Mokchae Konghak 30(3) : 85~90, 2002

Dimensional Stability of Bentwoods by Treatment Conditions*1

In-Suk Jung*2, Weon-Hee Lee*2†, Jun-Pok Chang*3, and Hyun-Mi Bae*4

ABSTRACT

This study was carried out to investigate the dimensional stability of bentwoods by three treatments: steaming, urethane varnish coating, and polyethylene glycol (PEG) treatment. Bentwood processing employed a bending-jig with only 4 cm radius of curvature (ROC). The used species were bitter wood (*Picrasma quassioides*), painted maple (*Acer mono*), and birch (*Betula schmidtii*). The bending properties of these are well-known in bentwood production (Jung *et al.*, 2002). The bentwoods were treated repeated at room temperature [20°C, RH 80% (12 hours) and 40°C under RH 10% (12 hours)]. To estimate the dimensional stability of bentwoods, we measured the radius of curvature and end-distance. The best results could be attained with PEG treatment. Steaming was the worst treatment. Comparing the properties of the different species, the dimensional stability of bitter wood was excellent. It was concluded that the steaming treatment was unsuitable for dimensional stability of bentwoods.

Keywords: bentwood, dimensional stability, PEG treatment, steaming, urethane varnish coating

1. INTRODUCTION

The bending quality of wood can vary widely among different species and even within the same species. Dimensions of bentwoods can be changed by moisture content (MC) after bending process.

The changes are primarily caused by lengthwise swelling or shrinkage of the inner (concave) face, the fibers of which become wrinkled or folded during the bending operation [1].

Steaming treatment improves the dimensional stability for structural changes.

The reasons are: 1) degradation of hemicellulose, 2) increase of the regularity of crystalline lattice spacing of the microfibrils or the formation of cross linkages between cell wall polymers, and 3) decomposition of lignin as well as hemicellulose (Dwianto *et al.*, 2000).

Generally, PEG treatment results in 30% improved dimensional stability because of its

*1 Received May 13, 2002; accepted on August 29, 2002.
This study was financially supported by Agricultural R&D Promotion Center.
*2 Department Group of Forestry and Wood Sci.& Tech., College of Agriculture, Kyungpook Nat'l. Univ., Daegu 702-701, Korea
*3 Division of Life Resource Science, Joongbu Univ., Kumsan 312-940, Korea
*4 Division of Architecture & Landscape, Mokpo Nat'l., Univ., Muan 534-729, Korea
† Corresponding author : Weon-Hee Lee (lovewood21@hanmail.net)

volume effect. PEG treatment was more effective with greenwood than in dry conditions. In addition, PEG treatment uses little energy (Park & Hong, 1995). Urethane varnish coating seals moisture and improves clarity. Additionally, urethane varnish coating of wood polishes their surfaces.

In this study, we selected 3 species with good bending properties bitter wood (*Picrasma quassioides*), painted maple (*Acer mono*), and birch (*Betula schmidtii*) according to our earlier report (Jung *et al.*, 2002). We examined the dimensional stability by 3 different treatment methods (Steaming treatment, Urethane varnish coating, and PEG treatment).

2. MATERIALS and METHODS

2.1. Specimen

In this study, the used specimens were collected from the Kyungpook National University's Forest which is located in Chungsong County, Kyungpook Province, Korea.

The properties of species are described in Table 1.

The dimensions were 300(L)×10(R)×20 mm (T). The specimens were half-edge grain wood.

2.2. Test

2.2.1. Bending Process

The bending process utilized a bending-jig with 4 cm ROC. A metal-strap, carbon steel connected to a wood handle, was needed to

Fig. 1. Apparatus for bending process.

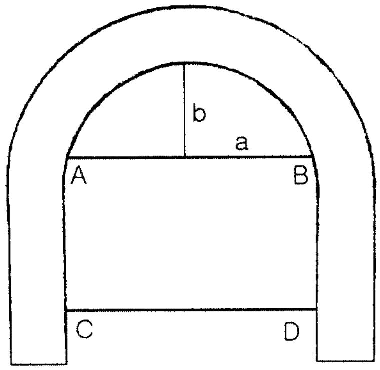

Fig. 2. Diagram for dimension measurement.

restrain the stretching along the outer side of each wood specimen.

