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DETERMIMATION OF DIMENSION STABILITY OF PLYWOOD WHICH EXPOSED WATER STEAM

Burhanettin UYSAL[*], Cemal ÖZCAN[*], M. Nuri YILDIRIM[*], Raşit ESEN[*], Recep KİBAROĞLU[*]
[*]Karabuk University, Technical Education Faculty, Karabuk

Abstract

In this study, the qualities of dimensional change and adhesion resistance of moulded concave plywood material after being exposed to water vapour have been investigated. To this end, for the production of moulded concave plywood material, Oriental Beech (Fagus orientalis) was used as the wood material; and Urea formaldehyde was used as the adhesive. The moulded plywoods were exposed to water vapour for 2, 6, 12, 24, 48 and 96 according to TS 3639 standards and their dimensional stabilisations according to TS 318 standards and adhesion resistances according to BS EN 205 standards were determined. As a result; average exact dry density has been established as 0,708g/cm³ and air dry density has been established as 0,814g/cm³. The dimensional increases are found to be % 1,03 in wideness, % 8,08 in thickness, % 5,08 in arc openness, % 3,21 in arc and environment longitude. In the adherence resistance, the highest value is stated in the control group paralel to the fibres with 4.07 N/mm²; the lowest one is stated as 1.19 N/mm² in the examples which are vertical to the fibres and were exposed to hot water vapour for 96 hours. According to this: moulded concave plywood can be used in the areas prone to be exposed to water vapour for 48 hours or less.

Key words **:** Moulded plywood, dimensional stability, steam.

1. Introduction

Wood is an important construction material used everywhere human being is found since the ancient times. Its distinctive features are being light, being resistant to physical and mechanical effects. Along with these, its qualities of being able to take form in suitable conditions, to be processed easily, to be provided with any colour and pattern with being exposed to the processes of painting and varnishing make the wood material more attractive than other construction elements.

The reason why plywood industry was born is to change some lame qualities of trees and to provide material as humdrum and dimensional as its own structure. It is known that the wood material grows its volume by taking water into its structure. It narrows its dimensions as a result of drying. Namely, as dimension stability can't be provided, several problems emerge in the wood technology. The work of trees is parallel to the fibres, tangential to the annual rings. Plywood is produced to remove the problems like trees' changing their working ways.

Plywoods are wood materials which are produced by sticking the barking discs, which are provided by barking round wood from outwards towards the centre with barking machines, vertical to each other and pressing in hot presses. However, formed plywood has a different production process after a certain point when compared to plain plywood.

Another negative point of producing something with wood material is that its price is high. Moulded plywood is produced to provide solidity and not to diminish the material produced to get formed surface. Considering the studies in this field, no experimental study related to determining the lines of moulded plywood and moulded plywood productions has been found so far.

Corresponded Author;cemalozcan@karabuk.edu.tr

The surface roughness of the plywood, which is discrete and others (2005) are treated with different fire-delayers, is examined. The coverings of Akaba wood, which were produced for commerce, were treated with borax, boric acid, monoammoniumphosphate and diaammoniumphosphate chemicals, and then plywood sheets were produced out of these coverings. The obtained results show that, the surface quality of the panels decreased as the chemical concentration increased [1].

Kantay and his friends (2004) showed that, rough coverings decrease the contact between the layers. That leads to weak adhesive line, thereby, the plywood's having lower endurance qualities [2].

Dündar and the orhers (2008) examined the effects of covering thickness, cutting haste, knife leaning, vertical and horizental barking, drying heat on the surface roughness in the Makore coverings and rotary cut beech coverings in their study. As a result, it was stated that, the surface roughness of the plywood which was produced with the coverings made out of beech wood with the method of barked covering was diminished at the rate of % 50 when the covering was cut vertically, and when it was cut horizentally it diminished at the rate of % 85 [3].

