KFS Journal, Vol. 18(2), 2007: 143-146

Dimensional Stability of Plastic Processing Wood Material - Compression Wood and Bentwood[1]-

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ABSTRACT

This study was carried out to assess the dimensional stability of wood material treated by plastic processing for bentwood and compression wood. The evaluation method was different between two wood materials, but the treatments for them were very similar to each other. One of the main methods is heat treatment with sufficient water vapor.

In bentwood, the used species were painted maple (*Acer mono*), bitter wood (*Picrasma quassioides*) and birch (*Betula schmidtii*). Steaming was the worst treatment method for dimensional stabilization of bentwood. The best results could be attained with PEG treatment for dimensional stabilization of bentwood. Dimensional stability of bitter wood was found to be conspicuous. However the steaming treatment at lower temperatures, i.e., about 130℃ was not suitable for dimensional stability of bentwood.

In compression wood, the used specimen was Italian poplar wood (*Populus euramericana*). Two heat compressive pressing conditions, an open-press system and an air-tighten closed-press system, were used. The recovery rate was measured after boiling and/or absorbing in water to estimate the dimensional stability of heat compressed wood. The best dimensional stability of compressed wood in the air-tighten closed-press system was found to be better at 200℃ than 180℃. The best compression rate for dimensional stability was 73 percent.

Key words: Dimensional stability, Plastic processing, Bentwood, Compression wood.

INTRODUCTION

To utilize the low density wood for furniture, engineered wood products, flooring board and so on, it is necessary to improve the wood strength and appearance characteristics such as surface hardness, abrasion resistance and curved shape for its aesthetics. Plastic processing of compressed wood and bentwood is an effective method to improve these properties (Inoue et al. 1993 and Dwianto et al. 1999).

However, the fixation of deformation such as compressed state and bent state of wood is only apparent, because it can be almost completely recovered by water absorbing. It is considered that the wood is composed of hydrophilic groups such as celluloses and hemicelluloses. To improve the

Received for publication: March 30, 2007.

1) This study (Technical Innovation Project No. S0604212-C0341307) was financially supported by Small and Medium Business Administration in Korea.

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dimensional stability of wood, hydrophilic group such as hydroxyl radical should be replaced or removed. In the past, many attempts have been made to fix the compressive deformation of wood permanently (Hsu et al. 1988, Inoue et al. 1993 and Eiji and Huruno 1997). Low molecular weight resins are polymerized during the deformation stage of wood and chemical application of heat compressed wood for effective dimensional stabilization. Thermal treatment at high temperatures is another effective method for permanent fixation of wood deformation. The deformation did not recover when pressed under conditions having caused a flow of lignin to relieve an internal stress. The most suitable condition for permanent fixation of wood deformation is determined by the combinations of heating temperature & time and moisture content. Inoue and Norimoto examined the permanent fixation of compressive deformation of sugi wood (*Cryptomeria japonica* D. Don) by thermal treatment under dry conditions (Inoue et al. 1993). Steam treatment with wet wood or high moisture content at high temperatures is also an effective method for the dimensional stability of wood. Steaming is conducted in an autoclave device or in a hot press with an airtight sealing device (Dwianto et al. 1999).

In general, it is known that steaming treatment is the most optimum method for permanent fixation of wood deformations. Dwianto reported steaming treatment of wood at the temperatures above 160℃ improves wood fixation for dimensional stability.

This study was carried out to estimate the dimensional stability at each treatment methods for bentwoods and the dimensional recovery of heating compression woods by boiling and water absorption.

MATERIALS AND METHODS

Bitter wood (*Picrasma quassioides*), painted maple (*Acer mono*) and birch (*Betula schmiditii*) were used for bentwood. Specimens' dimensions were 300(L) × 10(R) × 20(T) mm and half-edge grain wood.

Radius of curvature (ROC) of jig for the bending process was 40mm. After finishing process, bentwood specimens were steamed at 130 ℃ and urethane varnish coating and PEG coating.

Tests for measuring ROC's strain (%) of bentwood specimens (Jung et al. 2002) were repeatedly performed in a dryer at 40℃ and 80% RH at 20℃ for 12hours. Total test period was 4 weeks.

The Popular specimen's dimension for compression wood was 30(L) × 15(R) × 30(T) mm and 8 specimens for each test. After water absorption upto 80 percent MC, compression process was conducted at 180℃ and 200℃ for 20 minutes with 47, 60, and 73 percent for compression rate, respectively. Dimension recoveries (Jung and Lee 2002) of compressed wood specimens were estimated by boiling and water absorption test.

RESULTS AND DISCUSSION

Dimensional stability of bentwood

The result was illustrated in Fig. 1. Dimensions of bentwood after steaming were greatly changed by ROC strain. Shrinkage by steaming had the greatest value in all treatments. It was assumed that this phenomenon is due to the change of moisture content. In urethane varnish coating, a significant change in specimen was not observed. This treatment had no problems with less strain and little check. In PEG treatment, strain of ROC between wood species had no significances. In this study, however, it was found that PEG treatment was the best method for dimensional fixation of bentwood. In general, steaming treatment for dimensional fixation is the best method; however, it was considered that steaming is not an appropriate method for the dimensional stability of bentwood.

