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THE DIMENSIONAL STABILITY OF ENGINEERED WOOD FLOORING IN HEATING SYSTEMS

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ABSTRACT

In this work, the effect of decorative veneer type, wood structure and wood shape on the dimensional stability was studied in a laboratory with a simulated heating system. Poplar/seven layer plywood engineered hardwood (structure C) or a 9 mm thick poplar substrate layer wood which contained the two veneer surface layers, structure A and structure B were used. The results indicated that whatever the structure and decorative veneer of flooring were, the dimensional stability of engineered wood flooring had a better performance in length; In width, with the same structure and decorative veneer, the dimension stability of engineered wood flooring with the veneer shape of mono-block was better than the shape of three splice; With the same decorative veneer, the dimensional stability of structure C was best, the second was structure B, and structure A was the worst; With the same structure, the dimensional stability of engineered wood flooring decorated with birch was best, the second was eastern black walnut, the third was eucalyptus, and maple was the worst. Thus, the engineered wood flooring of structure C decorated with birch with mono-block veneer was judged to be better for the dimensional stability.

KEYWORDS: Engineered wood flooring, heating systems, dimensional stability, decorative veneer, veneer shape.

INTRODUCTION

Over a period of time, the engineered wood flooring had been in common usage, as early as 1970, it continued to be popular in Europe. Sawn wood or plywood makes up the engineered wood flooring with a thin fancy veneer bonded onto poplar panels or plywood using melamine-formaldehyde (MF) and urea-formaldehyde (UF) resins as hot press adhesive (Kim and Kim

2006). Engineered wood flooring made up 1/3 of all floorings in the United States in 1999. At the same time, 63.8 % of wood flooring was engineered wood flooring in Europe (Blanchet et al. 2003). Engineered wood flooring increased the total yield by 39 % in China from 2004 to 2005, in addition, the engineered wood flooring output growth rate was increasing ranging from 5 to 20 % (Wang and Guo 2006). Engineered wood flooring exhibited a natural grain, provided a fine comfort level, and had good stability, its use had flourished in home renovation (Chen et al. 2015a, Guo et al. 2015).

Floor heating systems have a long story, as early as 400 B.C floor heating systems have been used in Korea. When it began wood was used as fuel which maybe a gate or a desk, then the floor heating systems have been improved many times for a variety of reasons, such as to avoid death by carbon monoxide poisoning, etc. (Song 1996). Today, the indoor flooring heating systems consist of a copper pipe instead of wood or briquettes installed with a narrow pitch in a cement mortar, and the hot water through the pipe as heating medium (Kim and Kim 2005). On the surface of the floor, heat from the hot water is radiates to warm the air and human body. Floor heating systems begin to be more and more popular especially in Korea, Koreans not only sit directly on the floor heating systems but also sleep on the floor heating systems (Song 2005).

Because of the particularity of floor heating systems, the engineered wood floor put in the floor heating systems must be a good performance, such as dimensional stability. Blanchet et al. (2005) found that the non-homogeneous adsorption or desorption of moisture by engineered wood flooring may induce its deformation, thus decreasing the product value. Therefore, do a lot of researches to solve this problem. Blanchet et al. (2005) developed a three –dimensional finite element model of the hydro mechanical cupping in layered wood composite flooring. By this finite element model, the shrinkage and swelling of each layer can be taken into account. Fang et al. (2012) found that densified sugar maple treated by oil-heat showed lower swelling in the width and length directions than non-densified sugar maple. Reinprecht et al. (2013) found that dimensional stability of wood can be improved by various modification processes, such as silicones.

This research focused on finding the effect of decorative veneer, structure and wood shape of engineered wood flooring on dimensional stability. The dimensional stability is an important index to evaluate the quality of the flooring, especially the engineered wood flooring in heating systems. Because of great changes for the temperature and humidity, it is easier to change the dimension of the flooring (Blanchet 2008). Therefore, the aim of the work is to find the better kind of engineered wood flooring in heating systems and provide technical support for improving dimensional stability of engineered wood flooring used in heating systems.

