Studies on the Chipboard

Report 3 ; Some Experiments on the Improvement of Dimensional Stabilities of Chipboard.

Wood Physics, Section II.

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The effects of some treatments on the dimensional stabilities and its related properties of chipboard were investigated. This report is concerned with the results of experiments on the influences of addition of paraffin emulsion, heat treatment of shavings and molar ratio of urea resin binder on the swelling property, hygroscopicity and bending strength of chipboard.

Experimental procedure

Preperation of chipboard

The wood shavings used in this experiments are divided into the following three types.

A-type : 3 cm. long, 4 mm. wide and 0.12 mm. thick (Pine ; *Pinus densiflora* S. et. Z.)

B-type : 5 cm. long, 12 mm. wide and 0.3 mm. thick. (Pine)

C-type : 2.5 cm. long, 0.8 mm. wide and 0.8 mm. thick. (Pine)

Air-dried shavings were applied with 8 per cent urea resin and conditioned to 12 per cent moisture content, and hot-pressed at 110°C. for 20 min. The densities of the chipboards thus prepared were 0.75 (A-type), 0.65 (B-type) and 0.50 (C-type) g/cm^3.

Water absorption test

The test pieces for water absorption test are shown in Fig. 1. After oven-drying they were immersed in water (5°-10°C.) and the change of weight and thickness were measured at definite intervals. The rates of water absorption and thickness expansion were calculated by the same formulas as given in Report II[1].

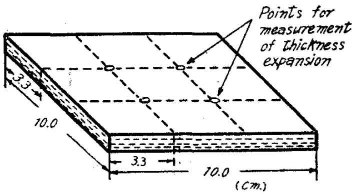

Fig. 1 : Thet piece for water absorption and moisture adsorption test.

Moisture adsorption test

After oven-drying the test pieces with the same dimensions as in the water absorption test were placed in a desiccator saturated with moisture at 5°-10°C. (A-type) or 40°C. (B-type).

The calculating methods for the rates of moisture adsorption and thickness expansion are as same as those used in the water absorption test.

Bending strength test.

The bending strength of chipboard (σ_b) was calculated by the following formula.

$$\sigma_b = \frac{3Pl}{2bh^2}\ (\text{kg./cm.}^2)$$

b ; width of test piece (cm.)
h ; thickness of test piece (cm.)
l ; span (cm.)
p ; maximum load (kg.)

Experimental results

Part I ; Effect of addition of paraffin water proofing agent.

In this experiment, the influences of paraffin water proofing agents on the dimensional stabilities and bending strength of chipboard made of various sizes of shavings were investigated.

Three types of water proofing agents, paraffin (M.P. 70°C.) emulsified with cationic, anionic and nonionic surface active agents, were used, and each of them was admixed with urea resin before spraying.

1. Water absorption

The relations of paraffin content to the rates of water absorption and

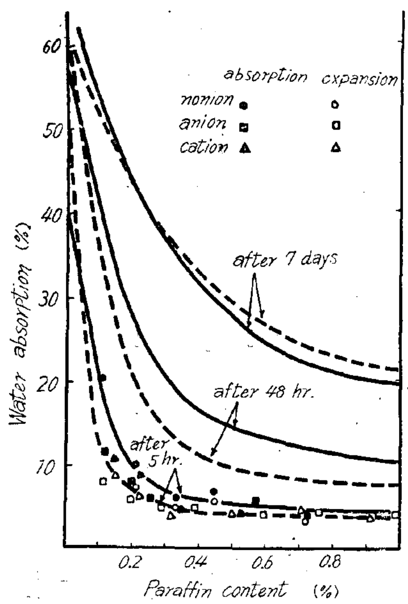

Fig. 2 : Effects of paraffin content on the water absorption and thickness expansion of chipboard (in 7°C. water).

