EFFECT OF IMMERSION TIME ON LOADING AND DISTRIBUTION OF BORIC ACID IN RUBBER WOOD BY DIFFUSION PROCESS

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Summary

Rubber wood squares of 2, 3 and 5 cm cross-sections were treated with boron compounds (boric acid and borax) by diffusion process. The effect of immersion time on the dry salt retention was studied. The dry salt retention increased with increase in immersion time, although rate of increase was low. For higher thicknesses, prolonged immersion time reduced the dry salt retention. From the relationship of concentration of solution, loading of chemicals, thickness of wood and immersion time, a constant of proportionality was arrived at for rubber wood.

Introduction

Preservative treatment of green wood by diffusion process was developed nearly four decades ago. Highly refractory woods, which cannot be treated to adequate retention of chemicals by pressure impregnation, can be treated by diffusion process. The two early methods of diffusion process developed in New Zealand are known as the 'hot immersion' method and 'momentary immersion' method. Water-soluble boron compounds are generally used as preservative chemicals. In the hot immersion method, the concentration of solution used is 3 to 6 per cent boric acid and the immersion time varies from 2 to 4 hours for 2.5 cm thick wood. In the momentary immersion method, 20 to 40 per cent solution is used and the green wood is dipped momentarily or sprayed on all surfaces. In both the methods, after immersion the wood is stacked closely in a restricted drying condition for the diffusion of chemicals.

The effect of specific gravity and moisture content of wood, temperature of treatment solution on the surface loading and diffusion rate have been well studied for different species of timber. Tamblyn (1949) found that low density woods can be treated more effectively than high density woods in dilute solutions. Harrow (1951) concluded from his study of tawa (*Beilschmiedia tawa*) that the loading of chemicals tended to be less with increase in density. However from the study of radiata pine he found that the effect of density was insignificant (Harrow, 1952).

The loading obtained in radiata pine was higher in wood having a high green-moisture content than in that with a low green moisture content (Harrow, 1952). MacLean (1962) observed in western hemlock that high moisture content ensured rapid and complete penetration of the sapwood. He also observed that if the wood was partly air-dried, diffusion could not take place or took place very slowly to a limited extent Another study (BWPA, 1968) on the effec of moisture content on the loading showed that diffusion rate, in general, was greatest at high moisture contents and decreased as the timber dried. However, adequate loading of boron chemicals reached the centre of the timber even at 30–35 per cen moisture contents, although much more slowly than with the green timber.

The effect of solution temperature between 71 and 93° C was found significant but small on the loading and distribution of boric acid in 2.5 cm green tawa (Harrow, 1951). Warren *et al.* (1968) found that it was feasible to shorten diffusion times by keeping timber at an elevated temperature during the diffusion period.

The loading is directly proportional to the concentration of the solution and immersion time, and inversely proportional to thickness. This study was conducted with rubber wood to find the effect of immersion time on the dry salt retention and to determine the constant of proportionality in the empirical equation.

Material and Methods

Freshly sawn rubber wood squares of size 2, 3 and 5 cm cross-section with 10 replicates were used. The length of pieces was 30 cm. The preservative solution was prepared by mixing 2 parts of boric acid with 3 parts of borax in the requisite quantity of water to give a 10 per cent boric acid equivalent (BAE) solution. A fungicide, sodium pentachlorophenoxide (NaPCP) was added at 0.5 per cent by weight. The study was limited to one concentration only, namely, 10 per cent BAE.

Based on previous study (Gnanaharan, 1982), one conservative immersion time was chosen for each thickness (20 minutes for 2 cm, 45 minutes for 3 cm and 125 minutes for 5 cm) such as to give an average dry salt retention of 0.4 per cent BAE. It was decided to see the effect of prolonged immersion on the loading of chemicals and immersion times which are nearly 1.5 times the former were tried, 30 minutes for 2 cm, 70 minutes for 3 cm and 190 minutes for 5 cm. (Because of some technical difficulty, 5 cm thick specimens were kept immersed for 230 minutes instead of 190 minutes.) Also the effect of a constant time of immersion for these three thicknesses (60 minutes) was also studied. So, the immersion times for 2 cm specimens were 20, 30 and 60 minutes, for 3 cm, 45, 60 and 70 minutes, and for 5 cm, 60, 125 and 230 minutes.

The 2 cm thick specimens were kept for 3 weeks diffusion storage; 3 cm thick for 5 weeks and 5 cm thick for 8 weeks. After diffusion storage, the specimens were air-dried and chemically analysed by leaching the borates by refluxing with a mixture of distilled water and hydrochloric acid, followed by titration with alkali in the presence of neutral mannitol using pyrocatechol violet as an indicator (Wilson, 1959).

For chemical analysis, three samples of about 5 to 6 mm thickness were taken from the middle portion of the treated specimens. One was used to analyse the core and surface and the other for net average retention. The third sample was used for determining moisture content. The core was taken as one-ninth of the area of the cross-section taken at the geometrical centre of the wood piece and analysed. From the remaining portion, about 3 mm strip from the periphery was taken as surface and analysed. To find the overall retention, two diagonal portions about 5 mm wide were taken and analysed.

