

**THE EFFECT OF THE WOOD SPECIES ON THE
ROUGHNESS OF THE SURFACE AND PROFILED AREAS
OF MEDIUM DENSITY FIBERBOARD**

TURGAY AKBULUT

ISTANBUL UNIVERSITY, FORESTRY FACULTY, DEPARTMENT OF FOREST PRODUCTS,
ISTANBUL, TURKEY

ENÜS KOÇ

SFC INTEGRATED WOOD PRODUCTS INDUSTRY, BARAJ YOLU KILLIK MEVKII,
KASTAMONU, TURKEY

ABSTRACT

The surface and profiled areas roughness of medium density fiberboard (MDF) is very important when MDF panels are used for the direct painting and thin laminating. There are many variables affecting the surface roughness, in this study, the effect of the single wood species and mixtures of species on the roughness of the surface and profiled areas were investigated. The results showed that the wood species had an effect on the roughness of the surface and especially profiled areas of MDF. Profiled MDF manufactured from 75% oak and 25% beech furnish were the roughest, with an average value of 14.20 μm and 17.18 μm , at 5 mm in depth from surface and core layers, respectively.

KEY WORDS: medium density fiberboard, profiled MDF, surface roughness, density profile, wood species

INTRODUCTION

A number of variables affect final board properties. Among the major variables are wood species, the type of raw material, the type and size of fiber generated, the resin type and amount, additives used, mat moisture content, and pressing conditions. Wood species is one of the most important variables among these. It has strong relationships with virtually every other variable. Some wood species are more suitable than others for final board properties and end use (Akbulut et al. 2000, Anonymous 1993, Koç 2002, Maloney 1993).

In general, low quality softwoods and hardwoods either as a single species or as a mixture depending on local timber availability, in the form of round wood, slab wood, forest thinnings and sawmill and factory residues can be used to manufacture of medium density fiberboard (MDF) in many countries.

The future trend shows that mixtures of species from both hardwoods and softwoods of widely varying densities will become even more common. In the usual case, therefore, the process must be able to cope with wide variations in the species mix (Maloney 1993).

If a single species is used, the production process can be adjusted to have maximum uniformity in panels properties. However, a mixture of species is an important factor for influencing both physical and mechanical properties of the final product (Akbulut et al. 2000).

Softwood consists primarily of longitudinal tracheids that are relatively long, four- to six-sided, prismatic elements with tapered, closed ends. These tracheids are the important pulp fibers. In hardwoods, the vessels, which are large tubelike cells that also are thin walled and short and contribute little to the pulp mass. The important fiber type is the fiber tracheid. It is similar to the softwood tracheid, rather thick walled and long with pointed ends. Hardwoods parenchyma cells and vessels break up readily in the pulping process and produce much of the "fine" fraction of the pulp (Suchland and Woodson 1986).

The degree of surface roughness is function of both raw materials properties and production processes. Fiber size and geometry are examples of some of the most important raw material characteristics; resin content, pressing, and sanding are the major manufacturing parameters that affect surface quality of the final board products. The surface roughness of MDF is significant when panels are used as the substrate for overlays such as thin melamine paper or vinyl. Fine irregularities on the board surface will show through overlays, and this affects product grade, quality, finishing, and gluing (Hiziroglu 1996).

Even closer compaction of the fibers in high density MDF enhances the machining characteristics of the board allowing more complicated profiles to be cut. The well compacted surfaces and edges result in excellent paint finishes with only minimum surface preparation. Several bedroom and kitchen door manufacturers are using high density MDF to take advantage of these good machining and finishing characteristics (Anonymous 1993, Wang et al 2001).

For the direct painting and thin laminating of profiled MDF to be successful, the surfaces and profiled areas have to be smooth and stable. Hence, in this study, the effect of the single wood species and mixtures of species on the roughness of the surface and profiled areas were investigated.

MATERIAL AND METHODS

Wood species and board manufacturing

Medium density fiberboards (488 by 210 by 18 mm sanded) used in this study were manufactured at Divapan Integrated Wood Panel Company located in Duzce, Turkey. The details of the manufacturing conditions and other properties of the experimental boards are shown in Tab. 1 and 2.