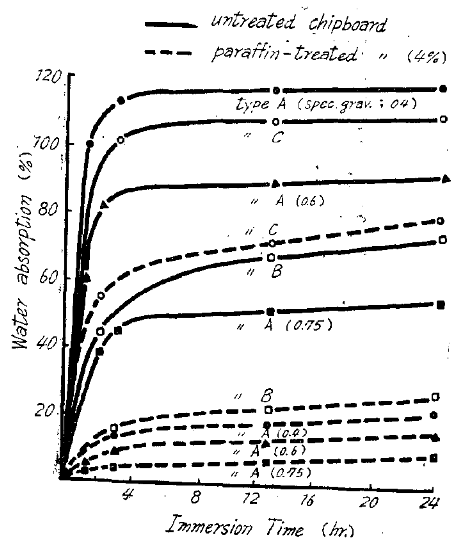

Fig. 3 : Effects of paraffin on water absorption of chipboard varied in specific gravity or type of shavings.
Shavings types A : $30\times4\times0.12$ mm^3.
B : $50\times12\times0.3$ mm^3.
C : $25\times0.8\times0.8$ mm^3.

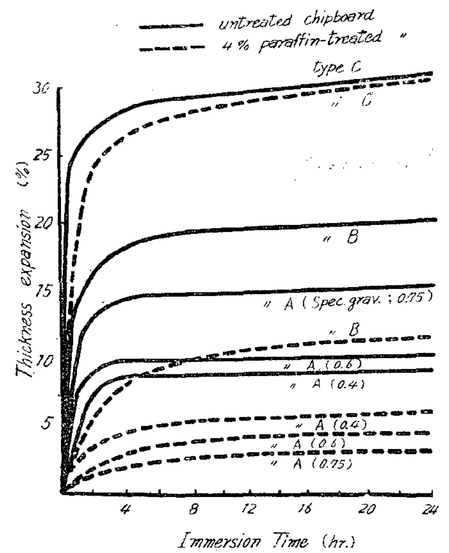

Fig. 4 : Effects of paraffin on thickness expansion of chipboard varied in specific gravity or type of shavings.
Shavings types are as same as in Fig. 3.

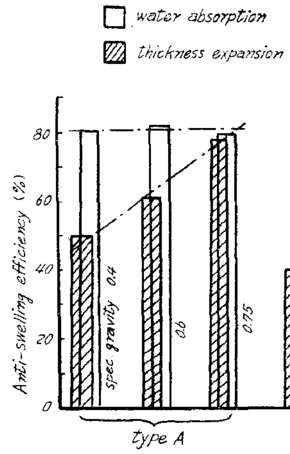

Fig. 5 : Anti-swelling efficiency of paraffin-treated chipboard in Fig. 3 and Fig. 4. (after 24 hr. immersion)

thicknesse expansion of chipboard made of A-type shavings are shown in Fig. 2. The dotted curves show the rate of thickness expansion. According to these results, the swelling properties of chipboard are remarkably reduced by addition of a little amount of paraffin emulsion especially at short time immersion, while there is no difference between the kinds of emulsion.

The similar experiments for the chipboard having various densities and types of shavings were made and they are shown in Fig. 3–Fig. 5. In these figures dotted curves show the water absorption and thickness expansion of paraffin-treated chipboard. The results of this experiment, as clearly shown by Fig. 5, showed that anti-swelling efficiency of paraffin was more effective on the chipboard made of thinner shavings and in higher specific gravity.

These effects resemble the effects of the moisture content of shavings before panel making on the swelling properties of chipboard[1].

2. Moisture adsorption

The relations of rates of moisture adsorption and thickness expansion of chipboard made of A-tyoe shavings to paraffin content are shown in Fig. 6.

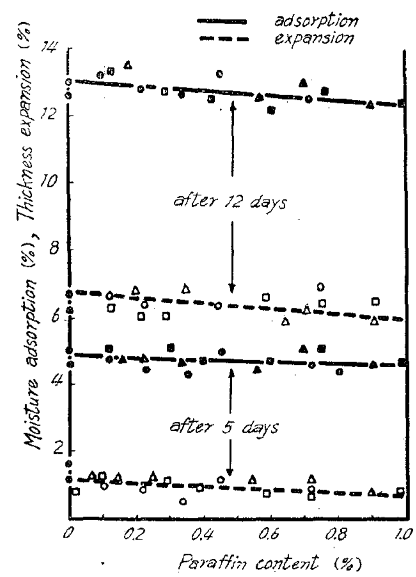

Fig. 6 : Effects of paraffin content on the moisture adsorption and thickness expansion of chipboard in a desiccator saturated by moisture at 7° C.

