. The results showed that the optimal conditions for minimizing the delamination are high spindle speed, low feed rate, and small drill diameter (6mm).

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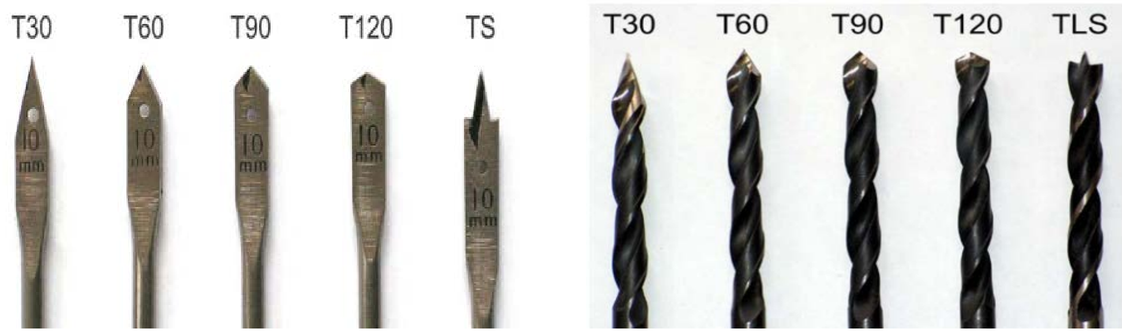
OBJECTIVE

The objective of this study is to evaluate the influence of the tool type, geometry and feed speed on the drilling quality of the medium density fibreboards (MDF) panels. The processing quality was evaluated by de size of delamination measured, both, at the entrance and exit sides of the drilled holes. In order to evaluate the delamination damage occurred during drilling, the delamination factor was taken into consideration.

MATERIAL, METHOD, EQUIPMENT

The experiments were performed using 4 flat drill bits (rake angle γ = 0°) with 10mm cutting diameter, with different tip angles ($2\kappa_r$ = 30°, 60°, 90°, 120°) and one spade drill bit (Fig. 1a). The clearance angle of all drills was the same α = 20°. The symbols used for these drills were tip angle related: T30, T60, T90, T120, respectively TS for the spade drill. The second type of drills used were 4 twist (helical) drill bits with 10mm cutting diameter, with different tip angles ($2\kappa_r$ = 30°, 60°, 90°, 120°) and one lip and spur drill bit (Fig. 1b). The clearance angle of all drills was the same α = 20°. The symbols used for these drills were tip angle related: T30, T60, T90, T120, respectively TLS for the lip and spur drill.

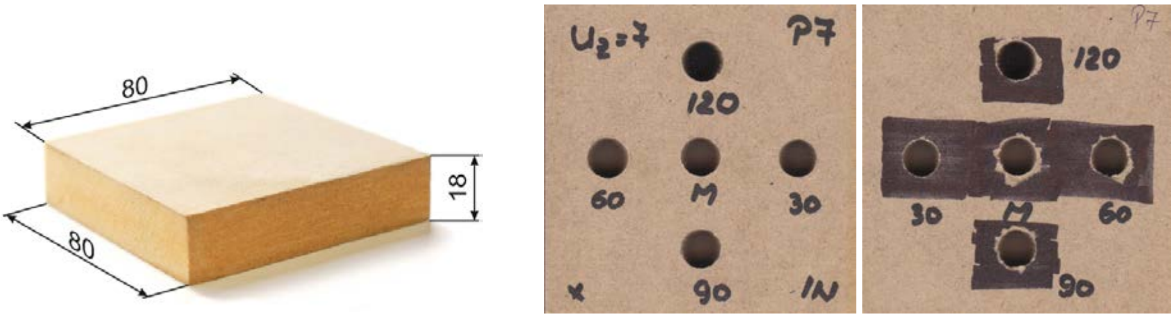


a. b.

Fig. 1.

