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Connecting Sliced Veneers of Japanese Cedar (Sugi) by Hot-pressing and Development of Deep Wood Tray without Adhesive

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Japanese cedar (sugi) is the wood with density at air-dried condition of about $0.35g/cm^3$, and is soft and easy to be transformed. In this study, it was confirmed that the sliced veneers of sugi were able to be connected together by only hot-pressing. From this performance of sugi, the method of producing a deep wood tray without using adhesive was examined. Two sliced veneers of sugi with moisture contents of about 10-20%, are plied as the grain direction of each veneer is mutually orthogonal, and hot-pressed up to the thickness of a veneer at temperature of 180-200 ° C for a few minutes. The characteristics of this tray developed in this study are the depth of over 6cm and not using adhesive. This wood tray gives extremely few loads to the environment, and is a very safe, sanitary container where food can be put.

Key words: without adhesive, hot- press, Japanese cedar, sliced veneer, deep wood tray

1. INTRODUCTION

Most of the trays for food are made from the oil drawn up from underground, and there are many problems in the abandonment process because of their difficulties of being burnt or being rotted after use. The use of the tray made of plastics will be a serious environmental problem in the future, because the collecting and recycling systems of that tray have not been constructed yet.

Nowadays, quite a lot of trays for foods are used in the market, and the use of the wood tray instead of plastic can greatly contribute to improvement of the environmental problems that include global warming. Recently, a so-called wood tray has come to be developed from the consumer's increased consideration to environmental problems and intention for natural materials. However, some kinds of wood trays which have been developed up to now are manufactured by bonding some odd numbers of veneer as well as plywood [1]. The use of adhesive might cause a lot of problems related to the safety of food and the emission of gases.

Although some wood trays are manufactured by only hot-pressing single veneer without adhesive, it is almost impossible to make deep wood trays because of damage such as cracks and tears at the curved surface in the bottom. So, the depths of these trays are limited to about 30mm and there is no deep wood tray which can keep bulky foods like grapes and mushrooms.

Then, this study was conducted to obtain necessary information for the manufacturing technology of deep wood trays without adhesive. Especially, the possibility of binder less joints by only hot-pressing the sliced veneers obtained from Japanese cedar, sugi (*Cryptomeria japonica* D. Don). This wood is comparatively soft and easy to deform, and their optimum hot pressing conditions are examined.

Concerning the connection of veneers by hot-pressing, the influence of hot-pressing conditions such as; moisture content, thickness of veneer, hot-pressing temperature and time on the joint performance such as tensile shear strength and tensile strength in thickness direction of veneer, were examined.

The optimum shape of tray was decided and the prototype of a wood tray was made using a metal mold by only hot-pressing.

2. EXPERIMENTAL PROCEDURE

2.1 Materials

Sliced veneers of sugi, grown in Miyazaki Prefecture, were used for test materials. The size of the veneer was 180mm in length and 180mm in width, and in three types of thickness, 1.0, 1.5 and 2.0mm. The veneer had been seasoned to the moisture content of about 30%. In the examination concerning the influence of the moisture content, the moisture content was varied for four levels, such as about 200% (water saturated), about 30% (slightly wet), about 15% (air dried), and under 10% (kiln dried).

2.2 Connecting Veneers by hot-pressing

Two sliced veneers are overlapped by 50mm in fiber direction, and hot-pressed to the thickness of a single veneer. The moisture content, veneer thickness, hot-pressing temperature and hot-pressing time were considered as the parameters which affect connecting performance of veneers.

The hot-pressing conditions used in various examinations of this study are as follows,

①Influence of temperature and time of hot-pressing

Temperature : 160, 180 and 200℃
Time : 60, 120 and 180sec
Thickness : 1.0, 1.5 and 2.0mm

②Moisture content of veneer
Moisture content : about 200% (saturated), about 30% (slightly wet), about 15% (air dried), and under 10% (kiln dried)
Temperature : 180℃
Time : 60, 120 and 180sec
Thickness : 1.0 and 2.0mm

③Shortening hot-pressing time
Temperature : 200℃
Time : 15, 30 and 45sec
Thickness : 1.0 and 1.5mm

④for Tensile test in thickness direction
Temperature : 180℃
Time : 120 and 180sec
Thickness : 1.0, 1.5 and 2.0mm

2.3 Tensile shear test

The performance of connection for hot-pressed veneers was evaluated by the tensile shear test. The outline of the examination is shown in Fig.1. The test was conducted with a universal testing machine at loading speed of 1mm/min. The tensile shear strength was obtained by dividing the maximum load in the tensile shear test with the area of the connected part. The area of the connected part was 30mm×50mm.