In this figure the dotted lines show the rate of thickness expansion, and the kinds of paraffin emulsion used are the same as used in water absorption test. From the results of this experment, it seems that paraffin is not effective in reduction of the hygroscopic properties of chipboard, at least in the range of paraffin content used in this experiments.

3. Bending scrength

The effect of paraffin content on the bending strength of chipboard made of A-type shavings is shown in Fig. 7. and in this figure, the dotted curves show

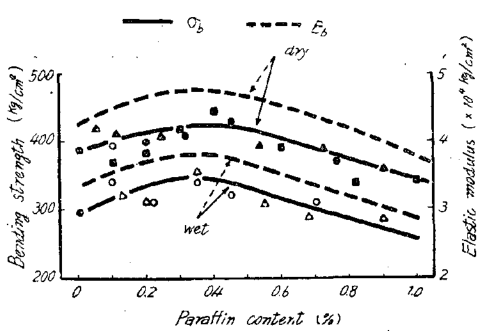

Fig. 7 : Relations between paraffin content and bending strength (σ_b) or modulus of Elasticity (E_b) of chipboard.

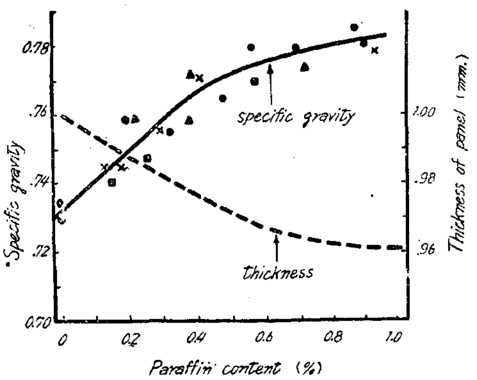

Fig. 8 : Effects of paraffin content on the specific gravity and thickness of chipboard.

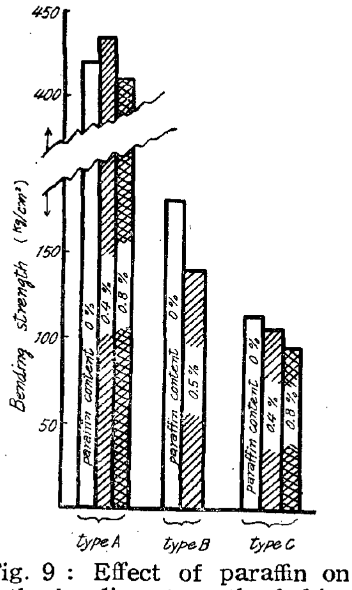

Fig. 9 : Effect of paraffin on the bending strength of chipboard made of various shavings.

the modulus of elasticity. These tests were made under the conditions of 12 per cent and 18 per cent moisture contents of specimens.

According to this figure, the bending strength of chipboard increased slightly with the increase of the paraffin content in case of lower paraffin content, while in higher paraffin contents it seems to decrease contrarily. This result is unreasonable from the view-point of mechanism of adhesion, but it was supposed to be caused by the increase of density of chipboard shown in Fig. 8. Fig. 9 shows the effect of paraffin on the bending strength of chipboards made of each of three kinds of shavings mentioned above. From the result of this experiment, it may be said that the influence of paraffin emulsion is negligible for A-type chipboard, but for B and C types the bending strength of chipboard was decreased by addition of paraffin emulsion. The effect of paraffin emulsion on the joint-strength of urea resin made under various molar ratios (formaldehyde/urea) is presented in Table 1. In this table,

Table 1 ; Effect of paraffin (0.4%) on the joint-strength of plywood specimens made with urea resin.

	Joint-Strength (kg/in^2)					
Molar ratio (Formaldehyde/Urea)	2.5		2.0		1.8	
	Untreated	Paraffin treated	Untreated	Paraffin treated	Untreated	Paraffin treated
Birch	159 (100)	100 (0)	162 (100)	155 (100)	151 (12)	134 (0)
Pine	125 (30)	96 (0)	134 (70)	113 (50)	120 (40)	115 (5)

( ) ; Wood failure (%)

the joint-strength of urea resin is generally decreased by addition of paraffin emulsion, but with molar ratio 2 this tendency is not remarkable under this experimental condition. Some investigations on these problems will be reported later.

