UNIVERSITI PUTRA MALAYSIA

PRODUCTION AND PROPERTIES OF ISOCYANATE-BONDED MDF MANUFACTURED FROM ACACIA MANGIUM

SUWANNA PENSOOK

PRODUCTION AND PROPERTIES OF ISOCYANATE-BONDED MDF MANUFACTURED FROM *Acacia mangium*

BY

SUWANNA PENSOOK

MASTER OF SCIENCE

UNIVERSITI PERTANIAN MALAYSIA

1990

APPROVAL SHEET

Name of Candidate : **SUWANNA PENSOOK**

Name of Project : **PRODUCTION AND PROPERTIES OF ISOCYANATE-BONDED MDF MANUFACTURED FROM *Acacia mangium***

Approved by :

....

ASSOC.PROF. DR. RAZALI ABDUL KADER
(Examiner)

....

MRS. PARIDAH MD TAHIR
(Examiner)

....

DR. RAZALI ABDUL KADER
Associate Professor
(Coordinator, M.S. Wood Industries Technology Programme)

....

DR. KAMIS AWANG
Associate Professor
(Dean, Faculty of Forestry)

Date of Examination : November 1990

PRODUCTION AND PROPERTIES OF ISOCYANATE-BONDED MDF MANUFACTURED FROM *Acacia mangium*

BY

SUWANNA PENSOOK

This report is submitted in partial fulfilment of the requirement for the degree of Master of Science (Wood Industries Technology) in the Faculty of Forestry Universiti Pertanian Malaysia

November, 1990

ABSTRACT

Medium density fiberboards (MDF) were manufactured from fast-growing Acacia mangium wood. The boards were produced at two levels of density, 600 and 750 kg/m^3. Isocyanate and urea-formaldehyde resin adhesives were used as binders. The physical, mechanical and dimensional stability properties were determined according to JIS 5906. Both adhesive and density affect significantly the properties of boards tested. It was found that the higher the density, the better the quality of the boards. Isocyanate bonded boards showed higher strength and more stable than urea-formaldehyde bonded boards, even when used at lower percentage of resins, 3 % and 13 %, respectively. It was also found that isocyanate bonded boards at low density had properties meeting the Japanese Industrial Standard, JIS 5906, Type-150 board whereas at high density (750 kg/m^3), the boards met the Type-200. The properties of urea-formaldehyde bonded MDF also met JIS Type-150 for the lower density and Type-200 for the high density boards, but MOR in wet condition failed the standard.

ACKNOWLEDGEMENTS

The author wishes to express her sincere gratitude and appreciation to her major supervisor, Assoc. Prof. Dr. Razali Abdul Kader, for his understanding and guidance for this project. Appreciation also goes to the co-supervisor, Mrs. Paridah Md Tahir, for reading through the report and providing suggestions and constructive criticisms. The author also wishes to record her special thanks to the following :

- staff of the Forest Research Institute Malaysia, Kepong in particular Mr. Khoo K.C, my external supervisor, and Mr. Lee T.W for their unselfish help during the conduct of the experiment.

- the Dean of Forestry Faculty, Assoc. Prof. Dr. Kamis Awang, for extending the use of the faculty's facilities.

- ASEAN Timber Technology Centre for the financial support.

- members of the Faculty of Forestry who directly or indirectly assisted in the experiment.

Finally, the author would like to express her most sincere appreciation to her father for his loving care and encouragement. The study would not have been completed also without the inspiration of her fiancee.

TABLE OF CONTENTS

Page

Page

Page

LIST OF FIGURES

LIST OF TABLES

PART 1 : INTRODUCTION

In the past two decades, the forest area of Thailand has been diminishing quite rapidly. The existing area is only approximately 28 percent of the total land area. To solve this problem, a number of fast - growing species has been planted by the public sector through the Royal Forest Department in the reforestation programme. Since timber from fast growing trees can be produced within a shorter period compared to indigenous trees, it can be used to complement the demand of wood based industry (Anon,1989). Most of private sectors involvement in reforestation programme are based on economic factors rather than ecological and environmental factors. The fast - growing tree species planted under this programme usually have multiple - use characteristics which offer broader market potentials to justify their investment.

The most recently introduced species with promising potential for commercial plantation is Acacia mangium. This species was first tested by the Royal Forest Department and the Thailand Institute of Scientific and Technological research (TISTR). The report shows that Acacia mangium can grow rapidly within the first two years. The wood of Acacia mangium has high calorific value (4,903 kcal/kg) and is also suitable for pulp production (Boontawee, 1987 ; Yatasath, 1987).

To date, results of many researches on Acacia mangium have drawn interests of many institutions in Thailand, due to favorable pulp properties, high calorific value and rapid growth. Studies on optimum utilization especially as wood based panel products should also be carried out using this species.