Types of drills used for processing: a – four flat drills with the tip angle $2\kappa_r$ of 30°, 60°, 90°, 120° and one spade drill; b – four helical drills with the tip angle $2\kappa_r$ of 30°, 60°, 90°, 120° and one lip and spur drill.

For both types of drills, a set of fourty square samples □80mm were cut from a single pre-laminated 18mm thick particleboard (Fig. 2a).



a. b.

Fig. 2.

Samples used for drilling: a – sample dimensions; b - MDF specimens drilled with the flat drills (T30, T60, T90, T120, TS) when the tooth bite was 0.7mm at the entrance side and the exit side.

They were divided into four groups of ten specimens each. Each specimen was drilled with five different drills (T30, T60, T90, T120, TS respectively, T30, T60, T90, T120, TLS) (Fig. 2b).

Each group of ten specimens was drilled with a different feed speed so that the tooth bite, f_z, was different, having the following values: 0.1, 0.3, 0.5 and 0.7mm. The rotation speed of the drills was the same, n = 3000rpm. This led to four feed speed values, vf = 0.6, 1.8, 3.0 and 4.2m/min.

The processing machine was a CNC processing centre type ISEL GFV/GFY, which allowed the exact set-up of the drills rotation speed and of the feed speeds (Fig. 3).

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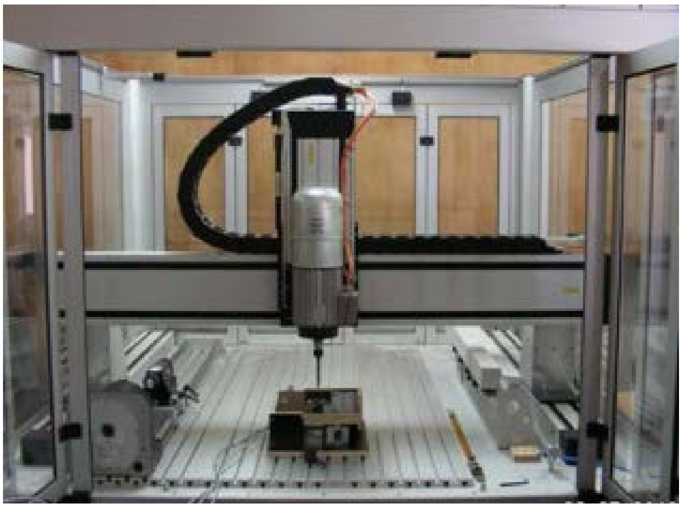

Fig. 3.
CNC processing centre type ISEL GFV/GFY used for drilling.

After drilling, each hole diameter was measured with an electronic calliper, with a 0.01mm precision, on two perpendicular directions and a mean diameter was calculated for both hole sides (entrance and exit), as can be seen in Fig.4. All drilled specimens were then scanned on both sides and received codes, IN, for entrance side, respectively OUT, for exit side (Fig. 2b).

The scanned images were used to evaluate the delaminations that occurred around each hole, on both sides. The delamination was evaluated by the delamination factor F_d, given in equation 1:

$$F_d = \frac{D_{\max}}{D} \tag{1}$$

- where: D_{max} is the diameter of the circle circumscribed to the defect, while D is the mean hole diameter given by calliper measurements D1 and D2 (Fig. 4)

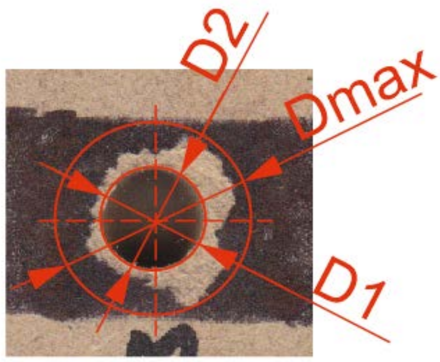

Fig. 4.
The measurement of diameters for calculation of the delamination factor in order to evaluate the delamination caused by drilling on the MDF sample.