Aydın and Çolakoğlu (2002) examined the effect of the heat of covering protection on surface roughness, some qualities of the plywood and heatablity, and found out that the surface smoothness of the two alder and spruce coverings increased when the protection heat increased [4].

Mascia and Lucia (2009) states that, in the plywood girders united mechanically, the joint deformations have an important effect on the range of inner forces and hardness of the girder. To determine the level of this effect, the mechanical behaviours of the joints are required [5].

Moubarik and his friends (2009) worked to determine the performance of tannin based resin named cornstarch – quebracho which is used as adhesive in the production of plywood. They examined the pulling resistance and three pointed bending resistance as the mechanical quality. The performances of these pannels was compared with the performance qualities of the commercial plywoods produced with PF (fenol formalhedit). As a result, they found out that the plywood pannels which were connected with cornstarch – quebracho gave better results than the performance qualities of the commercial plywoods produced with PF [6].

The aim of this study is to determine the dimensional change and adhesive resistance qualities of moulded concave plywood material after being exposed to water vapour. To this end, for the production of the moulded concave plywood material Oriental Beech (Fagus orientalis) was used as the wood material and Urea formaldehyde was used as the adhesive.

2. Materials and Methods

2.1. Wood Material

In this study, barked covering, which is made out of oriental beech, being a native tree species used commonly in wood material industry, was preferred in prepearing the experiment samples. It was taken into account that the wood material chosen for the study was knotless, stright in trunk, not exposed to harmful things like pest and fungus and from the green wood part. The wood material used was provided from the timber sellers in Ankara.

2.2. Adhesive

In the study, Urea formaldehyde adhesive, which can be resistant to water and water vapour, was used [7]. The urea formaldehyde adhesive was prepared as in the following in the course of the experiment;

1. Preperation of % 27 percentage hardening agent: it is mixed until 8 units of water and 3 units of ammonium chloride solution are obtained.
2. Preperation of % 65 percentage adhesive solution: % 65 percentage adhesive solution is obtained through mixing 8 units adhesive from liquid urea formaldehyde in volume with 3 units flour (padding) and 1/8 units liquid ammonia.

Urea formaldehyde resin is used between 5^{o}C and 100^{o}C. The adhesive is applied to the surface as g/m2 in line with the proposal of the producing company. The viscosity of the adhesive is 400-700MPa.s in 20 °C, its density is 1.2±0.05 g/cc in 20 °C, gelling is 30-35 sn in 100°C, PH is 7.50-850 in 20°C.

2.3. Preperation at the Test Samples

The experimental samples were provided from Kastamonu – Taşköprü – ekol plywood. They were produced as 7 bedded out of beech buck coverings 1,5 mm in thickness and 10x420x100 in dimension. In propearing the models, nearly 150-180 g/m² adhesive was applied on the surfaces of the samples. The press force applied was 1.2 N/mm², the press time was 3 munites, the press heat was 110°C; and it was pressed with Radio Frequency method. The experiment model used in the study was given in Figure 1.

