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EFFECT OF HIGH FREQUENCY HEATING TIME ON GLUE BOND QUALITY IN LAMINATED RUBBERWOOD

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BY

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ABSTRACT

About 70% of Malaysia's furniture are made from Rubberwood. Most of the rubberwood used in this industry are in the form of laminated boards. One of the critical factors in the production line of wood lamination is the curing time of the glue line. One way to overcome the time consumption is by using High Frequency curing method. This study is aimed to determine and to assess the performance of glue bond quality under different heating times using wood at various grain patterns. Polyvinyl acetate (PVAc) plus a hardener was used as the bonding agent. The boards were subjected to 10 heating times, starting from 1.5 minutes with an increment of 1 minute. The glued boards were of 4 types of grain pattern; radial-radial faces, radial-tangential faces, tangential-tangential faces and bastard sawn. Thirty samples were prepared for each grain pattern arrangement at each heating time and were subjected to shear block test. The shear results obtained were statically analyzed using analysis of variance. It was found that the 1.5 minutes curing time was sufficient to produce the necessary glued bond quality. This heating time produces results that satisfy the requirements of Japan Agricultural Standard. The requirements called for bond quality with a minimum of 60kgf/cm^2 and 60% wood failure when subjected to block shear test, and the ratio of delamination must not exceed 1/3 of the total length. The results also indicated that as early as 1.5 minutes, the glue line temperature had achieved 100^{o}C which is the minimum temperature required to cure the adhesive. The adhesive used is found to be highly moisture resistant since none of the samples delaminated during the cold water soak test. No significant difference was found among the position eventhough the middle position gave the highest shear strength. Tangential-tangential faces has the highest shear strength, however, when compared to bastard sawn lamination, it was not significantly different. By comparing heating time, it shows that 1.5 minutes has the highest shear strength and wood failure (139.80 kgf/cm^2, 95% respectively), which is highly significant compared to the other heating times.

CHAPTER 1

1.0 INTRODUCTION

1.1 Background

The furniture industry has developed and become one of the major wood-based industries in increasing export earnings. Great emphasis on further development of the furniture industry is given in the Sixth Malaysia Plan (1991-1995). The government has taken several measures, such as Pioneer Status/Investment Tax Allowance (ITA), Import Duty Exemption and Exports incentives to help promote and encourage the development of furniture and other wood based industries (Kaziah, 1990). This is one of the ways for cooperation between the government and the industries to provide future expansion and improvement. Malaysia can have a great prospect given the existence of material, manufacturing resources and the back up from the government.

In the production of wooden furniture in Malaysia, Rubberwood (*Hevea brasiliensis*) has been extensively used. It is estimated that approximately 70% of the total exports of wooden furniture in 1989 were from Rubberwood (Chew and Roszehan, 1990). Lamination has been the main practice in order to obtained large

dimensioned boards because of the small rubberwood log diameter obtained. Wood lamination for table tops consist of sawn boards or small squares arranged with the grain roughly parallel and glued together thickness wise, widthwise and lengthwise (Anonymous, 1985).

The apparent problems which are faced by the industries are lack of knowledge of markets and techniques of production of high quality laminated products. Those involved in laminated table top industries tend to stick to their traditional way of handling things; they are either ignorant or afraid of venturing into something new.

The introduction of high frequency glue curing technique in the 1960's was geared more towards plywood manufacturing. High frequency irradiation is new to the glue lamination process. This method has only recently been introduced to the local mills for the production of glue laminated wooden items. There are, thus, insufficient data and information on gluing properties of Rubberwood cured by the high frequency irradiation technique. Many aspects are not yet examined such as exposure to high frequency effects, different sawing pattern, etc. and thus, expansion and improvement cannot be achieved unless the basic data are available.

1.2 Objectives of Study

The potential utilization of high frequency irradiation technique as a major time saving process to speed up the production is dependent on the bond quality of the laminated product. This study is initiated as an attempt towards determining the performance of laminated Rubberwood under the influence of high frequency curing.