RESULTS AND DISCUSSION

The mean values, standard deviation and coefficients of variation were calculated for the delamination factor F_d (Table 1 and Table 2, for flat drills).

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Table 1

The mean values, standard deviations and coefficients of variation for the DELAMINATION FACTOR, at the ENTRANCE SIDE of the specimens drilled with FLAT DRILLS, for various feed rates and drill geometries

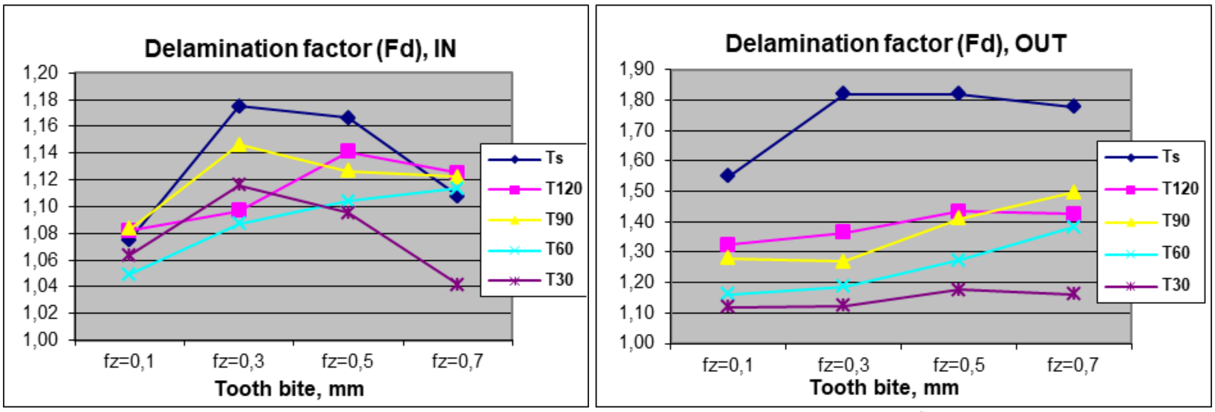
IN	fz = 0,1			fz = 0,3			fz = 0,5			fz = 0,7		
	mean	SD	cvar (%)	mean	SD	cvar (%)	mean	SD	cvar (%)	mean	SD	cvar (%)
T30	1,06	0,05	4,98	1,12	0,06	5,34	1,10	0,05	4,81	1,04	0,02	2,33
T60	1,05	0,01	1,17	1,09	0,03	2,35	1,10	0,03	2,93	1,11	0,04	3,29
T90	1,08	0,01	0,85	1,15	0,04	3,74	1,13	0,04	3,52	1,12	0,04	3,33
T120	1,08	0,04	3,72	1,10	0,02	2,16	1,14	0,04	3,74	1,12	0,04	3,22
TS	1,08	0,04	3,48	1,18	0,05	3,99	1,17	0,07	5,65	1,11	0,07	6,04

Table 2

The mean values, standard deviations and coefficients of variation for the DELAMINATION FACTOR, at the EXIT SIDE of the specimens drilled with FLAT DRILLS, for various feed rates and drill geometries

OUT	fz = 0,1			fz = 0,3			fz = 0,5			fz = 0,7		
	mean	SD	cvar (%)	mean	SD	cvar (%)	mean	SD	cvar (%)	mean	SD	cvar (%)
T30	1,12	0,04	3,64	1,12	0,04	3,29	1,18	0,07	5,60	1,16	0,03	2,84
T60	1,16	0,03	2,16	1,19	0,04	3,70	1,27	0,08	5,96	1,38	0,14	9,99
T90	1,28	0,05	4,26	1,27	0,05	4,17	1,41	0,18	12,80	1,50	0,19	12,58
T120	1,32	0,12	8,84	1,36	0,10	7,35	1,43	0,14	9,59	1,42	0,12	8,35
TS	1,55	0,29	18,64	1,82	0,18	9,76	1,82	0,15	8,17	1,78	0,12	7,03

By drilling with flat drills, there was a general trend of delamination increase with the increase of the tooth bite (feed rate) (Fig. 5).



a. b.