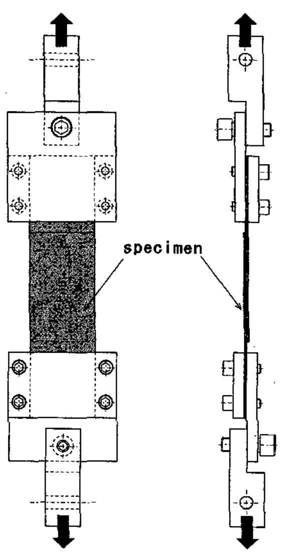

Fig.1. Outline of tensile shear test for connected veneers.

2.4 Tensile test in thickness direction

Figure 2 shows the outline of the tensile test in thickness direction of veneer. L figured jigs were bonded to the surface of each veneer at the edge in the connected part, and the tensile load in thickness direction was given to the specimen through the jigs. Because the bonding area of L figured jig was 15×30mm, the tensile strength in thickness direction was calculated by dividing the maximum load with this area. The test was conducted with a universal testing machine at loading speed of 1mm/min.

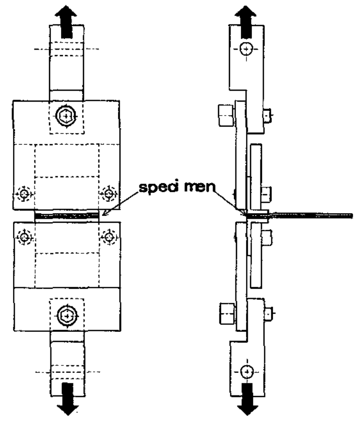

Fig.2. Outline of tensile test in thickness direction of veneer.

3. RESULTS AND DISCUSSION

3.1 Influence of hot-pressing temperature and time

The influence of temperature and time of hot-pressing on the tensile shear strength of the connected specimens for different thickness of veneer are shown in Fig. 3. The tensile shear strength increased with increasing hot-pressing time for every thickness of veneer, and for every hot-pressing temperature.

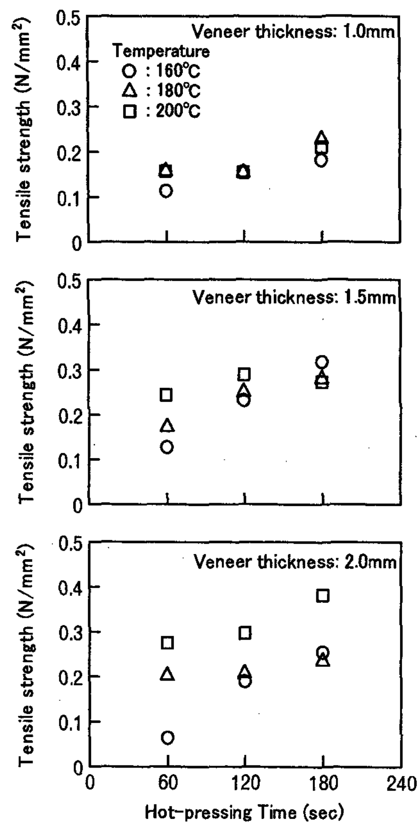

Fig.3. Influence of hot-pressing temperature and time on connecting performance.

There was a trend for the influence of temperature to be remarkably greater on thick veneer, although the difference of tensile shear strength was very small when the veneer was thin. The tensile shear strength increased with increasing veneer thickness. It is considered that the embedment of both veneers became large and the tensile shear strength increased, when the veneer was thick.