The objectives of this study are:

a) To determine the glue bond strength for various heating times by high frequency method.

b) To determine the mode of failure for various heating times.

c) To determine the accelerated degradation effect at various heating times.

d) To establish and recommend suitable heating times for gluing properties under high frequency curing of Rubberwood.

e) To provide information on gluing properties under high frequency curing for furniture manufacturer.

Although high frequency curing has been used in table top manufacturing, it seems that data on the strength of the glue bond laminated Rubberwood are not being considered. Knowledge of

the factors influencing the performance of glue bond is essential. Therefore, it is necessary to determine the effect of heating time on the glue bond and its accelerated degradation characteristics. This study is expected to provide the basic information and to serve as a basis for further research.

CHAPTER II

2.0 LITERATURE REVIEW

2.1 Rubberwood: Raw Material Resource

Rubberwood has become one of the valuable sources of timber for furniture manufacturing because of its light and even coloured texture. The wood is whitish yellow or pale cream when freshly cut; however when seasoned, it will change to light straw or light brown with slight pinkish tinge. The timber is classified as a light hardwood having an average diameter of about 500 mm at breast height. (Anon, 1990).

Rubberwood has become the favorite timber used in furniture production. Apart from its neutral colour, easy seasoning, machining and processing properties, it is also suitable for various staining to produce different colour tones (Ng, 1990), which is an advantage to other species.

In ASEAN region, rubber plantations are the largest man-made forest. Total land area planted with rubber is estimated at 6.4 million ha. and most plantations are concentrated in Indonesia, Malaysia and Thailand (Ser, 1990).

Currently, the total area under rubber trees in Malaysia is about 1.89 million hectares. The average replanting age for rubber trees is usually from around 25 to 30 years (Nor'ini et al, 1990). From the available data, Rubberwood has raised its status from a source of heat energy to vital raw material for furniture industries for both export and local markets. It is estimated that approximately 70% of the total exports of wooden furniture in 1989 are from Rubberwood (Chew and Roszehan, 1990).

2.2 Polyvinyl Acetate: Adhesive in Use

Polyvinyl Acetate (PVAc) is one of the leading synthetic adhesives for use in interior conditions. PVAc is thermoplastic whereby the process of adhesion can be reversible unlike other types of adhesives such as formaldehyde resins, epoxy glues or the polyurethane group of adhesives that are thermosetting. (Kollmann et al, 1975).

PVAc is being used to a large extent especially in the furniture manufacturing industries because it is easy to handle and clean to use. PVAc comes in one package only whereby in some adhesives, a mixture of hardener or catalyst is needed. Another factor is that PVAc has an unlimited storage time due to its thermoplastic condition. Users will have no problems in utiliz-

ing PVAc at anytime. Since it is synthetic, we can be assured of its resistivity to microorganisms. PVAc also does not stain the substrate, in this case the wood.

However, there are disadvantages in using PVAc. PVAc has a high sensitivity to water, therefore it is not suitable for exterior usage. There is also a rapid reduction of the strength under the influence of heat and moisture and there is the tendency to have large creep or low fatigue resistance (Kollmann et al, 1975).

2.3 High Frequency Curing Technique

Until now, majority of wood lamination was produced by the clamping method. Improved methods such as steam or electrically heated platens to accelerate the production of laminated wooden products have been introduced. Unfortunately, these methods are either too slow or too expensive. The idea of using high frequency irradiation is to produce a more economical and faster method of wood gluing.

High frequency is the radiation of electromagnetic energy in frequencies ranging from 1×10^4 to 3×10^9 cycles per second. When a relatively poor conductor is placed in between the metal

plates which are attached to the high frequency source, the conductor will get heated up. The action of radio waves generates heat by exciting the water molecules in the material (Clark Jr, 1983). This system provides a faster heat distribution throughout the material compared with heated plates where the heat has to penetrate the metal plates before it being generated.