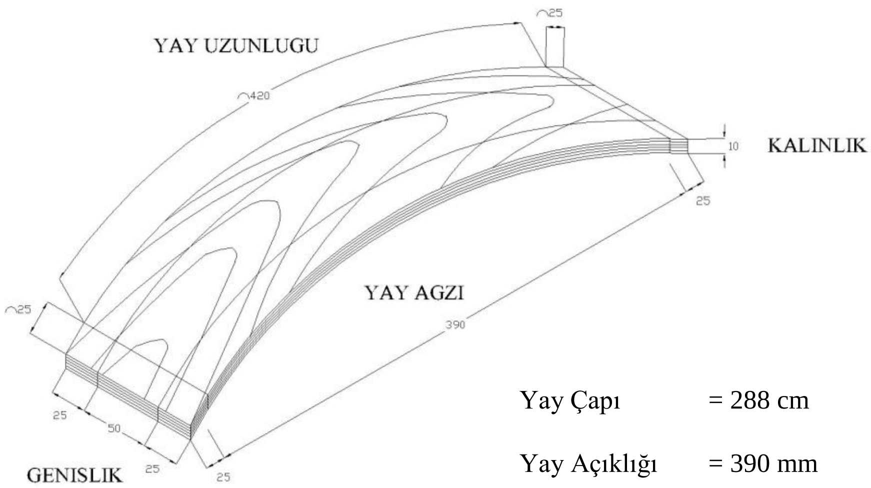

Figure 1. Test Samples

2.4. Execution Test

The experiment samples were kept in an experiment device whose diameter was 60 cm, lenght was 120 cm; and that device included the conditions of 49±2 °C heat and % 85±3 relative humidity according to TSE 3639 rules [8]. The measurement places of the experiment samples were determined under the TSE 4084 rules. Figure 1 the experiment samples were kept for 6, 12, 48, 96, hours. The samples which were measured at the end of every keeping time were exposed to the effect of water vapour for the next process. The measurements for the thickness increase were carried out on four points of every experiment samples, and they were averaged and recorded as a single value [9].

2.5. Weight Increase, Swell in Thickness and Expanding

The measurements of the experiment samples were carried out according to TS 3634 [10]. The weight increase was measured on an assay balance in terms of gram by taking the keeping time as basis, and thickness and wideness increase were measured with the help of digital micrometer in terms of mm by taking the keeping time as basis.

$$A= (M_{1\ldots9} – M_b) * 100/M_b \quad (1)$$

Here; Mb = first weight (g)
M1…9=Weight change (g)

$$G=(a1\ldots9 – ab) * 100/ab \quad (2)$$

Here; ab = First thickness (mm)
A1…9 = The thickness at the moment of measurement (mm)

2.6. İstatistik Yöntemler

Multi-variance analyses was applied the determine preperation samples of weight increase, swell in thickness and expanding.By use of the duncan test, each significant test group was compared with one another and itself.

3. Result and Discussion

The findings related to the exact or air dry density of the plywood which was produced by sticking 5 layers of bucks, made out of beech wood with the method of barked covering, with urea formaldehyde adhesive are given in Table 1.

Table 1. Average values of density (g/cm³)

Oven Dry Density (g/cm³)	Air Dry Density (g/cm³)
0.708	0.814

The average results related to the wideness values of the samples kept in water vapour are given in Table 2.

Table 2. Average results related to the wideness values of the samples kept in water vapour (mm)

Keeping time (hour)	Avarage Values (mm)	Maximum Values (mm)	Minimum Values (mm)
Control	99,96	100,17	99,74
6	100,02	100,23	99,80
24	100,08	100,29	99,86
48	100,31	100,53	100,10
60	100,53	100,74	100,20
96	100,99	100,77	101,31

The lowest value (99,74 mm) as the dimensional work was obtained in the control group at the end of keeping the samples in water vapour, and the highest (101,20 mm) one was obtained at the end of 96 hours keeping time. The single variance analyses related to the wideness value of the samples kept in control group and water vapour are given in Table 3.

Table 3. Variance analyses related to the wideness value of the samples kept in control group and water vapour

Source	Type II Sum of Squares	dF	Mean square	F	Significance
Corrected Model	23,03	5	4,60	12,87	0,00
Intercept	1811434,10	1	1811434,10	5063280,25	0,00
Factor A	23,03	5	4,60	12,87	0,00
Error	62,25	174	0,358	-	-
Total	1811519,38	180	-	-	-
Corrected	85,28	179	-	-	-

According to the single variance analysis results, the effect of keeping times on the wideness is found to be significant with the level of $P \leq 0,05$. The results of Duncan test which was carried out to determine the degree of significance of this difference among the groups are given in Table 4.