MATERIAL AND METHODS

Materials

The experimental materials were all Engineered wood flooring provided by Dare (Jiangsu) Parquet Col, Ltd., which was located in Danyang of Jiangsu province in China. The floorings can be divided into three forms according to the structure. As shown in Fig. 1, structure A was composed of 4 mm thick decorative face (upper) veneer, 9 mm thick poplar core boards and 2 mm thick poplar back (lower) veneer. Structure B was made of 4 mm thick face plates which contained 1.2 mm thick decorative face (upper) veneer and three-layer plywood, 9 mm thick poplar core boards and 2 mm thick poplar back (lower) veneer. Structure C consisted of 1.2 mm thick decorative face (upper) veneer, seven-layer core plywood and 2 mm of poplar back (lower) veneer (Chen et al. 2015b).

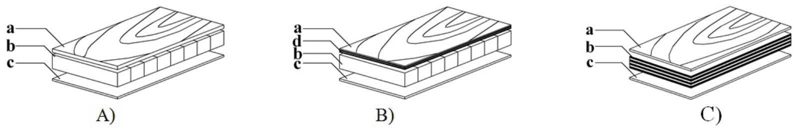

Fig. 1: Three forms of structure A), B), and C) of engineered wood flooring: a) decorative face (upper) veneer, b) core board, c) back (lower) plywood, and d) plywood

The structures in accordance with the form of decorative veneer can fall into two types: mono-block (Fig. 2a) and three splice (Fig. 2b). The floorings with structure A and C owned two types of decorative veneers and structure B only had one type of decorative veneer: mono-block. All of the mono-block samples had the dimensions: 910 x 125 x 15 mm (length x width x thickness), and the three splice samples had the dimensions: 2200 x 205 x and 15 mm.

Fig. 2: The two types of decorative veneers: a) mono-block and b) three splice.

Methods

Testing environment and equipment

We conducted the experiments in a heating system which simulated the normal heating conditions and included a laboratory room with the model of DKC18 manufactured by O.S.Panto S.r.l (Italy). The layout of the laboratory was shown in Fig. 3, hot water pipes were laid in the cement mortar ground, and the control system installed outside adjusted the temperature of the pipes. Polyethylene film with the thickness of 1 mm was covered above the cement floor on which laid the engineered wood floorings. In addition, there was a humidifier in the laboratory room adjusting the humidity by spraying into water vapor.

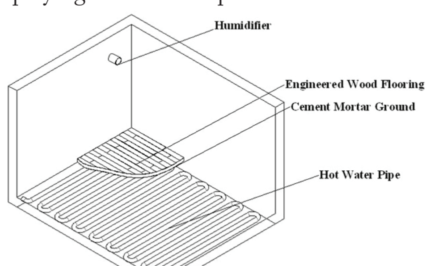

Fig. 3: The testing environment.

Plan of the experiment

Two factors were considered. The first one was to test the dimensional stability of engineered wood flooring with different structures. All samples kept the same decorated veneers, there were a total of five groups' samples. Structure A in mono-block veneer shape and three splice veneer shape; structure B in three splice veneer shape; structure C in mono-block veneer shape and three splice veneer shape. The second factor was the type of decorated veneers. There were a total of eight groups' samples. Structure A in mono-block with four different decorated veneers (Maple; Eastern black walnut; Eucalyptus and Birch) and structure A in three splice with four different decorated veneers (Maple; Eastern black walnut; Eucalyptus and Birch).

At first, measure and record the primary dimension of each engineered wood flooring sample. As Kang et al. (2003) have explored, the ideal flooring surface temperature may range from 22.0 to 38.8°C, the simulated environment: high temperature environment similar to the environment in winter (indoor temperature 25±2°C, relative humidity 25±5 %) was chosen. Then, the control system of the laboratory was opened and the temperature set to 25°C. A few hours later, the indoor temperature reached the specified temperature. Afterwards, place all the samples on the polyethylene film in the laboratory with the decorative veneers facing up. In addition, each sample was adjacent but not connected. Measure and record the changed length and width every five days.

Dimension measurement

The dimension of floorings was measured using a tape measure and a caliper. Measure and record the changed length and width every five days. The specific method of measuring the dimension referred to national standard GB/T18103-2013 (2013). The method was shown in Fig. 4.

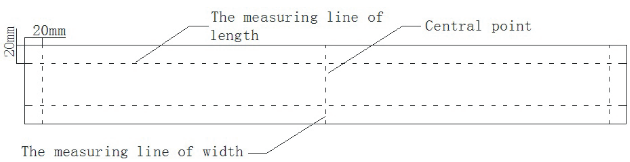

Fig. 4: The measurement of length and width.