2.2.2. Test of Temperature and Humidity Repeat

Tests were repeatedly conducted in an oven-dryer at 40°C and 20°C room temperature and

Table 1. Index of sample trees.

	D.B.H (cm)	Tree age (year)	MC (%)	S.G.	Porosity
bitter wood (*Picrasma quassioides*)	18	40	15	0.63	Ring-porous
painted maple (*Acer mono*)	17	50	15	0.70	Diffuse-porous
birch (*Betula schmidtii*)	18	45	15	0.93	Diffuse-porous

at 80 percent relative humidity(RH). Each test was 12 hours. One cycle was 24 hours. Radius of curvature and end-distance were measured every 1 week. The total test periods were 4 weeks.

2.2.3. Measurement of ROC (Radius of Curvature) and End-distance

Based on Fig. 2, a straight line AB linked to A and B point. ROC (ρ) and end-distance strain (φ) were measured as follows:

$$\rho = \frac{a^2 + b^2}{2b} \qquad (1)$$

$$\delta = \frac{|\rho - \rho'|}{\rho} \times 100 \qquad (2)$$

$$\varphi = \frac{(CD - C'D')}{CD} \times 100 \qquad (3)$$

AB: original length
CD: original end-distance
C′D′ : end-distance after one-week
ρ': ROC after one-week.

2.2.4. Steaming Treatment

Steaming treatment was performed in an autoclave at 130°C for 60 minutes on fixations by metal-strap.

2.2.5. Urethane Varnish Coating

In this study, the used urethane varnish was made by G. company and was one-liquid type urethane varnish. 8 g urethane varnish was applied twice using a roller brush.

2.2.6. PEG(Polyethylene Glycol) Treatment

PEG-1500 (Junsei Chemical CO.) was used in this study. The PEG solution was 30 percent. Wood specimens were fixed on a cast and digested for 12 hours at room temperature.

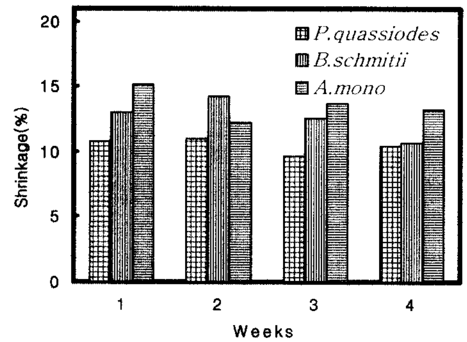

Fig. 3. Shrinkage of ROC by steaming.

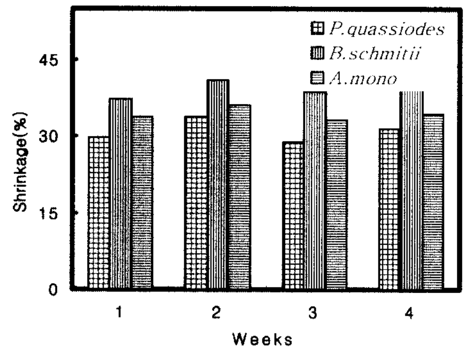

Fig. 4. Shrinkage of end-distance by steaming.

3. RESULTS and DISCUSSION

3.1. Steaming Treatment

In generally, steaming treatment was efficient over 180°C (Inoue *et al.*, 1993; Dwianto *et al.*, 1999). However, steaming treatment has conducted this study at 130°C for 60 minutes because of insufficient of autoclave size and it's heating ability. Therefore, more study must be conducted for bentwood steaming treatment about it's apparatus, temperature and treatment times.

The dimensions after steaming treatment were greatly changed on end-distance than ROC strain. Partial hydrolysis of hemicellulose by heating increased in both hardwood and softwood (Hsu *et al.*, 1988). Shrinkage of birch and painted maple were greatly enhanced. Though ROC and end distance increased up to two-weeks, this tendency decreased after three-weeks.