A total of 20 panels, four for each type of furnish, were manufactured. The panels surfaces were sanded with a sequence of 50, 80 and 120 grit size following the cooling. Then, all panels were conditioned at 65 % relative humidity and 25 °C in a conditioning chamber. A total of 48 profiles, 12 for each panel, from each type of panel were prepared for the roughness of surfaces and profiled areas evaluations (Fig. 1).

Tab. 1: Manufacturing conditions of the experimental boards

Chip size	25 x 20 x 4.5 (mm)
Steaming time	3 (min.)
Steaming pressure	8 (bar)
Steaming temperature	181 ($^{\circ}$ C)
Defibrator type	Andritz – Sprout Waldron
Mat moisture content	11 (%)
Resin content (Urea-formaldehyde)	11 (%)
Hardener (NH_3SO_4)	0,8 (%)
Pressing pressure	3.8 (N/mm ²)
Pressing temperature	175 ($^{\circ}$ C)
Pressing time	250 (sec.)

Tab. 2: Some properties of the experimental boards

Panel type	Furnish type	Panel density*
A	75 % oak + 25 % beech	750
B	50 % oak + 50 % beech	750
C	33.3% pine + 33.3 % oak + 33.3 % beech	750
D	100 % ash	750
E	100 % poplar	750

*) Density at 12 % moisture content

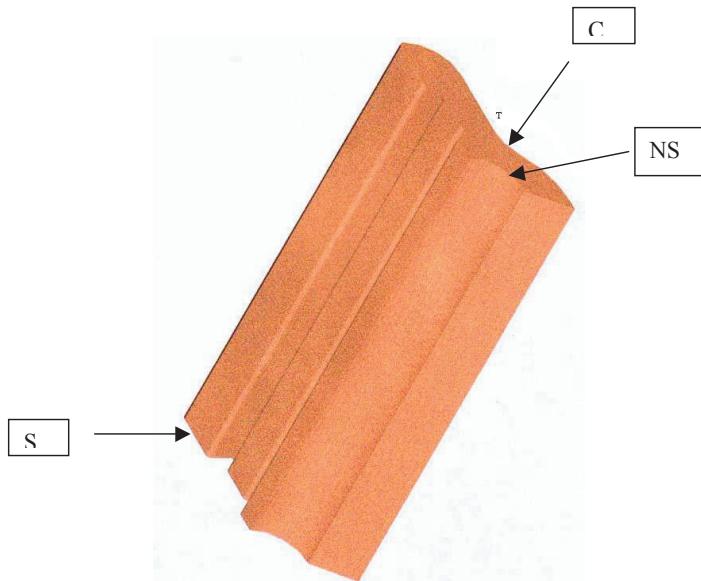


Fig. 1: Model of profile prepared and places of the roughness measurement on the profile, (C: core, S: surface and NS: near the surface.)

Roughness test

Roughness measurements were performed on the core (C), near the surface (at 5 mm in depth from surface, NS) and on the surface (S) of the sample profiles (Fig. 1). A total of 48 measurements with a 12.5 mm tracing length and $\lambda_c=2.5$ mm were conducted for each place of the measurement according to ISO 1997 using stylus type profilometer (*Mitutoyo SJ-301*). Average roughness (Ra) parameter was used to evaluate the surface characteristics of the profiles.

Fiber Sizes Analysis

Fiber sizes analysis were conducted to determine the relation between roughness values and wood species or mixtures on an *Imal VU 100* analyzer by taking three gr dried fiber from each furnish type.

In the end of fiber sizes analysis, fiber lengths (in mm) which correspond 16% (A16), 50% (A50) and 84% (A84) of total fiber weight; and percentages of total fiber weight which correspond 0.315 mm (*ratio of the best fiber*) and 1.0 mm (*ratio of good fiber*) fiber lengths were determined and given in Figure 2. Following values were determined.

$$\text{Mean fiber size} = (A16+A50+A84)/3 \text{ (mm)}$$

$$\text{Normal size range} = (A84-A16) \text{ (mm)}$$

It is usually accepted in fiber analysis that below the A16 is dust, and over the A84 is coarse fiber.

