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Моделювання впливу циклічної дії вологості навколишнього середовища на довговічність термопластичних клейових з'єднань деревини

Наведено математичний розрахунок вологоперенесення в клейовому з'єднанні деревини для граничних, початкових та стаціонарних умов. Змоделювано процес впливу циклічної дії вологості навколишнього середовища на клейові з'єднання деревини під час експлуатації.
Ключові слова: клейове з'єднання, вологість, вологоперенесення, стаціонарні і змінні умови, пружно-деформаційний стан.

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THE STUDY OF METHODS OF WOOD BENDING

Existing methods for bending wood. The basic perspective directions of manufacturing curved details and examples of finished products. The analysis of technology, given the advantages and disadvantages of each. Using new methods of bending is one way to save wood resources.
Keywords: bending, kerfing, laminated bending, vacuum, compression bending, internal heating.

Wood bending is one of the techniques used in the wood processing from a long time ago. Nowadays, there are various designs for chair with a value-added element, and to make it as a product, the need to learn the manufacturing technique and its application becomes very important. From now on, wood bending is one of the techniques that is necessary in the furniture making and also in its design strategy, make us able to make and design furniture accompanied with a new value-added elements. Bending process such as a heating method, depends on the different of the method used, could be classified as below. These are simple explanation for every bending process [1-14].

<table>
<tr><td rowspan="12">Wood Bending</td><td colspan="6">Laminated Bending</td></tr>
<tr><td rowspan="11">Solid Wood Bending</td><td colspan="5">Kerfing</td></tr>
<tr><td colspan="3" rowspan="2">Bending process using a chemical treatment</td><td>Ammonia treatment</td></tr>
<tr><td>Alkali treatment</td></tr>
<tr><td colspan="5">Compression bending</td></tr>
<tr><td colspan="5">Cold bending</td></tr>
<tr><td rowspan="6">Hot bending</td><td colspan="4">Internal heating (microwave heating)</td></tr>
<tr><td rowspan="5">External bending</td><td colspan="3">Direct heating method</td></tr>
<tr><td colspan="3">Hotplate method</td></tr>
<tr><td colspan="3">Boiling method</td></tr>
<tr><td rowspan="2">Steaming method</td><td>High pressure method</td></tr>
<tr><td>Low pressure method</td></tr>
</table>

Fig. 1. Type of bending process

Laminated Bending. The method used in laminated bending is to press the lamination of veneers glued at the former made from metal, plywood etc. With the former, this method is comparatively easy to make the bend component. It is widely used in the making of chair component for the mass production. In laminated bending the thin layer is chosen so that it would be easy to bend (between 1mm to 5mm) depends on its curvature. For the mass produc-

tion, the ready-made veneer is widely used. Regarding the former, it is better to make both the male former and the female former, but for a trial making or a partial component making, we can make only the one side former and do the clamping. In America, we can see the laminated bending technique using a vacuum type mold device. Here, the molding range is limited, but of course one side mold is already enough. Different from a pure bending technique, the laminated bending technique keeps the 'R' shape of the product from straightening out when it is removed from the mold. It has the strength. One of the merit is there is almost no spring back occurred to the material. Keeping a fixed shape of the 'R', and to get a same quality of the components means a big merit for the maker side. Moreover, since the laminated bending using a large quantity of adhesive material causes a rise in the moisture content, it is important to fully dry it before removing it from the former. Basically, if the drying process is done carefully after applying the adhesive to the material, there should be no spring back problem.

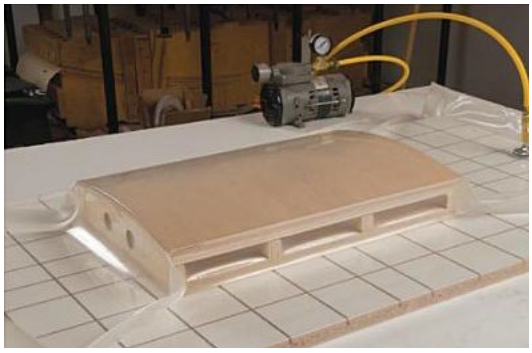

Fig. 2. Vacuum type mold device

But, if it is removed from the mold too quickly, spring back will occur. Moreover, the problem in the manufacturing of the veneer, small crack along the grain of the material after the molding caused by its moisture content are some of the things that might occur. In the case where a gap occurs between the veneer layers, wood dust is applied to the place and super glue is used to fix it (use a low adhesive type used for metal use, high adhesive type for wood material use is not good enough to be used). More, the efficiency would increase if we use a spray type primer.

Fig. 3. Prototypeat thelaminatedbending

The reference figures show the bending process work and prototype. Figure at the previous page shows the laminated veneers with a thickness of 1.5mm. Since it is just for modeling, only one side mold is made.