2.4 Factors Affecting the Glue Bond Quality of Rubberwood

Rubberwood is a small diameter tree and the production of certain furniture component especially table top requires boards of larger dimensions. Glue lamination has thus been recommended (Menon and Burgess, 1979).

2.4.1 Properties of Rubberwood

Studies have been done (Ho and Choo, 1982) on the processing of Rubberwood. From the studies, the sawn boards can be machined to a fairly smooth surface. They are however, prone to seasoning defects such as bow, spring and end splitting. Juvenile wood, presence of internal stresses both aggravated by the inclusion of pith are responsible for these defects. It is also

found that the average recovery and average production rates are lower compared to others when sawn 'through and through' by the frame gang-saw. The seasoning defects can be minimised by exclusion of the pith. In addition, warp relief treatment should be applied. It is also found that Rubberwood has a low shrinkage and low movement compared to other Malaysian timbers.

2.4.2 Moisture Content

The effect of moisture content and preservative treatment on the glue bond strength have also been studied and it is found that satisfactory glue bond can be achieved from Mengkulang (*Heritiera spp.*) with a moisture contents in the range of 9 to 20% using phenol resorcinol formaldehyde adhesive (Ser and Lopez, 1983). For the case of softwoods, phenolic adhesive can be used satisfactorily at a moisture content up to 26% and for other wood adhesives, application can be made to air dried timber with moisture content of 18% to 22%.

2.4.3 Preservative Treatment

Ser and Lopez (1983) also reported on the significant effect of copper-chromium-arsenic preservative in the timber on

glue bond strength due to the preservative that affect the setting of phenol resorcinol formaldehyde adhesive. Recommendation was made to rectify the problem by curing the glue lines at elevated temperature which could produce satisfactory glue bond (Chugg, 1964).

2.4.4 Types of Adhesive

Further investigation on Rubberwood gluing properties was conducted by Mohd Shukari et al (1985). The experiment was conducted using the normal clamping method and comparison of results with Mengkulang (*Heritiera spp.*), Kapur (*Dryobalanops spp.*) and Keruing (*Dipterecarpus spp.*) Adhesives used were the urea formaldehyde and phenol resorcinol formaldehyde. From the study conducted, it was found that Rubberwood gluing properties were superior.

The introduction of high frequency in 1960's was geared more towards plywood manufacturing. High frequency curing is relatively new to the process of glue lamination. This method has only recently been introduced to the local industries for the production of glue laminated wooden items.

Similarly, the factors mentioned above do influence the glue bond performance under high frequency. Influence of current flow and duration of exposure are among other major factors that influence the glue bond quality (Grefart, 1965).

Given the steady availability of Rubberwood, and the current emphasis on further processing to manufacture value added products, this study could help to remedy the lack of technical information mentioned in 1.1.

CHAPTER III

3.0 MATERIALS AND METHODS

3.1 Materials

The timber consisted of treated Rubberwood (*Hevea brasiliensis*) in strips form. The criterion used in the selection of the material was that it is commonly used species and is the leading species for wooden furniture especially in laminated table tops.

The material was obtained from a Rubberwood supplier in Kelang. It originated mainly from Sungai Siput and Sepang plantations. The Rubberwood was pressure treated using Copper-Chrome-Boron chemicals and kiln dried to a moisture content less than 10%.