Fig. 5.
The variation of the delamination factor with the tool feed speed and geometry, using flat drills (figures represent mean values): a - at the entrance side of the drilled specimens; b - at the exit side of the drilled specimens.

Whatever the specimen (hole) side, the biggest delaminations occured when drilling with the spade drill bit (TS), regardless of the used feed speed (exception: delaminations on entrance side produced when drilling with f_z=0.1mm and f_z=0.7mm). This trend can be noticed better on the exit side of the specimens. On the entrance side, where the delamination is very small (sometimes almost non-existent) and the maximum value of the delamination factor is F_d=1.17, the influence of the tool geometry on the delamination size did not have a clear trend.

As expected the delamination factor has higher values on the exit side of the specimens than on the entrance side.

The mean values, standard deviation and coefficients of variation were also calculated for the delamination factor F_d, by drilling with the twist drills (Table 3 and Table 4).

Table 3

The mean values, standard deviations and coefficients of variation for the DELAMINATION FACTOR, at the ENTRANCE SIDE of the specimens drilled with TWIST DRILLS, for various feed rates and drill geometries

IN	fz = 0,1			fz = 0,3			fz = 0,5			fz = 0,7		
	mean	SD	cvar (%)	mean	SD	cvar (%)	mean	SD	cvar (%)	mean	SD	cvar (%)
T30	1,00	0,00	0,00	1,01	0,02	2,18	1,02	0,04	3,48	1,10	0,04	3,95
T60	1,00	0,00	0,00	1,01	0,03	2,60	1,06	0,06	6,01	1,17	0,08	7,10
T90	1,00	0,00	0,00	1,01	0,03	3,14	1,05	0,06	5,66	1,16	0,05	4,23
T120	1,00	0,00	0,00	1,01	0,02	2,44	1,12	0,06	5,03	1,20	0,07	5,73
TS	1,00	0,00	0,00	1,02	0,04	3,49	1,02	0,04	4,25	1,12	0,06	5,26

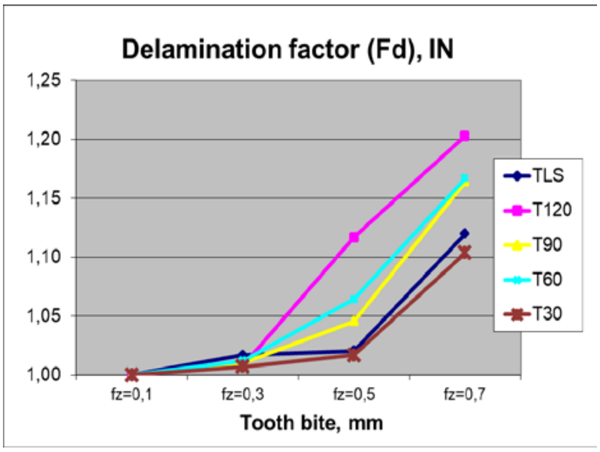
Table 4

The mean values, standard deviations and coefficients of variation for the DELAMINATION FACTOR, at the EXIT SIDE of the specimens drilled with TWIST DRILLS, for various feed rates and drill geometries

