Preliminary

Continuous Manufacture of Cylindrical Laminated Veneer Lumber*[1]

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Introduction

"Spiral-winding methods" are well-known manufacturing processes for cylindrical industrial products including paper tubes and fiber reinforced plastics. A batch type spiral-winding method has recently been applied to manufacture cylindrical laminated veneer lumber (LVL) with interlocked fiber-oriented structure.

This manufacturing system, however, has involved a problem on low-productivity; the time required for winding veneer tape is in proportion to the ply number of LVL. Therefore, rather long manufacturing time is required for producing thick cylindrical LVL.

This paper deals with the development of continuous manufacturing process by using a spiral-winding method to improve the productivity of cylindrical LVL.

Materials and Methods

A formula based on the spiral-winding method leads mathematically to the manufacturing conditions of the products as following.

$$W = \pi D \cos\theta, \quad (1)$$

where W is a width of a tape of material wound around mandrel, D is a mandrel diameter or an inside diameter of a cylindrical product and θ is an entrance angle. In this study, D and θ were set 80 mm and 80 degree, respectively, for making standard cylindrical LVL. The tape used in this experiment was 1-mm thick veneer with a standard width of 43.6 mm on the basis of the Eq. (1).

The continuous manufacturing process was designed as follows (Fig. 1); the veneer tapes coated with an adhesive resin are wound on the mandrel simultaneously, and then the laminated veneers are pressed and sent forward with an elastic belt as shown in Fig. 1.

Generally, parallel laminated veneer tends to be cleaved parallel to the fiber direction. Therefore, it is effective to make cylindrical LVL with fiber-interlocked structure for preventing this cleavage. In the batch type manufacturing process, veneer tapes are wound on the mandrel in clock-wise or counter clock-wise directions for alternate layers, which makes interlocked cylindrical LVL[1]. This method is not available for the continuous manufacturing process for the veneer tapes are wound on the mandrel in the same direction.

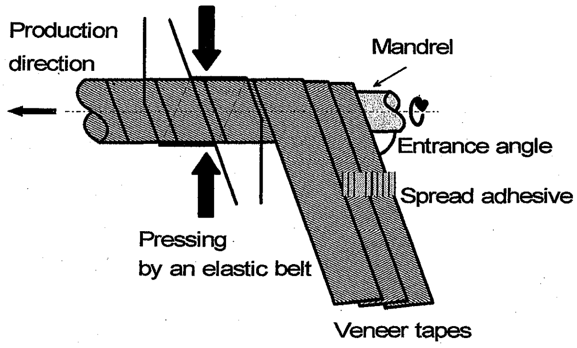

Fig. 1. Illustration of manufacturing system of cylindrical LVL.

Rotary cut veneer with the thickness and density of 1mm and 0.42 g/m^3, respectively, made of Japanese cypress (*Chamaecyparis obtus*) was used for the material of manufacturing cylindrical LVL. Two types of the veneer tapes prepared for winding *Z*-spiral and *S*-spiral alternatively, were mutually laminated in order to make an interlocked cylindrical LVL. A hot melt polyurethane reactive (PUR) adhesive was used to achieve sufficient bonding strength and durability in a short pressing time.

As for the production of cylindrical LVL, reasonable end-joint intervals were limited due to the limitation of the veneer tape width provided by manufacturing conditions. Therefore, a frequency of joints across the thickness highly affects the mechanical properties of cylindrical LVL. To reduce this negative effect on the mechanical properties, the adjacent joints interval was selected to be one third of standard tape width, so the joints across the thickness appeared at the same position in every 3 layers.

A spiral-winder for the production of paper tube was applied to the continuous manufacture of 3-ply cylindrical LVL bonded with a PUR adhesive in a running speed of about 30 cm/min. The manufactured cylindrical LVL was cut into every 2 m for four-point bending test under a span of 1,806 mm.

Results and Discussion

Fig. 2 shows the continuous manufacturing process of

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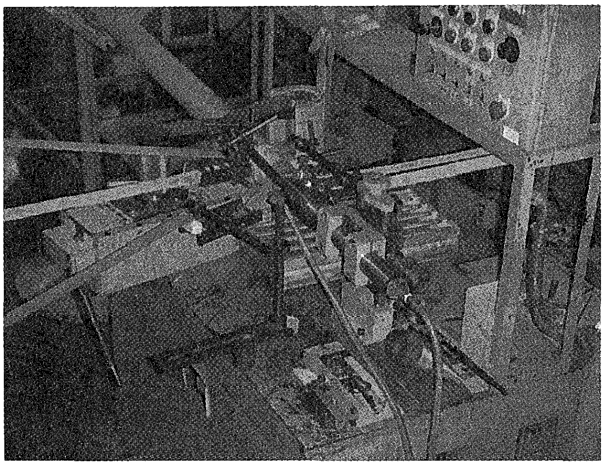

Fig. 2. Continuous manufacture of cylindrical LVL.

the cylindrical LVL. The cylindrical LVL was extruded in the constant direction with an elastic belt driving system.

In the bending test, buckling in pure bending section was observed. Continuous type cylindrical LVL manufactured in this experiment provides the MOR value of 25.9 MPa, which showed higher value than those in these previous studies. For an example, HATA *et al.*[2] reported that MOR of lauan cylindrical LVL with the continuous joints across the thickness was 10.1 MPa. Thus, the joint control across the thickness led the remarkable improvement of MOR.

The system proved it possible to manufacture endless cylindrical LVL with the interlocked structure. Since the ply-number of LVL was only three in this study, it is necessary to investigate mechanical properties of cylindrical LVL with larger ply-number.

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