Kerfing. Generally, the method used is to make a saw kerf (cut) on the inner surface of the material. The formula for this kerf bending is the relation between the thickness of the material, the curve 'R' (outer side) and the quantity of the saw cut. Here we figure out how many saw cut can be made with in the R/4 of the circle. Quantity of saw cut = 1.75 x thickness of wood / thickness of saw blade. In the above formula, the quantity of the saw cut has no relation with the value of 'R'. For example, for the cuts with the thickness of 2mm, to get a 300mm radius of the outer 'R', we need to make 15.7 (about 16 cuts) to the material with the length 471 mm (1.57×300). Here, make about 1 ~ 2 mm of the outer side of the material remain uncut. Since the

'R' is not included in the formula, even the quantity of the cuts made decided from the formula, there will be a case where we could not get the desired 'R'. Here we need to make a little adjustment, by adding more cuts or by crushing the angle of the saw cut.

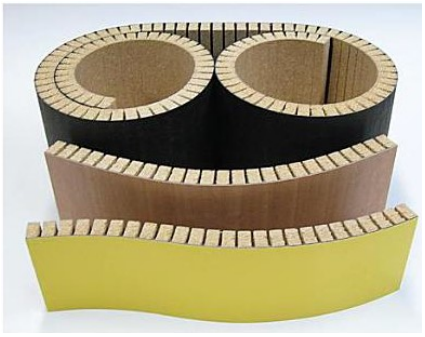

Fig. 4. Sample-kerf bending details

Compression bending. This is a new technique in bending process. Firstly, the material is pressed along its length direction (along the grain) before it is bended. Means, the structure of the fiber becomes like a bellow, making it easier to bend. However, compare to other method that usually use a heat (Tohnet's method: will be discussed later), it is weaker in term of the strength. The method used is to use a device that hold both the ends of the material firmly, then it is inserted into a casing (like a pipe etc) that just fit its size, and using a hydraulic cylinder the material is pressed along its length for about 10 %, and then it is returned back to about 5 %.The material used is the one with moisture content of about 20-30 %. After it is pressed, it is bended using a former and dried. During the bending, it is better to use the strap so that the material sticks to the former properly.

This method is same as Tohnet's except for the pressing process. After the material is processed, if we could maintain the content of the moisture, then we do not have to do the bending process right away. This is the merit of this method. Even it seems very simple in term of the theory, this method is still not a common thing. 'Compwood' Machine Company from Denmark is one of the little companies involves in the making and sale of the machinery equipment used for cold bending. In this patent system, material that already dried naturally to 20-25 % moisture content and processed using a planer is put to the autoclave and heated using a steam. Next, the process is complete when the steamed material is pressed along its grain with the hydraulic pressing device. By applying a pressure, a pleat occurs at the wall surface of the fiber (cellulose), and leaving it in several minutes would make it easy to bend even in the cold condition. Then, by dry it in its bended condition, the material would harden. Since, the material that is processed using this compressing method is suitable for storage, it is possible for an effective production control in the making of partial component.

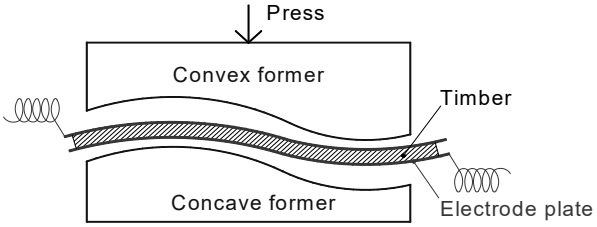

Fig. 5. High frequency heating

Internal heating / Microwave heating. This is a method of using a microwave to do the heating. Microwave is a wave with a frequency about 300 Hz to 300 kMHz, wavelength of about 1 m to 1 mm range. In this range we have UHF (Ultra-high Frequency, wavelength 10-1 cm), SHF (Super-high Frequency, wavelength 10-1 cm) and EHF (Extremely-high Frequency, wavelength 1-0.1 cm). The heating process is done using these waves. Microwave, like an AC current repeatedly irradiates a plus and minus charge to the material. At the other side, the molecules constructing the material itself, has a plus and minus characteristic. These molecules respond to the direction of the electric field comes from the external source, but when the fre-

quency becomes higher, they become more independent resulting a friction between the vibrating and rotating molecules. The friction generates heat to the material.

Moreover, water is very ideal substance in term of heating, because its absorption and loss of energy is big (generates heat easily). At the frequency of 10 GHz, 915 MHz and 2450 MHz, it shows a big loss of energy. For that reason, material contains water (moisture) generates heat more easily. The frequency of microwave in the microwave oven used at home is about 2450 MHz (245 millions cycles per seconds). By the way, microwave permeates through a ceramic, and reflected by a metal. For that reason, this method of bending is widely used during softening process, or during a molding process where the heat is applied at the same time (above figure), and the use scope is expanding. The device itself is simple, where the heating part consists of the microwave oscillator, heating room, wave guide assembly, antenna etc. Moreover, since it is possible to bring the microwave to some distance, it is possible to use it for a partial heating (there is a noise problem and there is a case of a maker using it for partial bonding).

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Дослідження методів гнуття деревини

Розглянуто існуючі методи гнуття деревини. Досліджено основні перспективні напрямки виготовлення криволінійних деталей. Наведено приклади готових виробів. Проведено аналіз технологій, подані переваги та недоліки кожної з них. Використання нових методів гнуття є одним із шляхів економії деревинних ресурсів.

Ключові слова: гнуття, ламіноване гнуття, вакуум, гнуття тиском, внутрішнє напруження.