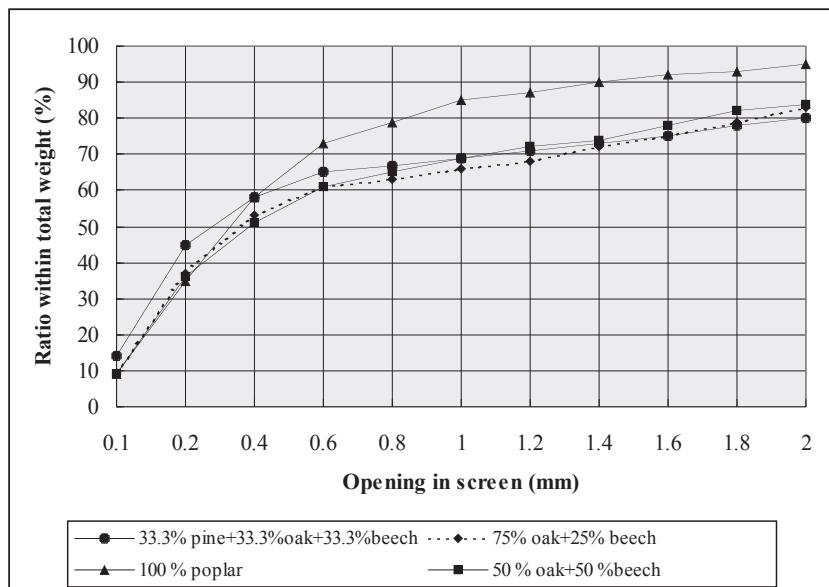


Fig. 2: Results of the fiber sizes analysis of all furnish types

Density profiles

Three specimens (50 by 50 mm) from each type of panel were used to determine the vertical density profiles on an *Imal DPX 100* x-ray scanning system.

Statistical method

Analysis of variance (ANOVA) was conducted ($\alpha=0.05$) for testing significant difference between wood species or mixtures in terms of the roughness of surface and profiled areas. When the variance analysis indicated a significant difference among the panels, a comparison of the means was done using a Duncan test to identify which panel was significantly different from other.

RESULTS AND DISCUSSION

Roughness measurements of the specimens

Average roughness values of the surface and profiled areas of all panels are presented in Tab. 3.

Tab. 3: Average roughness values of the surface and profiled areas

Panel type	Mean	Place of the measurement		
		Surface (S)	At 5 mm in depth from surface (NS)	Core (C)
A	Ra (μm)	2.50(0.52)* A**	14.20(2.37)* A**	17.18(1.78)* A**
B	Ra (μm)	3.21(0.68) B	11.65(1.57) B	14.60(1.73) B
C	Ra (μm)	3.53(0.67) C	10.25(2.89) C	11.76(1.47) D
D	Ra (μm)	3.11 (0.39) B	7.87(1.40) D	13.37(1.64) C
E	Ra (μm)	3.36 (0.65) CB	14.13(1.70) A	14.87(1.68) B

*)Numbers in parentheses are standard deviation

**)There is no significant difference among the Ra values of the being same letter panel types

Fiber Size Analysis

Results of the fiber sizes analysis of all furnish types are presented in Tab. 4 and Fig. 3.

Tab. 4: Results of the fiber sizes analysis of all furnish types

Property	A	B	C	E
Mean fiber size (mm)	0.830	0.832	0.87	0.527
Normal size range (mm)	1.88	1.864	2.14	0.99
Ratio of the best fiber (%)	47	45	55	50
Ratio of good fiber (%)	66	68	69.5	83

The fiber size analysis showed that B and A furnish types gave approximately the same results. Ratio of the best fiber size and ratio of good fiber size of the C furnish type were better than those of A and B, while mean fiber size and normal fiber size range were coarser. E furnish type gave the best values among all the furnish types in terms of general fiber size properties.

Density profiles

Density profiles of the panels are presented in Fig. 3. Average surface roughness values and surface density values of all panel types are presented in Tab. 5.