Wood based panel is an interesting development in producing a new product which has the ability to replace solid wood. The range of wood based panel has grown dramatically during the last twenty years. There are many new panel products introduced through technical innovation and modification such as oriented strand board (OSB), waferboard and currently the medium density fiberboard (MDF).

Medium density fiberboard is a new type of wood based panel, first manufactured in the United States in 1966. MDF has now, over nearly twenty years, come to be accepted as the prime panel product for use in high quality furniture construction, having displaced good percentages of both plywood and particleboard as well as natural wood. It is the most dynamic growth in the forest products industries now and has a dramatic rise in demand. The capacity of MDF grew by 12.1 percent per year from 1980 - 1988. Europe is the leading regional position in world capacity (William, 1989). The world consumption of MDF is also increasing rapidly about 9.4 percent, compared to sawn timber and other panels. The United States is the nation with highest consumption per capita (Anon, 1989). But in the Southeast Asian region MDF is quite a new product, being first manufactured in Thailand in 1985 (Anon, 1989).

The special reasons which bring MDF more well known now are, its advantageous properties over the other wood based panels. MDF has a homogeneous structure with uniform texture and properties throughout : no identifiable grain can be seen at edge, end or face and no knot. There is no internal voids or pits and there is no variation in surface hardness. MDF can be nailed, stapled, routed, sanded, screwed, and painted to produce almost any board finish (Anon,1989).

The density of MDF is generally 725 - 750 kg/m^3 which is higher than particleboard (640 kg/m^3). In a recent report by Wilson (1989), Nelson Pine Industries has produce a light weight MDF with a density of 600 kg/m^3 and has been rapidly accepted in the Japanese market. This new product, although it is 25 percent lighter than the standard MDF, it is just as strong and offers the same smooth surface and stability. Some advantages of this light - weight MDF over the standard MDF and particleboard are lower raw material cost, longer tool life when working with this board, easier to work with, less weight in furniture, and lower freight costs.

Most MDF are used as core material in furniture manufacture and other interior uses which quite saturated nowadays. Urea - formaldehyde (UF) is generally used as the binder for these boards. This adhesive imposes problem in air pollution ; emission of formaldehyde which causes health hazard. Since urea - formaldehyde is not water resistant, therefore for new applications such as exterior uses and bathroom cabinets, the use of these boards are not feasible. Hence, other alternative has to be sought.

In this study *Acacia mangium* is used to produce medium density fiberboard by the dry process. Isocyanate and urea-formaldehyde are used as the binders. The objective of this study is to determine the suitability of converting *Acacia mangium* wood into MDF bonded with the isocyanate binder.

PART 2 : LITERATURE REVIEW

1. General

Medium density fiberboard (MDF) is a dry formed panel product manufactured from lignocellulosic fibers combined with a synthetic resin or other suitable binder. The panels are compressed to a density of 660 - 860 kg/m^3 in a hot press by a process in which substantially the entire inter fiber bond is created by the added binder (Malony, 1977). Figure 1 shows the typical density range for the higher density grade of medium density fiberboard.

The fibers are dried before they are formed into a mat for pressing. In the absence of water, and at lower pressing temperature compared with those used for hardboard, inter fiber bonding derived from the natural resins in the wood is not effective. The strength of MDF is achieved by the addition of a synthetic resin binder (FIRA, 1985). In other words, binder added to MDF gives it a major strength advantage over other boards.

MDF can be regarded as intermediate between hardboard and wood chipboard in that it is manufactured from fibers