Upon obtaining the material, selection of true radial and tangential faces was made. Figure 1 is the diagram of such faces. The sawntimber was then cut into the radial and tangential face pattern as well as bastard sawn. Strips of 25 x 50 mm were then formed and finger jointed as necessary to achieve a standard length of 2000 mm as shown in Figure 2. The strips were then conditioned to a moisture content of 12% - 14%. Summary of the specification of strips for these experiments is as follows:-

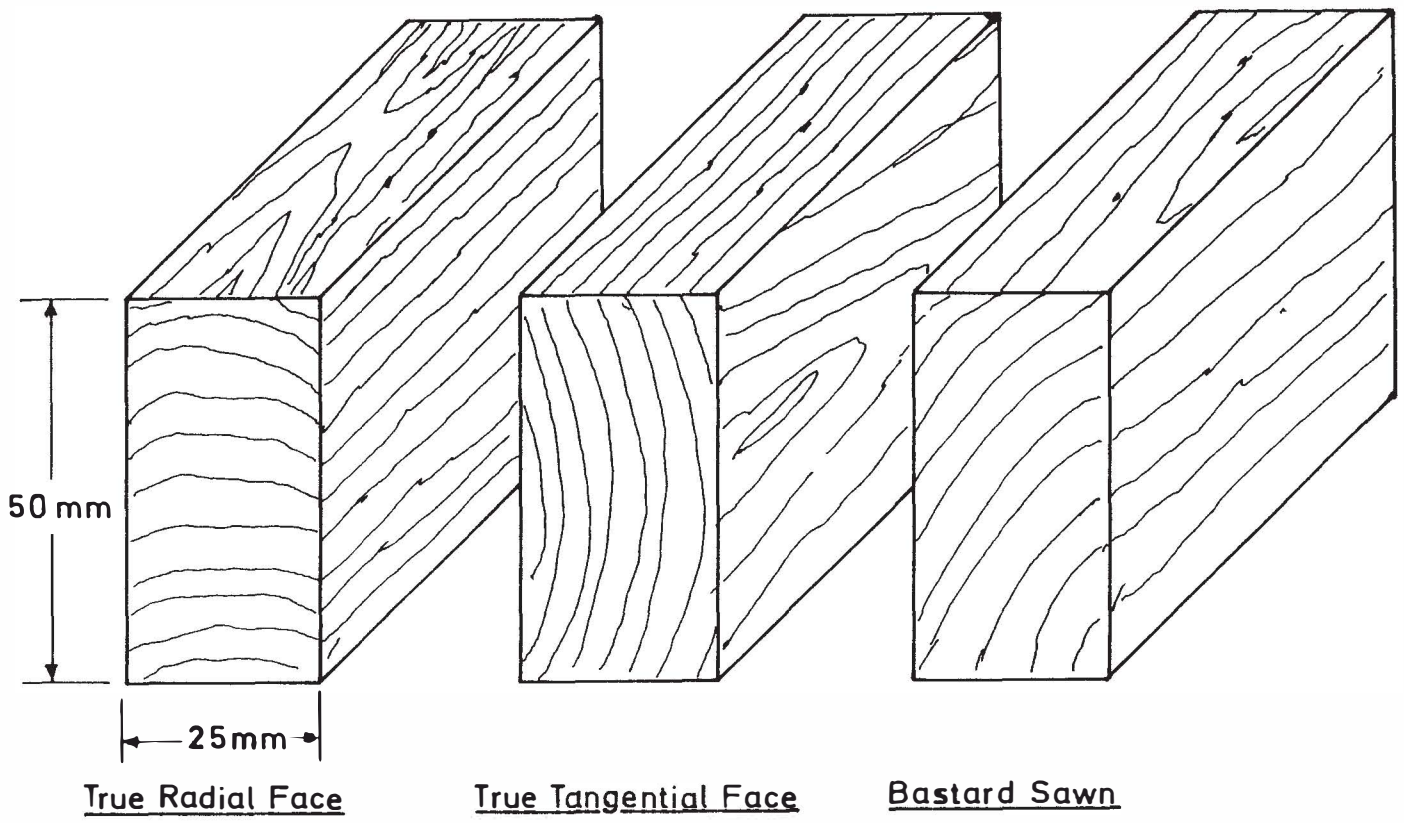

Figure 1. Selection of true radial , true tangential and bastard sawn faces