Analysis measurement

The dimension stability in this research was represented by dimensional change ratio in length and width. Specifically:

$$L_e = \frac{L_1 - L_0}{L_0} \times 100\% \quad (\%) \qquad (1)$$

where: L_e - The dimensional change rate in length (%),
L_0 - The primary dimension in length (mm),
L_1 - The dimension after processing in length (mm).

$$W_e = \frac{W_1 - W_0}{W_0} \times 100\% \quad (\%) \qquad (2)$$

where: W_e - The dimensional change rate in width (%),
W_0 - The primary dimension in width (mm),
W_1 -The dimension after processing in width (mm).

RESULTS AND DISCUSSION

Dimensional stability in length

Tab. 1 showed the measuring results of dimensional stability in length by comparison of primary length, final length and the dimensional change ratio in length when the structure of flooring was different as eastern black walnut decorated the veneer.

Tab. 1: The dimensional stability in length with different structures.

Veneer shape	Length index	Structure A	Structure B	Structure C
Mono-block	L_0 (mm)	909.9	910.0	910.0
	L_1 (mm)	909.9	910.1	910.0
	L_e (%)	0	0	0
Three splice	L_0 (mm)	2200.0	-	2200.0
	L_1 (mm)	2200.1	-	2200.0
	L_e (%)	0	-	0

Tab. 2 showed the measuring results of dimensional stability in length by comparison of primary length, final length and the dimensional change ratio in length when the decorative veneer type was different as same structure in different veneer shape.

Tab. 2: The dimensional stability in length with different veneer type.

Veneer shape	Length index	Maple	Eastern black walnut	Eucalyptus	Birch
Mono-block	L_0 (mm)	910.1	909.9	910.1	910.0
	L_1 (mm)	910.1	909.9	910.2	910.1
	L_e (%)	0	0	0	0
Three splice	L_0 (mm)	2199.7	2200.0	2200.0	2200.0
	L_1 (mm)	2199.8	2200.1	2200.2	2200.1
	L_e (%)	0	0	0	0

From Tabs. 1 and 2, it can be seen that whatever the structure and decorative veneer of flooring were, there was minimal change of dimension in length. There may be two reasons. In the way of wood anatomical structure, wood consisted of cells which almost arranged along a longitudinal direction, the secondary wall was with the greatest thickness which made up the cell walls. The micro fibril angle was small and dimension mostly changed in length between micro fibril. In the way of wood chemical structure, cell walls were made of cellulose, in length direction of cellulose was hydrophobic with C-O bonds which led to the minimal change of dimension in length (Panshin et al. 1991, Liu and Meng 2003). That was to say, the dimensional stability of engineered wood flooring in length was better.

Dimensional stability in width

Tab. 3 showed the measuring results of dimensional stability in width by comparison of primary width, final width and the dimensional change ratio in width when the structure of flooring was different as eastern black walnut decorated the veneer.

Tab. 3: The dimensional stability in width with different structures.

Veneer shape	Width index	Structure A	Structure B	Structure C
Mono-block	W_0 (mm)	125.14	124.83	125.31
	W_1 (mm)	126.17	125.76	125.53
	W_e (%)	0.82	0.75	0.18
Three splice	W_0 (mm)	204.99	-	204.78
	W_1 (mm)	207.54	-	206.72
	W_e (%)	1.24	-	0.95

Figs. 6 and 7 showed variation trend of width with the time going when the structure of flooring was different with mono-block and three splice.

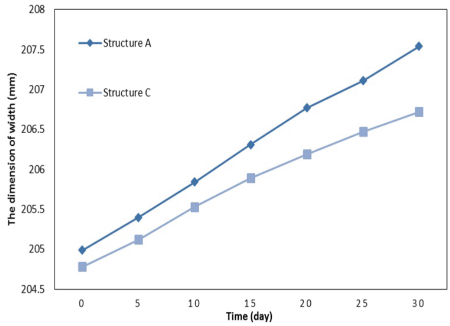

Fig. 6: The width change trend of structure A, B and C in mono-block.

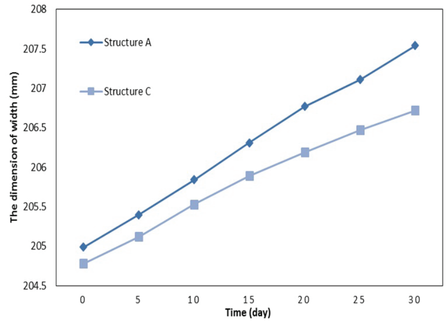

Fig. 7: The width change trend of structure A and C in three splice.

