Mokchae Konghak 28(4) : 51~55, 2000

Manufacturing Characteristics of Woodceramics from Thinned Small Logs (I)*1

- Resin Impregnation Rate and Bending Strength -

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ABSTRACT

The woodceramics which are new porous carbon materials were obtained by carbonizing from thinned small log of Aomori HIBA (*Thujopsis dolabrata* S. *et*. Z. var. *hondae* M.) impregnated with phenol resin in a vacuum furnace. During the carbonization process, the resin changes into glassy carbon, which has superior property. The resin impregnation rate and bending strength depend on the types of board and density. In this paper, the manufacturing method of woodceramics made from thinned small logs of Aomori HIBA was introduced and some properties were examined.

Keywords : Woodceramics, steam board, bending strength, resin impregnation rate

1. INTRODUCTION

Recently, the concern about the utilization of wood resources is rising due to the exhaustion of wood. The great number of tree has been planted, but the ratio of young age forests is very high. Specially, 30-40 year forests occupy 30% in Japan. Then much volume of tree is being thinned every year. However, the usage of thinned small logs is limited to low added values which examples such as the assistant of construction materials and pulps etc. Its effective usage is important for preservation of wood resources and protection of environment. Therefore, we make a new porous carbon material "woodceramics" which is impregnated with phenol resin and carbonized in a vacuum furnace at a high temperature to produce the high additional value materials. In this research, the woodceramics are made from thinned small logs. Woodceramics have superior characteristics as ecological and industrial materials and have so many merits such as hardness, heat resistance, lightness etc. (Hokkirigawa *et al.*, 1996b; Okabe & Saito, 1995a). Some of the properties of woodceramics have been reported previously (Hokkirigawa *et al.*, 1995, 1996a; Kano *et al.*, 1996; Kasai *et al.*, 1996; Okabe and Saito, 1995b; Okabe *et al.*, 1995a, 1995b). But the research of woodceramics made from thinned small logs is few investigated. This report describes that manufacturing method of two types

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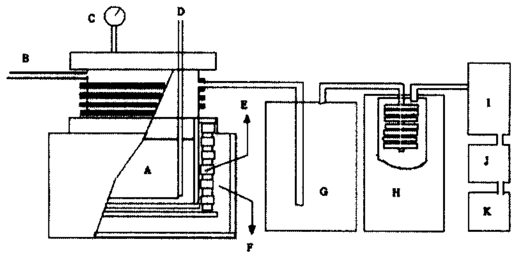
of board and bending strength of woodceramics according to the board type made from thinned small logs of Aomori HIBA for the examination the application of woodceramics.

2. EXPERIMENTAL PROCEDURE

2.1 Specimen

Two types of board were made from thinned small logs of Aomori HIBA (*Thujopsis dolabrata* S. *et*. Z. var. *hondae* M.) according to the density. In order to make a board, it was cut into small size with chipper and refiner (Toyo press Co., Ltd.) and mixed with powder phenol resin (BRP 5933, Showa Hoghpolymer Co., Ltd.) in a ratio of 10:1 by weight. Table 1 shows the condition of the board manufacturing.

After the board was manufactured, it was impregnated with liquid phenol resin (PX-1600, Honen Corporation) using an ultrasonic impregnation system descried in the previous reports (Okabe *et al*., 1995, 1996a, 1996b). Table 2 shows the characteristics of phenol resin. Impregnated boards were dried and hardened in high temperature for 8 hours at 60℃, 6 hours at 135°C and burned to make a woodceramics at 650°C using the indirect heating charcoal kiln (Okabe & Satio, 1995a; Okabe *et al*., 1995, 1996a, 1996b). The temperature in the furnace was increased by 5°C/min, kept at 730℃ for 2 hours and decreased gradually at about 0.5 C/min (Shibata *et al*., 1997). Figure 1 outlines the woodceramics production apparatus.



A : Material, B : Cooling Tube, C : Pressure gauge, D : Thermometer, E : Heater, F : Insulating material, G : Water trap, H : Cold trap, I : Activated carbon filter, J : Air filter, K : Vacuum pump

Fig. 1. Schematic illustration of woodceramics production apparatus.

2.2 Measuring the density of board

After making the two types of board, to investigate the structure of density in steamed board and non-steamed board, the section of board was cut into three area and the density was measured according to the board type.

2.3 Measuring the resin impregnation rate

To effect of the process on resin content was investigated after impregnated phenol resin board made from thinned small logs of Aomori HIBA. The resin impregnation rate was measured in board and impregnated phenol resin board, respectively. To calculate the change of resin impregnation rate during the impregnation, digital vernier calipers (Mitutoyo, Co., Ltd.) and electric balance (ER-120, A&D Co., Ltd.) were used.

Table 1. Board manufacturing conditions.

Species	Board type	Density	Pressing time	Pressure	Steaming time
Aomori	Steamed board	0.5-0.9	15 min	3 MPa	5 min
HIBA	Non-steamed board	0.5-0.9	15 min	3 MPa	

Table 2. Characteristics of phenol resin.

Powder resin (Novolak type)		Liquid resin (Resol type)	
Density (g/cm^3)	0.26-0.34	Non-volatile (% 1 hr/135°C)	46.0
Plate flow (mm)	330-40	Specific gravity (D 25/4)	1.12
Melting point (°C)	74-84	Viscosity (Poise/25°C)	0.16
Gelation time (Sec)	80-120	Gelation time (Min./135°C)	11.0
Moisture content (%)	below 1	PH (25°C)	8.5
Amount of hexane (%)	5.9-6.9	Water tolerance	2.8

2.4 Bending test

Bending tests were done using a universal testing machine (Autograph, AGS-10KNG, Shimadzu) in a constant temperature and humidity chamber. The span was 70 mm and load was applied to the center of the beam at cross-head speed at 5 mm/min. The direction of loading was parallel to the thickness.