Tab. 5: Average surface roughness values and surface density values of all panel types

Property	C	E	B	D	A
Surface roughness (μm)	3.53	3.36	3.21	3.11	2.50
Surface density (kg/m^3)	1181	1215	1265	1215	1219

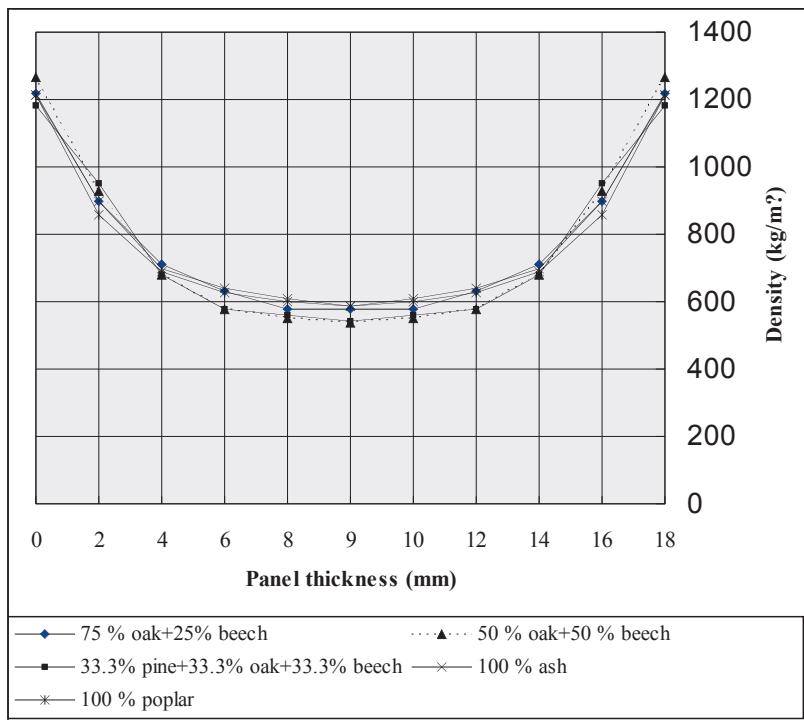


Fig. 3: Density profiles of the panels

As seen in Tab. 5, C type panels (%33.3 pine + %33.3 oak + %33.3 beech), its surface density was the lowest (1181 kg/m^3), gave the roughest surface. Yet, panels did not show a definitive relationship between surface density and Ra values. Similar results were also found by Hiziroglu (1996). Surface roughness also depends on the sanding process; in fact, there is no large scale difference between surface roughness values of the panels.

Average core roughness values and core density values of all panel types are presented Tab. 6.

Tab. 6: Average core roughness values and core density values

Property	A	E	B	D	C
Core roughness (μm)	17.18	14.87	14.60	13.77	11.76
Core density (kg/m^3)	576	586	539	587	543

As seen in Tab. 6, core roughness value ($17.8 \mu\text{m}$) of A type (75 % oak and 25 % beech) profiles was rougher than others. Whereas, surface roughness of this profile was the smoothest ($2.50 \mu\text{m}$). Core roughness of the profiles can be related to both fiber characteristics and manufacturing parameters. The porous anatomical structure of oak is a main factor causing higher roughness compared to the other panels.

Core roughness of E type (100% poplar) profiles is also relatively high ($14.87 \mu\text{m}$) in spite of having the best fiber size properties and high core density. This case was a result of poplar wood that contains high proportion of tension wood that was grown in plantation. The tension wood is characterized by less trachea, more fibers, thicker cell wall, and greater shrinkage than normal wood. Beside, gelatinous fibers are characteristic of the tension wood of many species. In the machining, gelatinous fibers were not cut cleanly and these results in a woolly condition on the surface of profiled surfaces. Similarly, in solid wood, Desch (1953) and Perem (1964) pointed out that when surfaced on a rotary planer the tension wood was inclined to be woolly where the cutting went against the grain.

Although the core density of B type panel (50% oak + 50 beech) was lower (539 kg/m^3) than those (576 kg/m^3) of A type panel (75%oak + 25%beech), the reduction of oak proportion from 75 % to 50 % decreased the core roughness value from $17.18 \mu\text{m}$ to $14.60 \mu\text{m}$. In fact, surface roughness of the solid beech parquets is also lower than those of oak (Unsal and Kantay 2002).