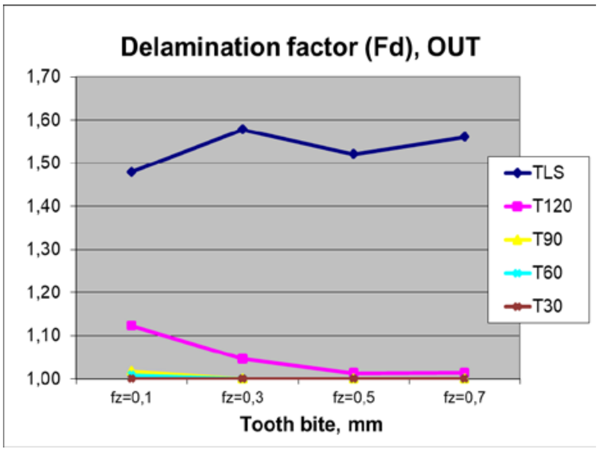
OUT	fz = 0,1			fz = 0,3			fz = 0,5			fz = 0,7		
	mean	SD	cvar (%)	mean	SD	cvar (%)	mean	SD	cvar (%)	mean	SD	cvar (%)
T30	1,00	0,00	0,00	1,00	0,00	0,00	1,00	0,00	0,00	1,00	0,00	0,00
T60	1,01	0,03	2,55	1,00	0,00	0,00	1,00	0,00	0,00	1,00	0,00	0,00
T90	1,02	0,05	5,13	1,00	0,00	0,00	1,00	0,00	0,00	1,00	0,00	0,00
T120	1,12	0,08	7,17	1,05	0,05	5,22	1,01	0,04	4,09	1,01	0,04	4,33
TS	1,48	0,18	12,03	1,58	0,23	14,82	1,52	0,10	6,50	1,56	0,14	9,07

The samples drilled with the twist drills have small delaminations on the entrance side, for drilling with a feed rate f_z=0.7mm for all types of twist drill bit (with very low values), while, for the other feed rates (f_z=0.1mm, f_z=0.3mm and sometimes f_z=0.5mm) the quality of the processing was very good (Fig. 7).

On the exit side of the specimens, drilling with T30, T60, and T90 twist drill bits, gave a very good quality also, without delaminations, while drilling with T120 drill bit, delaminations appeared only at a feed rate of f_z=0.1 and f_z=0.3, with very low values for the delaminiation factor (Fig. 6).



a.



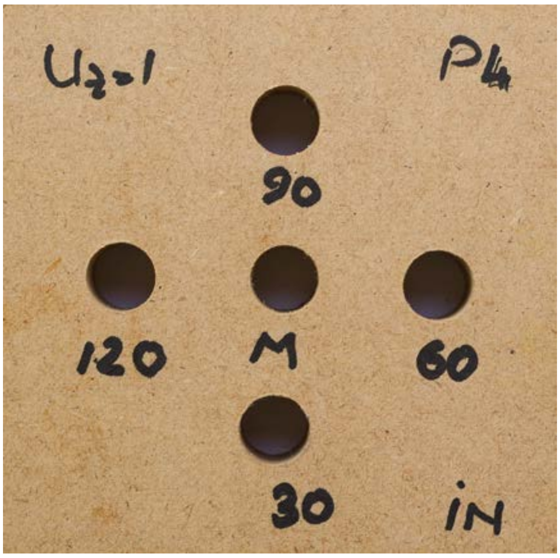
b.

Fig. 6.

The variation of the delamination factor with the tool feed speed and geometry, using twist drills (figures represent mean values): a - at the entrance side of the drilled specimens; b - at the exit side of the drilled specimens.

Whatever the specimen (hole), the biggest delaminations occured on the exit side, when drilling with the lip and spur drill bit (TLS), regardless of the used feed speed.

Drilling with the twist drill bits gave lower values for the delamination factor and a better quality of the processing, than drilling with the flat drill bits.



a.

b.

Fig.7.
Sample drilled with twist drills and tooth byte f_z of 0.1mm:
a - at the entrance side b - at the exit side.

In general, T30, T60 and sometimes T90 gave a better processing quality than T120. TLS gave the worse quality by far, on both types of drills: flat drills and twist drills. However, because of its elongated tip geometry, processing with T30 drill bit in case of thin boards is limited to manufacturing through holes rather than with limited depth (Fig. 8).