Specimens with tensile shear strength higher than 0.25N/mm^2 were broken at a place other than the connected section. Most of the failure occurred along the fiber within thickness direction. When the thick veneer was hot-pressed, the veneer embedded to the other was remarkably deformed and the failure occurred at the deformed portion of veneer. It was considered that the connecting strength of the specimen broken at the place other than the connected section was stronger than that of veneer itself.

3.2 Influence of Moisture content

In order to examine the influence of moisture content of veneer on the strength of the connection, veneer was seasoned at four levels of moisture content, such as water saturated condition (about 200%), wet condition (about 30%), air dried condition (about 10%) and kiln dried condition (below 10%). The results of tensile shear test for the specimens with a thickness of 1mm and 2mm are shown in Fig.4. The tensile shear strength for any veneer thickness increased with increasing moisture content within the range up to the moisture content of 30%. There was a tendency that the tensile shear strength for the specimen with thickness of 2mm increased with increasing hot-pressing time.

The pollution of the metal mold and the reduction of strength due to the damage caused by puncturing were found when the veneer was in the water saturated condition. Therefore, it can be judged that using the veneer adjusted between 15% and 30% of moisture content is more suitable to manufacture the wood tray than using veneer in a water saturated condition.

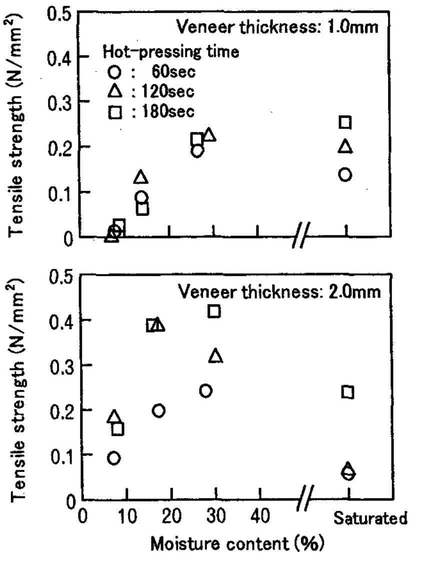

Fig.4. Influence of moisture content of veneer on connecting performance.

3.3 Shortening of hot-pressing time

For the economics of mass production, the possibilities of shortening the hot-pressing time by using higher temperature were examined. A temperature of 200℃, which was maximum temperature of hot-press machine used in this study, and hot-pressing times of 15, 30 and 45seconds were used.

The results for the veneer thickness of 1.0 and 1.5mm are shown in Fig.5. The results for the hot-pressing time of 60,120 and 180seconds are additionally shown in the same figure. The tensile shear strength was strongly dependent on the hot-pressing time, when the hot-pressing time was shorter than 60seconds. In other words, it seems that more than 60seconds of hot-pressing time is necessary to obtain enough strength of connection in any case of veneer thickness of 1.0mm and 1.5mm.

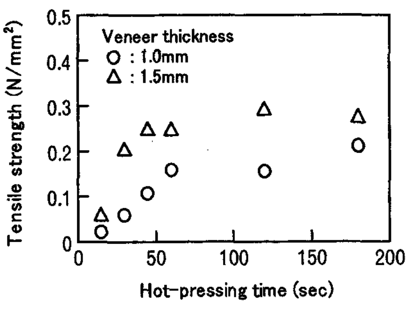

Fig.5. Influence of hot-pressing time on connecting performance when temperature is 200℃.

3.4 Tensile test in thickness direction

The tensile strength in thickness direction for three kinds of veneer thickness, when the hot-pressing time was at 120 and 180seconds, is shown in Fig.6. It was found that the connection of veneers by hot-pressing was very weak for the tensile load in thickness direction, compared with the tensile load along the fiber of the veneer. In other words, the strength of the hot-pressed veneer connection is greatly different depending on the direction of load, parallel or perpendicular to the fiber of veneer. So, it can be expected that a product with functionality can be developed which, while it is strong in service, can be easily broken down after use.

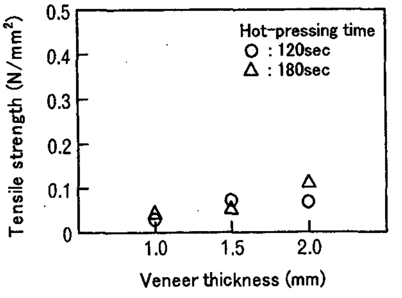

Fig.6. Tensile strength in thickness direction.