It was considered that the reason for this phenomenon was the change of moisture content of the wood. Especially, shrinkage of end-distance by steaming treatment had a larger value than in any other condition, and was over 30 percent.

3.2. Urethane Varnish Coating

Wood specimens were manufactured with a planer; however, a finishing operation was not conducted in this study.

8 g urethane varnish was applied twice using a roller brush: the undercoating and the finish coating. In addition, urethane varnish has good properties such as bending ability, adhesive power, abrasion resistance, chemical resistance and polish. Therefore, this treatment has no problems such as less shrinkage and a little check (Lee, 1995). As Figs. 5 and 6, the test specimen of urethane varnish coating showed less shrinkage than the steaming treatment relatively. In the case of urethane varnish coating, a significant change in the specimen did not appeared during the repeated test on both ROC and end-distance.

In characteristics of wood species, shrinkage of birch and painted maple had a larger value than any other treatment methods.

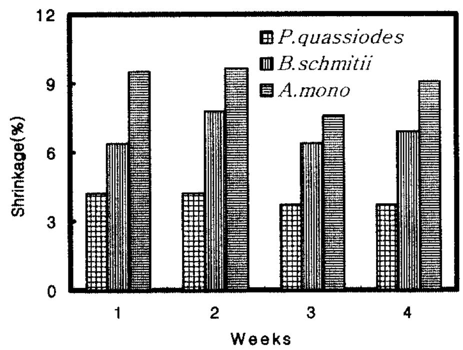

Fig. 5. Shrinkage of ROC by coating.

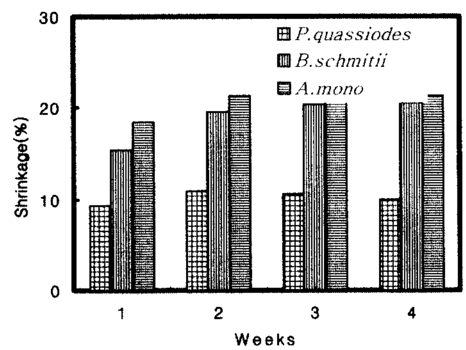

Fig. 6. Shrinkage of end-distance by coating.

3.3. PEG Treatment

PEG treatment exhibits different injection properties according to its concentration and molecular weight. However, dimensional stability under concentrations of 30 percent was the best condition (Kwon & Kim, 2002). In this study, however, it was not useful to estimate dimensional stabilization, because the dimension and shape of all bentwoods were the same after PEG treatment. Therefore, differences were with the other treatment methods. In PEG treatment, shrinkage of ROC occurred less than 6 percent of all wood species. Shrinkage of end-distance was around 10 percent except in the birch.

However, change of ROC of birch with high specific gravity indicated large values for 1~2 weeks in all test specimens.

3.4. Non-treatment

Non-treated bentwood exhibited greater shrinkage than in urethane varnish coating and PEG treatment. The end-distance of birch and bitter wood had a similar tendency except the painted maple. The end-distance of painted maple was 5 percent after 3 weeks.

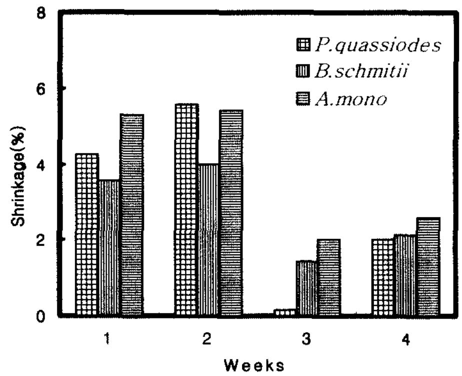

Fig. 7. Shrinkage of ROC by PEG treatment.