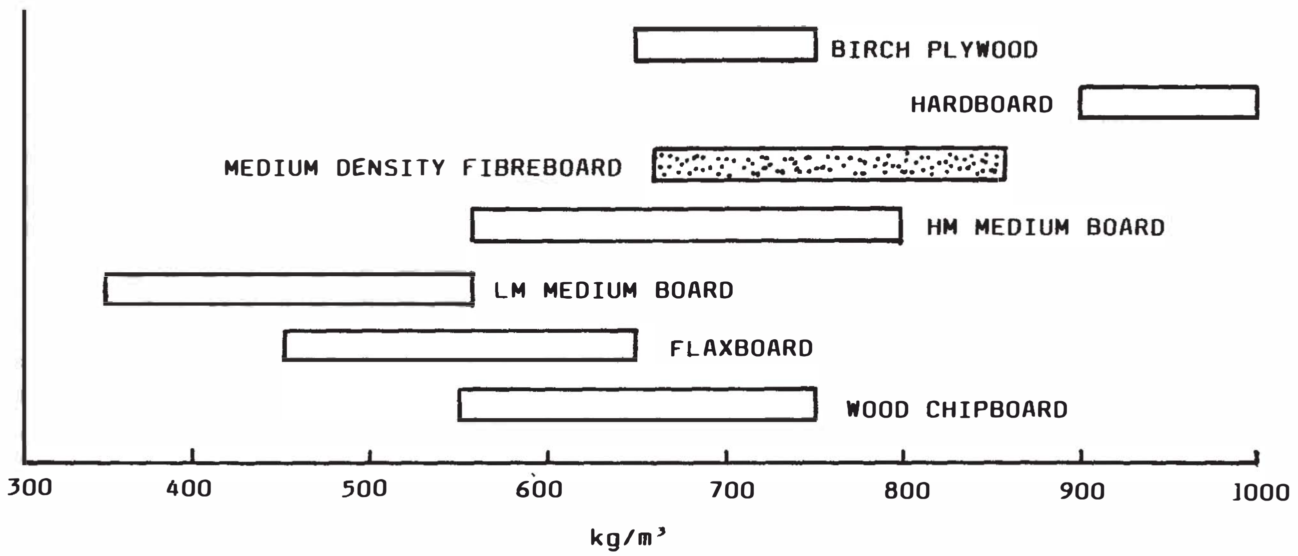

Figure 1. Typical density of some wood-based sheet materials.

Source : FIRA, 1985

like hardboard, and its high internal bond strength is derived from added resin binder as used for the manufacture of wood chipboard. MDF has also the combined advantages and favourable properties of hardboard and wood chipboard (FIRA,1985).

2. Characteristics of Medium Density Fiberboard

According to Klinga and Toll (1983), MDF panels possess special properties which make it more advantageous over other wood based panels. These properties are :

1. Homogeneity in nature with uniform physical properties (it can be turned).
2. Superior dimensional stability with minimal effect from changes in relative humidity.
3. Fine texture and dense surface characteristics enabling better and all forms of overlay.
4. Excellent edge properties giving superior machinability.
5. Excellent screw holding on both edge and face.

These characteristics, in themselves have further advanced MDF to a position where it is readily compatible with wood veneer, vinyl and melamine low and high pressure laminate overlays. It indeed rivaling clear timber as a basic material in the furniture and joinery industries. Without doubt MDF is now firmly established as the closest man made alternative to clear timber, a natural resource which is becoming scarce and incresing in price (Klinga and Toll, 1983).

3. Raw Materials for Medium Density Fiberboard

3.1. Wood

MDF can be manufactured from a broad range of raw materials. Softwoods and hardwoods in the form of roundwood, slabwood, forest thinnings and sawmill residues such as waste veneer and veneer core can be used for the manufacture of MDF (FIRA, 1985). The fiberboard industry however, would prefer softwoods whereas hardwoods usually are cheaper and easier to obtain. Most hardwoods are utilized for the manufacture of hardboard (Kollmann,et.al,1975). Klinga and Toll (1983) showed that softwoods can be used as well as hardwoods or both separately as well as in mixture with each other. The tropical hardwoods can be used to make a good quality fiberboard and meet the requirements of the U.S. Product Standard for basic hardboard (Meyer, 1979). For maintaining consistency in product performance levels, Suchsland and Woodson (1986) suggested that the uniformity of raw material input is at least as important as the quality of board and should be controlled because the variability would cause difficulties in processing and large property tolerance of fiberboard. For these reasons the fiberboard industry tries to be selective in procuring its raw materials.

3.2. Non Wood

Annual plant residues such as bagasses and cotton stalks can be used for manufacturing MDF (Kligna and Toll,1983). In Thailand, there is one MDF factory, KhonKaen M.D.F. Board, which uses bagasses as the raw material (Anon, 1989).

The economy of using certain low grade annual plant residues should be quite high because of the costs involved in their collecting, upgrading and transporting in large enough quantities to a fiberboard plant. Thus, where possible, it is always preferable to use some kind of wood as raw material (Klinga and Toll, 1983; Suchsland and Woodson, 1986).

4. Wood Characteristics for Medium Density Fiberboard

4.1. Wood Density

High specific gravity wood will generally result in high bulk density of fiber furnish. At a given board density, low specific gravity will give higher compression ratio (ratio of board density to wood specific gravity) than high wood specific gravity and promote more intimate contact between fibers as shown in Figure 2. For this reason, hardboard strength properties, which is mostly produced from hardwood and dry - formed, are negatively influenced by high wood specific gravity and mat bulk density (Suchsland and Woodson, 1986). Studies on dry - formed medium density hardboard confirmed the negative effect of species specific gravity on strength properties (Nelson, 1973).