Table 4. Effect of keeping times on the wideness

Factor	Samples	Mean	Homogenity Group
Control	30	99,962	a
6	30	100,020	ab
24	30	100,081	ab

48	30	100,318	bc
60	30	100,531	c
96	30	100,989	d

The average results related to the thickness values of the samples kept in water vapour are given in Table 5.

Table 5. Average results related to the thickness values of the samples kept in water vapour (mm)

Keeping time (hour)	Avarage Values (mm)	Maximum Values (mm)	Minimum Values (mm)
Control	8,53	8,60	8,45
6	8,62	8,69	8,55
24	8,89	8,96	8,82
48	8,93	9,01	8,86
60	9,17	9,25	9,10
96	9,22	9,29	9,15

The lowest value (8,45mm) as the dimensional work was obtained in the samples of control group after the samples were kept in water vapour, and the highest one (9,26 mm) was obtained at the end of keeping time for 96 hours. The single variance analyses related to the thickness values of the samples kept in the control group and water vapour is given in Table 6.

Table 6. Variance analyses related to the thickness values of the samples kept in the control group and water vapour

Source	Type II Sum of Squares	dF	Mean square	F	Significance
Corrected Model	14251,92	1	14251,92	346196,61	0,00
Intercept	11,90	5	2,38	57,82	0,00
Factor A	7,16	174	4,117E	-	-
Error	14270,99	180	-	-	-
Total	19,06	179	-	-	-

According to the results of the single variance analyses, the effect of keeping times on the thickness was found significant with the level of $P < 0,05$. The results of Duncan test which was carried out to determine the degree of significance of this difference among the groups are given in Table 7.

Table 7. Effect of keeping times on the thickness

Factor	Samples	Mean	Homogenity Group
Control	30	8,53	a
6	30	8,62	a
24	30	8,89	b
48	30	8,93	b
60	30	9,17	c
96	30	9,22	c

The average results related to the arc gap values of the samples kept in water vapour are given in Table 8.

Table 8. Average results related to the arc gap values of the samples kept in water vapour (mm)

Keeping time (hour)	Avarage Values (mm)	Maximum Values (mm)	Minimum Values (mm)
Control	37,40	37,64	37,15
6	38,09	38,34	37,85
24	38,42	38,67	38,17
48	38,72	38,97	38,48
60	38,96	39,20	38,71
96	39,30	39,55	39,05

The lowest value (37,15mm) as the dimensional work was obtained in the samples of control group after the samples were kept in water vapour, and the highest one (39,55 mm) was obtained at the end of keeping time for 96 hours. The single variance analyses related to the arc gap values of the samples kept in the control group and water vapour is given in Table 9.

Table 9. Variance analyses related to the arc gap values of the samples kept in the control group and water vapour

Source	Type II Sum of Squares	dF	Mean square	F	Significance
Corrected Model	133307,34	1	133307,34	579229,25	0,00
Intercept	34,36	5	6,87	29,86	0,00
Factor A	19,33	84	0,23	-	-
Error	133361,04	90	-	-	-
Total	53,69	89	-	-	-

According to the results of the single variance analyses, the effect of keeping times on the arc gap was found to be significan with the level of $P < 0,05$. The results of Duncan test which was carried out to determine the degree of isignificance of this difference among the groups are given in Table 10.

Table 10. Effect of keeping times on the arc gap

Factor	Samples	Mean	Homogenity Group
Control	15	37,40	a
6	15	38,09	b
24	15	38,42	bc
48	15	38,72	cd
60	15	38,96	de
96	15	39,30	e

The average results related to the arc lenght values of the samples kept in water vapour are given in Table 11.