It can be seen from Tab. 3, Figs. 6 and 7, the engineered wood flooring would be swelling in the experiment condition no matter what the structure was. That's because the width of the cellulose was hydrophilic with many hydroxyl groups and the water absorption of the hydroxyl groups led to the changes in dimension (Kollmann et al. 1991).

When the shape of veneer was mono-block, the swelling efficacy of the floorings was ranked as follows: structure A> structure B> structure C; when the shape of veneer was three splice, the swelling efficacy of structure A was bigger than structure C. It was summarized that the dimensional stability of structure C was best, the second was structure B, and structure A was worst. This may be because the engineered wood flooring of structure C was multi-layer which was made from plywood, it can't completely avoid the gap between the layers which can play a role of buffer in dimensional changes slowing the rate of swelling efficacy.

In addition, for structure A and structure C, the swelling efficacy of mono-block was bigger than three splice. It followed that the dimensional stability of floorings with mono-block veneer was better than three splice veneer. It was probably that the three splice veneer consisted of three single veneers which had big difference in density and may not come from one tree and the mechanical property of each single veneer was different which would lead to change in dimension (Kollmann et al. 1991).

Tab. 4 showed the measuring results of dimensional stability in width by comparison of primary width, final width and the dimensional change ratio in width when the decorative veneer was different as using the structure A with mono-block and three splice.

Tab. 4: The dimensional stability in width with different veneer type.

Veneer shape	Width index	Maple	Eastern black walnut	Eucalyptus	Birch
Mono-block	W_0 (mm)	124.89	125.17	125.09	125.39
	W_1 (mm)	126.71	126.13	126.31	126.19
	W_e (%)	1.44	0.77	0.98	0.64
Three splice	W_0 (mm)	205.11	204.95	205.28	204.80
	W_1 (mm)	208.31	207.52	207.92	206.39
	W_e (%)	1.56	1.25	1.29	0.78

Fig. 8 and 9 showed variation trend of width with the time going when the engineered wood flooring decorated with different types of veneers using structure A with mono block and three splice.

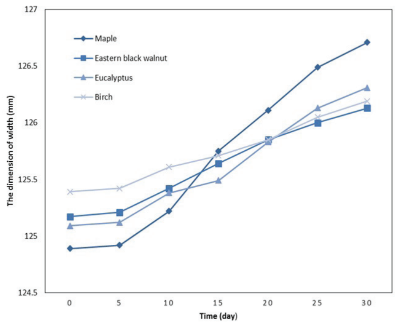

Fig. 8: The width change trend of structure A in mono-block.

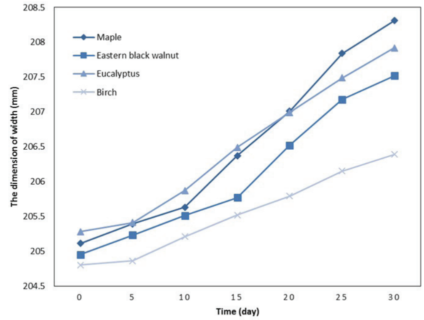

Fig. 9: The width change trend of structure A in three splice.

As shown in Tab. 4, with the same structure A and decorative veneer, veneer shape of mono-block performed better in dimensional stability than veneer shape of three splice. As said above.

In Figs. 8 and 9, as the time going on, the width would increase whatever the decorative veneer was. The width variation of maple and eucalyptus was larger than eastern black walnut and birch. It is as the coefficient of shrinkage of four decorative veneer from small to large: birch < eastern black walnut < eucalyptus < maple. The smaller the coefficient of shrinkage were, the little the wood dimension variation would be (Wang and Li 2010). This showed that the dimensional stability of engineered wood flooring which decorated with birch would be better.

CONCLUSIONS

1. In length, whatever the structure and decorative veneer of flooring were, the dimensional stability of engineered wood flooring had a better performance.
2. With the same structure and decorative veneer, the dimension stability of engineered wood flooring with the veneer shape of mono-block was better than the shape of three splice.
3. In width, with the same decorative veneer, the dimensional stability of structure C was best, the second was structure B, and structure A was the worst.
4. In width, with the same structure, the dimensional stability of engineered wood flooring decorated with birch was best, the second was eastern black walnut, the third was eucalyptus, and maple was the worst.
5. In conclusion, structure C decorated with birch with mono-block veneer was judged to be better for the dimensional stability.

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