From the above results it is presumed that paraffin emulsion affects on chipboard not only as water-proofing agent but also plastizer for shavings.

Part II ; Effects of heat treatment of shavings

As it has been mentioned in part I, hygroscopicity of chipboard could not be improved by the use of paraffin water-proofing agents.

It has been informed, however, that hygroscopicity of timber can be improved by heat treatment, so the influences of heat treatment of shavings on the dimensional stabilities of chipboard were investigated. Shavings were previously conditioned to about 10 per cent moisture content, and then heat-treated as shown in Table 2 and hot-pressed to chipboard with commercial urea resin under the conditions which were described above.

1. Water adsorption

The relations of rates of water absorption and thickness expansion of chipboard to immersion time are shown in Fig. 10. As clearly shown by this figure, heat treatment of shavings at 155° C. seems to have no effect on the swelling properties of chipboard, but the longer and the higher the temperature employed, the more

Table 2 ; Conditions of heat treatment of shavings.

symbol	temp. of heat tre tment	time of heat treatment
A - 5	155° C	5 min.
A - 10		10
A - 15		15
A - 25		25
A - 40		40
B - 5	180° C	5
B - 10		10
B - 15		15
B - 25		25
B - 40		40

the rates of water absorption and thickness expansion tend to increase. It seems that these phenomena are originated from decrease of joint-strength of shavings with each others.

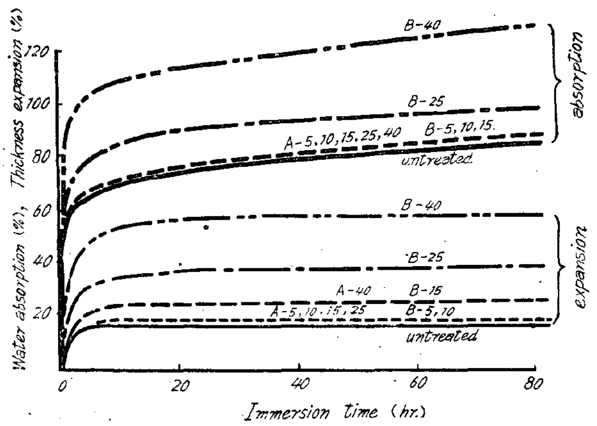

Fig. 10 : Effects of heat treatment of shavings on the water absorption and thickness expansion of chipboard.

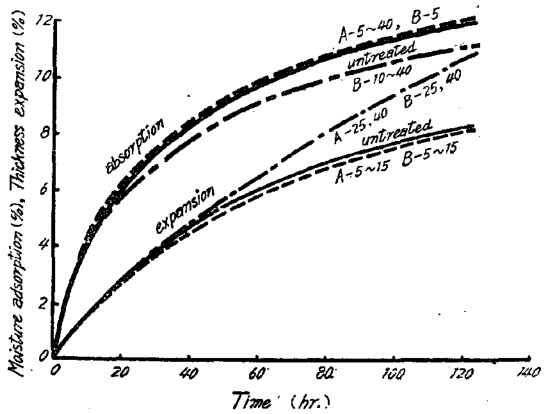

Fig. 11 : Effects of heat treatment of shavings on the moisture adsorption and thickness expansion of chipboard. (40° C.)

2. Moisture adsorption

Fig. 11 shows the relations of the rates of moisture adsorption and thickness expansion of chipboard to the time of adsorption. From this figure, it appears that the moisture adsorption of chipboard is not generally affected by heat treatment of shavings, but there is a slight reduction of the rate of moisture adsorption with 180° C. treatment. On the other hand thickness expansion of chipboard tends to increase considerably at intense heat treatment of shavings, and it seems also to be caused by the lower joint-strength of shavings each others.