In spite of the relatively low core density (543 kg/m^3), C type panels (33.3% pine +33.3% oak+33.3% beech) gave the smoothest core roughness in all panels.

Average roughness values of layer of the near to surface and density values of the same layer of all panel types are presented in Tab. 7.

Tab. 7: Average roughness values and density values at 5 mm in depth from surface

Property	A	E	B	C	D
Roughness at 5 mm in depth from surface (μm)	14.20	14.13	11.65	10.25	7.87
Density at 5 mm in depth from surface (kg/m^3)	670	670	640	650	670

At 5 mm in depth from surface, the highest roughness values were measured from A type

(75% oak and 25% beech) and E type (100% poplar) panels as being core layers despite their high densities. The reason why the roughness is high in these panels is that porous anatomical structure of oak and containing in high proportion of poplar tension wood.

D type panels (100 % ash) were the smoothest, with a 7.87 μm Ra value, on profile surface at 5 mm in depth from surface.

CONCLUSION

In this study, it was investigated the effect of the single wood species and mixtures of species on the roughness of the surface and profiled areas of MDF. The following conclusions can be made:

1. Wood species has an important effect on profiled areas roughness of MDF. According to the industrial practices, a superior MDF panel for cutting profile should have about 5-6 μm Ra in 1/3 thickness and 8-10 μm Ra in core. It is suggested that MDF panels used for manufacturing profile should have produced from tree species with fine fiber properties and wood material should contain none or minimum amount of tension wood.
2. Homogeneous density profiles of MDF make them suitable for profiling and molding. In addition, core density of MDF should be at least 685 kg/m^3 or greater for best profiling and finishing results. Hence, producers should attempt to influence density profile and core density through manipulation of manufacturing parameters (e.g. mat moisture content and press closing time).

REFERENCES

1. Akbulut, T., Hiziroglu, S., Ayrilmis, N., 2000: Surface absorption, surface roughness, and formaldehyde emission of Turkish medium density fiberboard. Forest Prod. J. 50 (6): 45-48
2. Anonymous, 1993: Euro MDF Board. A users Manuel. European Association of Medium Density Fiberboard Manufacturers. Giessen, Germany
3. Desch, H. E., 1953: Timber its structure and properties. London Macmillan and Co Ltd. U.K.
4. Hiziroglu, S., 1996: Surface roughness analysis of wood composites: A stylus method. Forest Prod. J. 46 (7/8):67-72
5. Koç, E., 2002: Effects of some factors on appearance properties of profiled MDF surface in covering. M.Sc. Thesis. Istanbul University, Institute of Science and Technology
6. Maloney, T. M., 1993: Modern particleboard and dry-process fiberboard manufacturing. Second edition. Miller Freeman Publications, Inc., San Francisco, California, USA
7. Perem, E., 1964: Tension wood in Canadian hardwoods. Forest products research branch. Dept. of Forestry Publ. No: 1057, Canada
8. Suchland, O., Woodson, G. E., 1986: Fiberboard manufacturing practices in the United States. USDA, Forest Service, Agriculture Handbook No.640, USA
9. Unsal, Ö., Kantay, R., 2002: Investigation of surface roughness of oak and beech wood parquets produced in Turkey. Review of the Faculty of Forestry, University of Istanbul, Series A, (52) 1, Turkey
10. Wang, S., Winistorfer, P. M., Young, T. M., Helton, C., 2001: Step-closing pressing of medium density fiberboard; Part 1:Influence on the vertical density profile. Holz als Roh- und Werkstoff (59): pp. 19-26

TURGAY AKBULUT
ISTANBUL UNIVERSITY
FORESTRY FACULTY
DEPARTMENT OF FOREST PRODUCTS
BAHCEKOY 80895

İSTANBUL
TURKEY

TEL: +90-212-2261100; FAX: +90-212-2261113
E-mail address: takbulut@istanbul.edu.tr

ENÜS Koç
SFC INTEGRATED WOOD PRODUCTS INDUSTRY
BARAJ YOLU KILLIK MEVKII
KASTAMONU
TURKEY