3. RESULTS and DISCUSSION

3.1 Density of board

The variation of density in steamed board and non-steamed board according to the board layer was shown in Figure 2. It is found that the density of steamed board was relatively uniform, but the density of non-steamed board was not. The density of middle layer was lower than surface in non-steamed board. Compared within the board type, the density profile in non-steamed board was higher than steamed board. The difference of density between surface area and middle area was decreased in steamed board because the distribution of humidity of each area is uniformed by steam injection. From the results, the large density profile have an effect on the property of woodceramics.

3.2 Resin impregnation rate

The resin impregnation rate changed according to the board type and density. The relationship between density and resin impregnation rate of

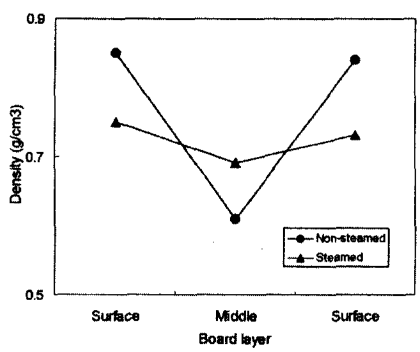


Fig. 2. Variation of density in steamed board and non-steamed board.

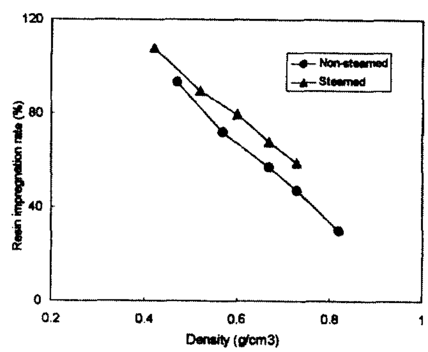


Fig. 3. Relationship between density and resin impregnation rate after impregnation of phenol resin.

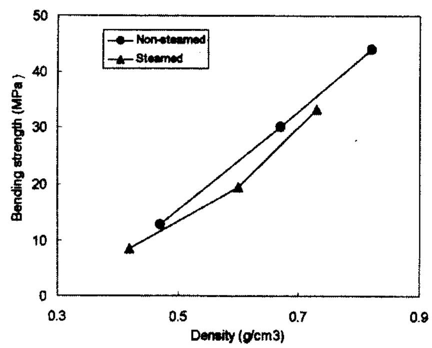


Fig. 4. Relationship between density and bending strength of board.

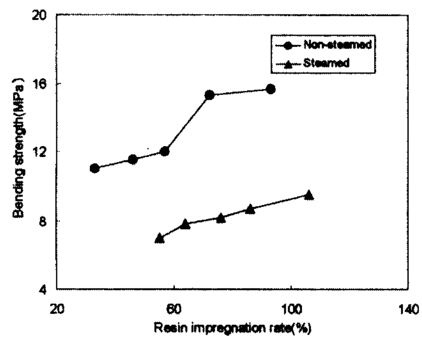


Fig. 5. Relationship between resin content and bending strength in woodceramics.

board after phenol resin impregnation were shown in Figure 3. After phenol resin impregnation, the density increased: resin impregnation rate had a tendency to decreased. This is similar to the tendency for Buna and MDF, which as increasing of densities, resin impregnation rate was increased as reported by Okabe *et al.* (1996a) and Nonaka *et al.* (1999). The resin impregnation rate ranged from 108 to 59.1% in steamed board and from 93.2 to 30.2% in non-steamed board according to the density of board. In general, the board of low density is easy to impregnate because it is more porous. The resin impregnation rate in steamed board was higher than non-steamed board because the density of section in steamed board was uniform.

3.3 Bending strength properties

Figures 4 and 5 showed the bending strength of two types of board and woodceramics which was made from thinned small log of Aomori HIBA impregnated phenol resin and burned at 650°C. The variation of bending strength had a tendency to increase as the density increases. The bending strength of woodceramics ranged from 11 to 15.6 MPa in non-steamed board and from 7 to 9.5 MPa in steamed board according to the resin impregnation rate. The bending strength of woodceramics in non-steamed board was higher than that of steamed board. Because the phenol resin of middle layer in non-steamed board has changed the volume fraction of glassy carbon formed during the carbonization (Okabe & Satio, 1995a; Okabe *et al.*, 1996a). This indicates that the bending strength of woodceramics is high in high density of surface and large density profile of board. Woodceramics undergo less structural change during the carbonization, and, after exposure to heat, they have a larger remainder of carbon. Glassy carbon exhibits the typical characteristics of carbon materials and has a corrosion resistance, strength and hardness (Okabe *et al.*, 1996a).

4. CONCLUSION

The manufacturing method, density, resin impregnation rate and bending strength of woodceramics which was made from thinned small logs of Aomori HIBA were examined according to the board types and density. The section of non-steamed board consist of three layers. The density of surface was higher than middle layer in non-steamed board. The density profile of non-steamed board was higher than that of steamed board. After impregnated phenol resin, the resin impregnation rate in steamed board was higher than that in non-steamed board. The bending strength of woodceramics from non-steamed board was higher than that from steamed board.

ACKNOWLEDGEMENT

The authors would like to thank the director of Industrial Research Institute of Aomori Prefecture TETUO KUDO for his assistant in carrying out this research.

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