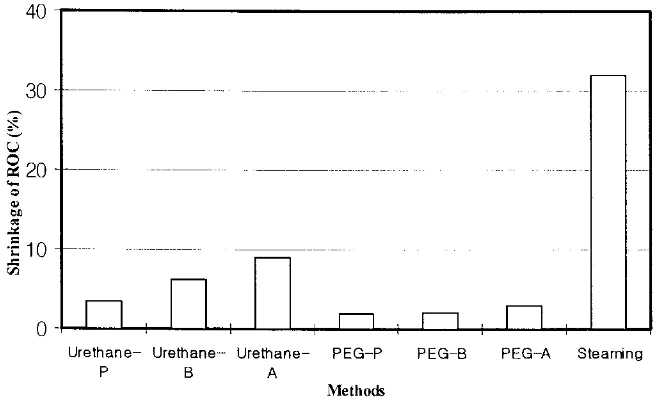

Fig.1. Shrinkage of ROC at each treatment. Last alphabets -P, -B, and -A represent bitter wood (*Picrasma quassioides*), birch (*Betula schmiditii*), and painted maple (*Acer mono*), respectively.

Dimensional recovery of compression wood

Dimensional recovery of compression wood was illustrated in Fig. 2. From the amount of recovery in this Figure, it was considered that heating temperature condition was more affected below 60 percent compression rate of wood. The existence of void volume in compressed wood is greatly affected on the recovery of compression wood. Void volume of compressed wood acts on moisture diffusion for swelling. However, dimensional recovery by water absorption was much lower values than boiling. In the Figure, the recovery amount became lower at high temperatures and greater compression set. From these results, it was considered that dimensional stability of compressed wood was improved at 200℃ with airtight condition and with greater deformation set.

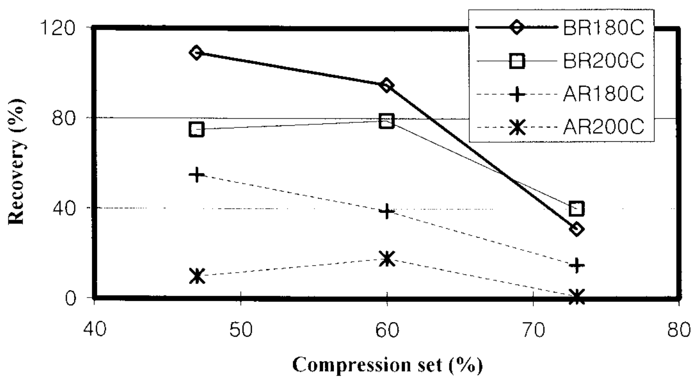

Fig.2. Dimensional recovery of compression wood at each condition. Legend: BR180C is recovery rate by boiling of compressed wood at 180℃ with air-tight, AR200C is recovery rate by water absorbing of compressed wood at 200℃ with airtight.

From the above mentioned, there was a distinct difference between the two treatments, dimensional stability of bentwood and compression wood.

In the past, Dr. Norimoto and Inoue studied in this research field. For the thermal treatment of compression wood, they showed the permanent fixation could be achieved at heating temperatures of 180℃ for 20 hours, 200℃ for 5 hours, or 220℃ for 3 hours (Inoue et al. 1993). In steaming treatment, they reported that permanent fixation was achieved at 180℃ for 8 minutes or at 200℃ for 1 minute. They also concluded that there was no effect of steaming for the fixation of dry specimen and moisture of wood was a very important element for dimensional stability. Furthermore, no remarked decrease in MOR or apparent color changes in heating and steaming treatment was observed. They thought the fixation was caused by a structural change in the cellulose. Hsu *et. al.* reported that pre-steaming of wood was a very effective method of dimensional stabilization improvement. They suggested that steam treatment could cause partial hydrolysis of hemicelluloses without any apparent changes in cellulose or lignin content which markedly increased with the wood compressibility and significantly reduced with the internal stress during hot pressing. From these results, it is considered that the mechanism of dimensional stability is increased by cellulose crystalline and release of internal stress stored in cell wall during hot pressing by partial hydrolysis of hemicelluloses.

By steaming treatment, almost complete dimensional stability can be achieved in a very short time and the device for fixation is very expensive and its operation is difficult. However, from an environmental point of view, heating or steaming is preferable to chemical treatments for the perfect dimensional stability of wood deformation. Besides compression wood, however, bentwood is necessary to be treated by the chemical coating method for dimensional stability because of its instability by mechanical residual stress.

CONCLUSIONS

The best condition for the dimensional stability of compressed wood was the air-tight press system at higher temperatures with above 200℃ and greater compression set. Dimensional stability of bentwood with PEG treatment was the best. In bentwood, it is considered that the existence of strong residual stress at bending processing is the main factor for the recovery power. Therefore, it is clear that there is a great difference between dimensional stabilization for compression wood and for bentwood.

ACKNOWLEDGEMENT

We acknowledge many appreciations to the Small and Medium Business Administration in Korea to conduct this project here.

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