3. Bending strength

The effects of heat treatment of shavings on the bending strength of chipboard are shown in Fig. 12. As clearly shown in this figure, the bending strength of chipboard is decreased by the increase of the time of heat treatment of shavings and this tendency is more remarkable at higher temperature. It seems that the decreases of strength of shavings themselves[2] and joint-strength of shaving with each others are the main causes of this phenomenon. In order to investigate the latter phenomenon, pine veneers (1 mm. thick) were heat-treated at 170° C. for 10-360 min., and after urea resin was spread (3.5 lbs./1,000 ft^2. solid content) they were hot-pressed to plywood. Fig. 13 shows the result of the plywood shear test. In this figure the dotted curve shows the moisture content of veneer before resin spreading. From this result it is clear that the joint-strength is decreased by heat treatment of veneer, and it seems to be caused by the "Case-hardening"[3] of veneer and the decrease of the moisture content before resin spreading[4].

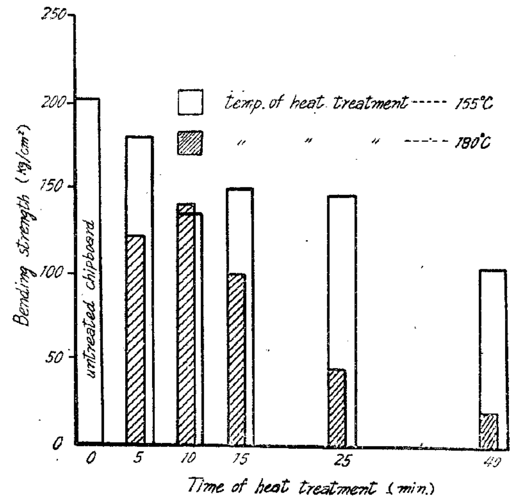

Fig. 12 : Effects of heart treatment of shavings on the bending strength of chipboard under absolutely dry condition.

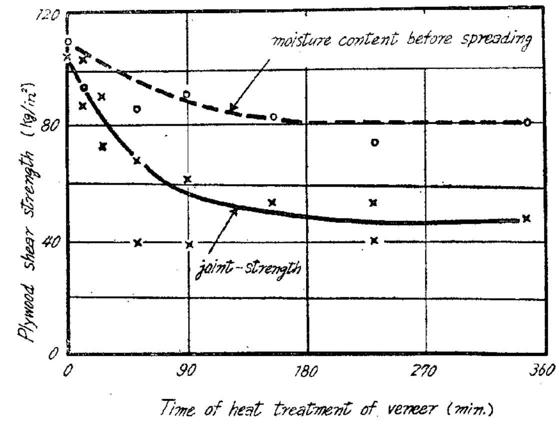

Fig. 13 : Effect of heat treatment 170° C. of veneer (Pine, 1 mm. thick) on the joint-strength of plywood specimen made with urea resin (3.6 lbs./1,000 ft². single glue line). Condition of hot-pressing : 10 kg./cm²., 110° C. and 10 min.

In brief, these experiments on heat treatment of shavings are concluded as follows ;

Water-resisting properties, thickness expansion and bending strength of chipboard are remarkably increased by heat treatment of shavings.

But, the moisture adsorption of chipboard are slightly decreased by heat treatment of shavings.

The heat treatment of shavings is not generally effective to improve the swelling properties of chipboard.

Part III ; Effects of molar ratio of urea resin

According to the results of preliminary experiments on the curing condition of

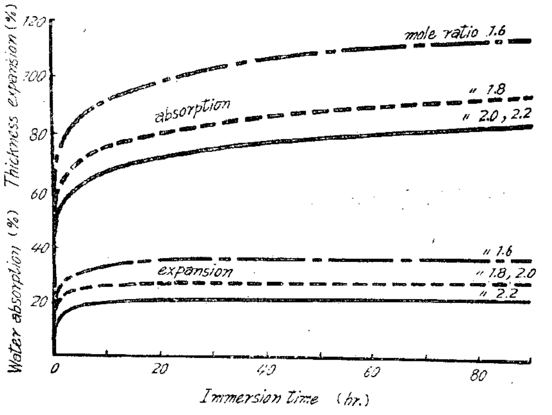

Fig. 14 : Effects of molar ratio of urea resin on the water absorption and thickness expansion of chipboard in 25° C. water.