Table 11. Average results related to the arc lenght values of the samples kept in water vapour (mm)

Keeping time (hour)	Avarage Values (mm)	Maximum Values (mm)	Minimum Values (mm)
Control	41,11	41,30	40,92
6	41,93	42,12	41,74
24	41,96	42,15	41,77
48	42,04	42,23	41,85
60	42,13	42,32	41,94
96	42,43	42,62	42,24

The lowest value (40,92mm) as the dimensional work was obtained in the samples of control group after the samples were kept in water vapour, and the highest one (42,62 mm) was obtained at the end of keeping time for 96 hours. The single variance analyses related to the arc length of the samples kept in the control group and water vapour is given in Table 12.

Tablo 12. Variance analyses related to the arc length of the samples kept in the control group and water vapour

Source	Type II Sum of Squares	dF	Mean square	F	Significance
Corrected Model	158295,56	1	158295,56	1163732,60	0,00
Intercept	14,47	5	2,89	21,27	0,00
Factor A	11,42	84	0, 136	-	-
Error	158321,46	90	-	-	-
Total	25,89	89	-	-	-

According to the results of the single variance analyses, the effect of keeping times on the arc length was found to be significant with the level of $P < 0,05$. The results of Duncan test which was carried out to determine the degree of significance of this difference among the groups are given in Table 13.

Table 13. Effect of keeping times on the arc length

Factor	Samples	Mean	Homogenity Group
Control	15	37,40	a
6	15	38,09	b
24	15	38,42	bc
48	15	38,72	cd
60	15	38,96	de
96	15	39,30	e

4. Conclusion

288 cm plywood with radius, which was produced by sticking 5 layers of the bucks, being obtained out of beech wood with the method of barked covering, with urea formaldehyde adhesive under the pressure, was exposed to water vapour for 6, 24, 48, 60 and 96 hours according to TSE 3639 standards and the following results were obtained.

The increase in volume was found as % 1,03 in the experiment pieces, whose highest value of wideness was measured as 100,99 mm and whose lowest value of wideness was measured as 99,96. The fact that the fibres were sticked to each other vertically diminished the amount of expansion of the covering panel with the effect of water vapour. However, it was seen that, as a result of the adhesive’s losing its quality after the third period, the outer layers got apart and showed more increase in volume.

The increase in measurement was found as % 8,09 in the experiment pieces, whose highest value of thickness was measured as 9,22 mm and whose lowest value of thickness was measured as 8,53 mm. Every layer expanded separately with the effect of water vapour. Increasing the amount of press, which is applied in the process of drying the buck covering and pressing it, can cause pressure and affect the increase of thickness.

The increase in measurement was found as % 3,21 in the experiment pieces, whose highest value of arc lenght was measured as 424,3 mm and whose lowest value of arc lenght was measured as 411,1 mm. The adhesive used to stick the buck covering sheets to each other, pressing time and its pressure, the kind of wood used can affect the tendency of formed plywood sheet of turning back to its shape before being pressed by affecting the sticking resistance.

The increase in measurement was found as % 5,08 in the experiment pieces, whose highest value of arc gap was measured as 393 mm and whose lowest value of arc gap was measured as 374 mm. The arc mouth gap and arc length showed increase directly proportional to each other. The adhesive used to stick the buck covering sheets to each other, pressing time and its pressure, the kind of wood used can affect the tendency of formed plywood sheet of turning back to its shape before being pressed by affecting the sticking resistance.

The resistance loss in the experiment pieces was found as % 17,65, whose highest value of sticking resistance (parallel to the fibres) was 3,8 N/mm2, and the lowest value of that was 3,23 N/mm².

Today, mechanical and physical test results about the productions are required from producers before selling moulded plywood productions. Producing formed plywoods according to their usage places and usage aim is only possible with some changes done in the process of production.

Taking the outer effects that a produced piece can be exposed to into consideration can prevent the problems that may come out later; for example, not using the adhesive kind that may cause deformation in a humid environment or knowing what is required to provide dimensional stabilisation can prevent such problems. As every fault will increase the cost of the production, it will be hard for the enterprises to carry their activity on. Therefore, moulded concave plywood can be used in the places which can be exposed to water vapour for 48 or fewer hours.

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