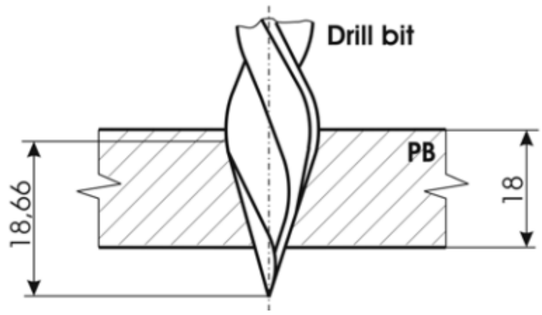


Fig. 8.
Limitation of T30 drill bit and its elongated tip geometry when manufacturing thin boards.

CONCLUSIONS

Free drilling is a common operation for medium density fibreboards in the furniture industry. The quality of this operation can be assessed by the delamination occurring around the hole. This paper examined this defect by means of a non-dimensional parameter one used also by other researchers, the delamination factor. The influence of the feed rate (tooth bite) and tool geometry (tip angle) was assessed by the above quality parameter.

Generally, the delamination increased with the increase of the tooth bite (feed rate) for all drill types and geometries. The defect zone was larger at the exit side of the drill compared to the entrance side with the greatest amount for the spade drill, followed by the other drills (respectively for the lip and spur drill).

Whatever the specimen, drilling with the twist drill bits gave lower values for the delamination factor and a better quality of the processing, than drilling with the flat drill bits.

If delamination and flexibility of hole depth is considered, a flat drill with 60° tip angle gave the best quality for small feed rates. The spade drill and the flat drill with the greatest tip angle, 120°, do not seem appropriate for processing medium density fibreboards (MDF).This conclusion also applies in case of drilling with twist drills and lip and spur drill.

Further studies may complete these results for various rotation speeds and other types of drills to optimise the process quality at drilling pre-laminated particleboards.

ONLINE ISSN 2069-7430
ISSN-L 1841-4737

PRO LIGNO
www.proligno.ro

Vol. 13 N° 4 2017
pp. 174-180

REFERENCES

Davim JP, Clemente VC, Silva S (2008) Drilling investigation of MDF (medium density fibreboard). Journal of Materials Processing Technology 203:537–541. Issues 1–3.

Gurau L, Timar MC, Cionca M, Olarescu A, Dumitrascu R (2010) An objective method to analyse some microscopic characteristics of two secondary beech wood resources. PRO LIGNO 6(1):35-45.

Ispas M, Gurau L, Racasan S (2014) Study Regarding the Variation of the Thrust Force, Drilling Torque and Surface Delamination with the Feed per Tooth and Drill Tip Angle at Drilling Pre-laminated Particleboard. PRO LIGNO 10(4):40-52.

Ispas M, Gurau L, Racasan S (2015) Influence of the Tool Point Angle and Feed Rate on the Delamination at Drilling of Pre-laminated Particleboard. PRO LIGNO 11(4):494-500.

Palanikumar K, Prakash S, Manoharan N (2009) Experimental Investigation and Analysis on Delamination in Drilling of Wood Composite Medium Density Fiber Boards. Materials and Manufacturing Processes 24, Issue 12.

Prakash S, Palanikumar K (2011) Modeling for prediction of surface roughness in drilling MDF panels using response surface methodology, Journal of Composite Materials 45(16):1639-1646.

Prakash S, Palanikumar K, Manoharan N (2009) Optimization of delamination factor in drilling medium-density fiberboards (MDF) using desirability-based approach. The International Journal of Advanced Manufacturing Technology 45:370-381. Issue 3-4.

Radu A (1967) Contributions to the establishment of the optimal parameters for wood drill bits (in Romanian); PhD Thesis. Institutul Politehnic Braşov.

Valarmathi TN, Palanikumar K, Latha B (2013) Measurement and analysis of thrust force in drilling of particleboard (PB) composite panels, Measurement 46:1220–1230. Issue 3

Valarmathi TN, Palanikumar K, Sekar S (2013) Parametric analysis on delamiation in drilling of wood composite panels. Indian journal of science and technology. Vol 6 (4):4348-4356.