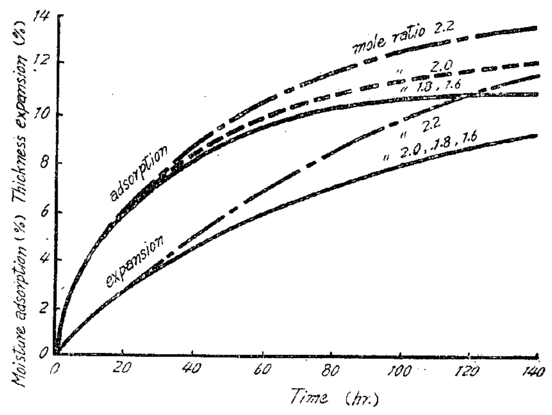

Fig. 15 : Effects of molar ratio of urea resin on the moisture adsorption and thickness expansion of chipboard in a desiccators aturated by moisture at 40° C.

urea resin as binder for chipboard, the molar ratio (formaldehyde/urea) was one of the largest factors affecting on the swelling properties of chipboard[1]. Therefore water absorption, moisture adsorption and bending strength of chipboards made of each of four kinds of urea resin cured with 1.6, 1.8, 2.0 and 2.2 molar ratios and B-type shavings, were investigated.

1. Water absorption

From Fig. 14 it appears that swelling of chipboard is higher at the lower molar ratios of urea resin[1], but there is no difference between 2.2 and 1.8 of molar ratios.

2. Moisture adsorption

As shown by Fig. 15 the moisture adsorption of chipboard tends to increase with molear ratio contrary to the case of water absorption, but generally molar ratio does not so remarkably affect on the moisture adsorption of chipboard.

The thickness expansion of chipboard is not affected by 1.6–2.0 of molar ratios but with 2.2 there is a comparatively large swelling properties.

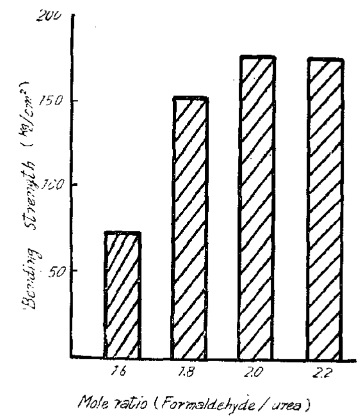

Fig. 16 : Relation between molar ratio of urea resin and bending strength of chipboard under air dry condition (Moisture content of chipboard U=12%).

3. Bending strength

Bending strength of chipboard increases with the increase of the molar ratio of urea resin, but between 2.0 and 2.2 the difference of strength is negligible (Fig. 16).

In short, molar ratio of urea resin, in the range taken in this experiment, did not so markedly affect on the swelling properties of chipboard. But strictly speaking, it seems that the lower the molar ratio is taken, the more the moisture-resisting property is improved, and the water-resisting property and bending strength are improved by higher molar ratio.

III Summary

Some experiments were performed to investigate the influences of paraffin water-proofing agent, heat treatment of shavings and molar ratio of urea resin binder on the swelling properties and their related properties of chipboard, and the results are as follows :

1. The water-resisting preperty of chipboard was markedly improved by addition of paraffin emulsion (Fig. 2). On the contrary it was decreased by heat treatment of shaving and decrease of molar ratio of binder (formaldehyde/

urea) (Fig. 10, 14).

2. The moisture-resisting property of chipboard was not generally influenced by paraffin emulsion (Fig. 6), and it was slightly improved by intense heat treatment of shavings, but in this case the stability of chipboard became lower (Fig. 11). On the other hand, this property was improved with decrease of molar ratio (Fig. 15).
3. On the bending strength of chipboard made of thin shavings (0.12 mm. thick) paraffin emulsion did not remarkably influence, but with chipboard made of thicker shavings (0.3 and 0.8 mm. thick) the bending strength of chipboard was reduced by addition of paraffin emulsion (Fig. 7~9).
   Heat treatment of shavings and decrease of molar ratio of urea resin binder reduced the bending strength of chipboard (Fig. 12, 16).

Literature cited

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4) W. Z. Olson ; F. P. L. Rep., No. R 1534, (1945).