Medium density fiberboard requires the production of a pulp of very low bulk density (33.7 kg/m^3 or less) which

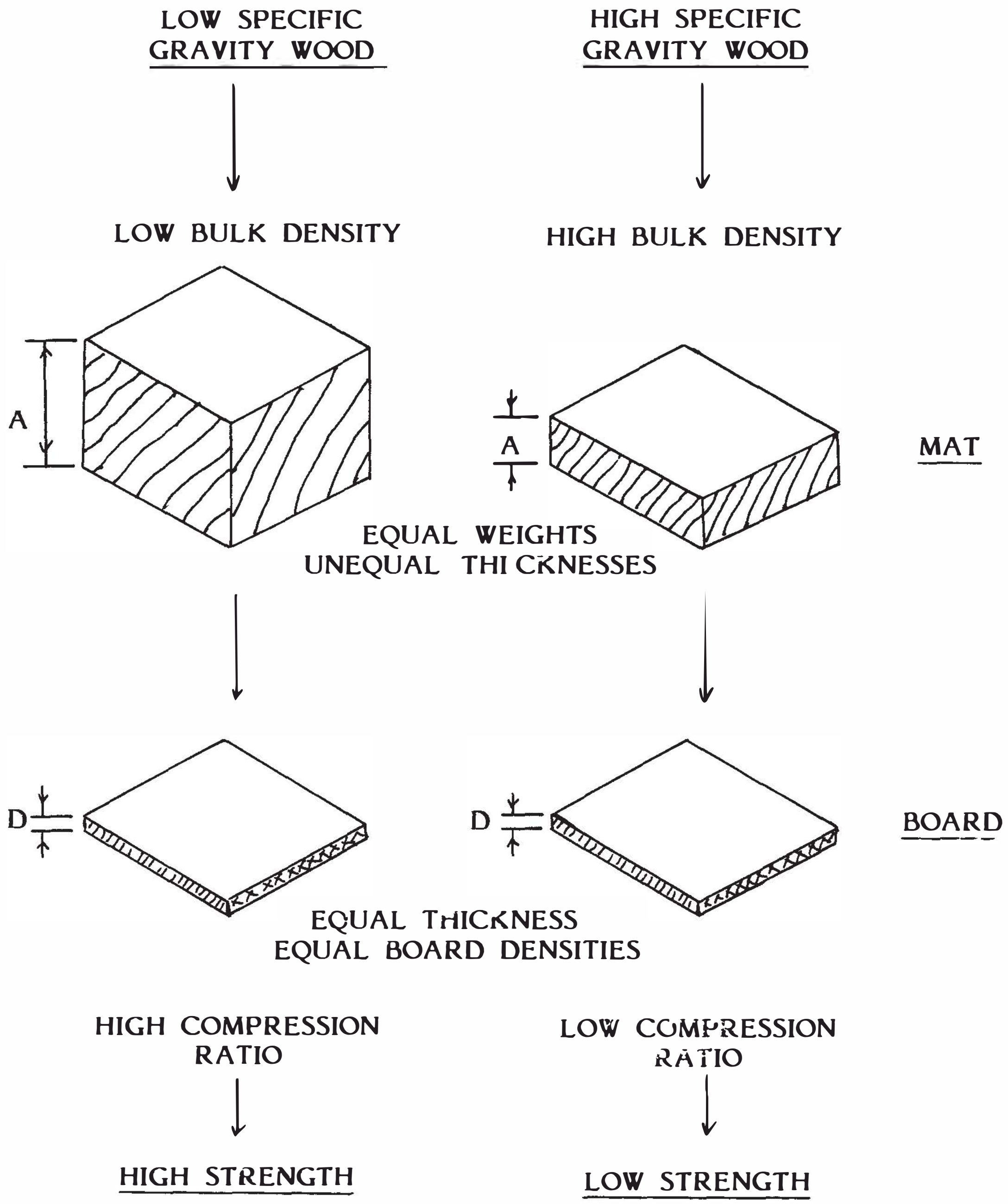

Figure 2. Manufacture of fiberboards of equal thickness and equal board density from low and high-specific-gravity wood.

Source : Suchsland and Woodson, 1986

develops good resin bonding during compression to normal board density (750 kg/m^3). Dry formed bond, both hardboard and MDF appear to be less sensitive to species characteristic than wet formed boards (Suchsland and Woodson, 1986).

4.2. Wood Fiber

Fiber length has a strong factor effect on the tearing strength of paper, because longer fiber can give larger bonding area in the sheet. In fiberboard, fiber length may be a factor controlling the orientation of fibers. Shorter fibers are much more likely to develop a vertical or z-component of fiber orientation than longer fibers. Longer fibers would also lend themselves better to artificial alignment in one of the principal dimensions of the board by mechanical or electrical means (Suchsland and Woodson, 1986) (Figure 3). Nelson (1973) studied the effects of pulp properties of dry - formed hardboard ; the length of wood fiber was positively related to linear stability, but has little or no effect on other board properties.