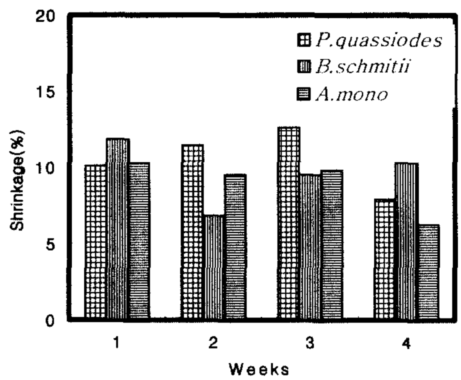

Fig. 8. Shrinkage of end-distance by PEG treatment.

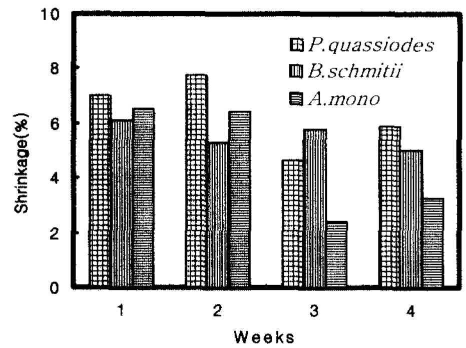

Fig. 9. Shrinkage of ROC on non-treatment.

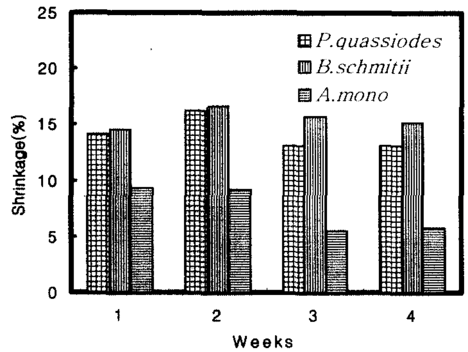

Fig. 10. Shrinkage of end-distance on non-treatment.

4. CONCLUSION

This study examined the effect of dimensional stability of bentwood according to treatment methods and treatment conditions. From the results, dimensional stability of PEG treatment wood was the best. Urethane varnish coating and steaming treatment exhibited lower dimensional stability than non-treatment. However, more study must conducted for bentwood steaming treatment because it's variety for temperatures and conditions. Non-treatment operation of high specific gravity wood was the best method for dimensional stability. On the other hand, dimensional stability of bitter wood with low specific gravity could be increased by urethane varnish coating and PEG treatment.

ACKNOWLEDGEMENT

The authors wish to thank the Agricultural R&D Promotion Center for their financial support.

REFERENCES

1. Forest Products Laboratory Forest Service U. S Department of Agriculture. Wood Handbook: Wood as an Engineering Material. 1987. pp. 13-5 ~13-6.
2. Dwianto, W., Morooka, T., and M. Norimoto. 2000. Compressive creep of wood under high temperature steam. *Holzforschung* 54(1): 104~105.

3. Park, S. B. and B. H. Hong. 1995. Handbook for Wood Reformation. Youngwoo Press. pp. 286~287.
4. Jung, I. S., Lee, W. H., Chang. J. P., and H. M. Bae. 2002. Evaluation of bending property on principal domestic species. *Mokchae Konghak* 30(2): 87~94.
5. Hsu, W. E., Schwald, W., Schwald, J., and J. A. Schwald. 1988. Chemical and physical changes required for producing dimensionally stable wood-based composites. *Wood Sci. Technol.* 22: 281~282.
6. Inoue, M., Norimoto, M., Tanahashi, M., and RM. Rowell. 1993. Steam or heat fixation of compressed wood. *Wood and Fiber Science* 25: 224~235.
7. Dwianto, W., Morooka, T., and M. Norimoto. 1999. Method for measuring viscoelastic properties wood under high temperature and high pressure steam conditions. *J. Wood Science* 45: 373~377.
8. Lee, H. C. 1995. Handbook for Finishing. Hakyoun Press. p. 168.
9. Kwon, G. J. and N. H. Kim. 2002. Dimensional stability of domestic small-diameter timbers treated with polyethylene glycol. *Mokchae Konghak* 30(1): 40~47.