The difference of tensile strength in thickness direction by the hot-pressing time was not obvious except for veneer thickness of 2.0mm, and the strength for longer hot-pressing time showed higher value when the thickness of veneer was 2.0mm. The tensile strength in thickness direction tended to be stronger, when the veneer was thicker, because the amount of embedment to the other veneer increased with increasing veneer thickness.

3.5 Manufacturing a prototype of deep wood tray

For the purpose of confirming the possibility of manufacturing the deep wood tray without adhesive under the technique of connecting sugi veneers by hot-pressing, a prototype of a deep wood tray using a metal mold was made.

The top view of the final prototype is an oval, 150mm in width, 210mm in length and 90mm in depth, as shown in Fig.9.

Figure 7 shows the shape and size of the veneer used for making the prototype. The size of veneer (A) was 250mm in fiber direction and 220mm in width, and it was trimmed by quadrant, radius of 40mm, at each corner in order to make the style of tray beautiful and to reduce the failure of the wrapping film. The size of veneer (B) was 180mm in fiber direction and 200mm in width. The veneers were arranged with veneer (B) fiber direction parallel to the short axis of the mold, with veneer (A) on top across the fiber direction of veneer (B), as shown in Fig.8.

The platen temperature of the hot-pressing machine was set to 200℃ and the hot-pressing time was set to 120seconds to avoid temperature reduction of the large metal mold. The moisture content of the veneer was adjusted within the range from 10 to 20%, because the veneer in a water saturated condition caused problems such as iron pollution and damage by puncture.

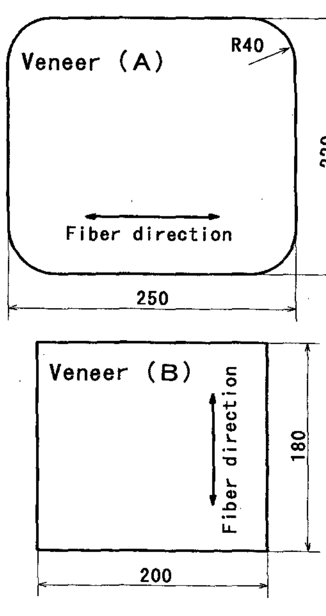

Fig.7. Shape and size of sliced veneers used for making deep wood trays

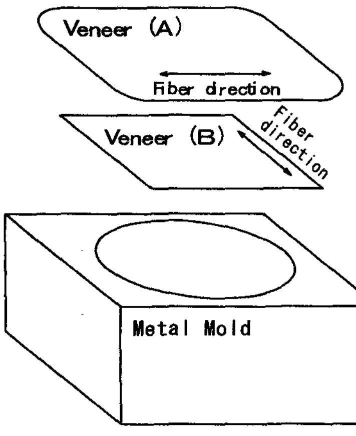

Fig.8. Assembling two sliced veneers

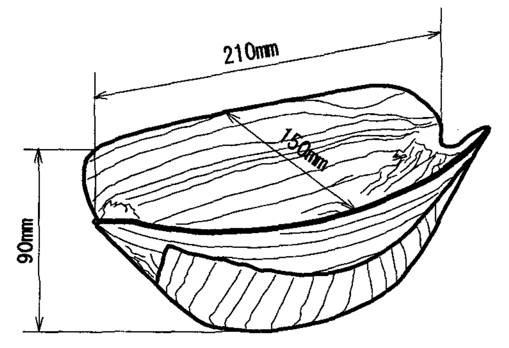

Fig.9. Sketch of the final prototype of deep wood tray

4. CONCLUSION

Two overlapping sliced veneers of sugi can be connected by hot-pressing, utilizing the properties that sugi is soft and easy to embed. The influences of moisture content; thickness of veneer; hot-pressing temperature, and time on the strength of the connections were analyzed and clarified by the tensile shear test and tensile test in thickness direction. The possibility of manufacturing deep wood trays by hot-pressing two sliced veneers of sugi placed orthogonally to each other without adhesives was confirmed.

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