Results and Discussion

The retention of chemicals as analysed chemically for various thicknesses and for various immersion times are recorded in Table 1. The data from the previous study (Gnanaharan, 1982) for 2.5 cm thick specimens were included for comparison. For 2 cm thick specimens the average retention of chemicals increased with immersion time and it exceeded the British Wood Preserving Association's (BWPA) requirement of 0.4 per cent BAE (BCL, 1972). There was no marked difference in 3 cm

TABLE 1

Average core and surface dry salt retention in rubber wood squares of different thicknesses with different immersion times and constant of proportionality

Cross-section	Immersion time (minutes)	Dry salt retention (% BAE)			Constant of proportionality (K)
		average	core	surface	
2 × 2 cm	20	0.63	0.55	0.67	4.6
	30	0.70	0.69	0.75	5.1
	60	0.85	0.84	0.96	5.9
3 × 3 cm	45	0.42	0.36	0.50	6.9
	60	0.42	0.30	0.49	7.9
	70	0.45	0.33	0.47	8.0
5 × 5 cm	60	0.16	0.0	0.30	12.5
	125	0.43	0.12	0.50	6.7
	230	0.38	0.13	0.50	10.3
2.5 × 2.5 cm	40	0.43	*	*	7.6
	50	0.50	*	*	7.3
	60	0.49	*	*	8.2
	80	0.56	*	*	8.3
	100	0.63	*	*	8.2

* Not determined.

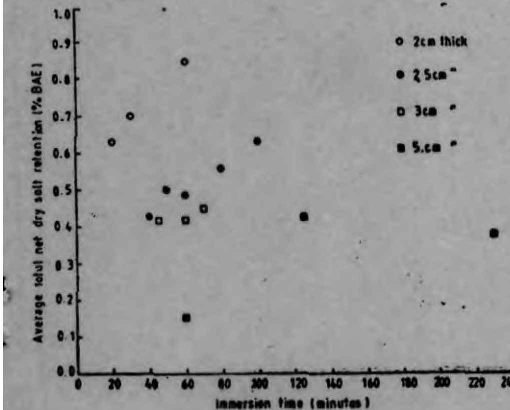

FIG. 1. Effect of immersion time on the average dry salt retention of chemicals in rubber wood.

thick specimens with the increase in immersion time, although all the values exceeded the BWPA specification. For 5 cm thick specimens retention increased with immersion time from 60 to 125 minutes; however, there was a little reduction in the average retention with prolonged immersion. Immersion time of 60 minutes was too low for 5 cm thick wood as is evidenced by the retention of chemicals. The rate of loading tended to decrease with the increase in immersion time (Fig. 1). It can be seen from Fig. 1, that for less thickwood (upto 2 cm), very short immersion time, in the order of 10 to 20 minutes, is sufficient to give the required retention of chemicals. About 45 minutes immersion gave adequate loading for 3 cm thick specimens and increasing the immersion time did not provide any appreciable increase in retention. For 5 cm thick specimens, prolonged immersion did not increase the retention but it reduced. This confirmed the observation with 2.5 cm thick specimens in the previous study that the rate of increase in loading decreased with immersion time (Gnanaharan, 1982).

For each thickness, dry salt retention of chemicals in the surface, core and average is shown in Fig. 2 to 4. The core retention was higher than the requirement of New Zealand and Australia (0.2 per cent BAE) for 2 cm and 3 cm thick material for all the immersion times tried (Fig. 2 and 3). For 5 cm thick specimens, with 125 minutes immersion, though the average retention was adequate, the core retention was below 0.2 per cent BAE (Fig. 4). This was because, half the replicates (5 pieces) were inadvertently kept for air-drying for a week, before completing the required diffusion storage period. This resulted in poor distribution of chemicals to the core.

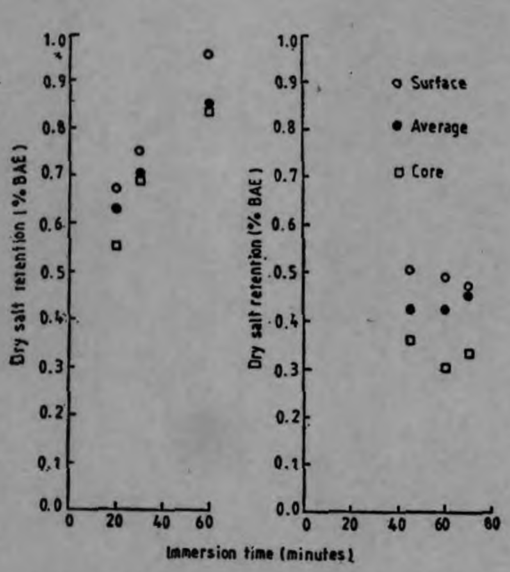

FIG. 2 and 3. Surface, average and core dry salt retention of chemicals in rubber wood pieces of cross-section 2 × 2 cm (Fig. 2) and 3 × 3 cm (Fig. 3) with different immersion times.

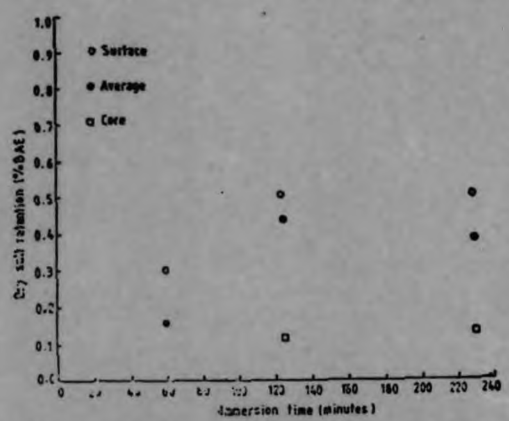

FIG. 4. Surface, average and core dry salt retention of chemicals in rubber wood pieces of cross-section 5 × 5 cm with different immersion times.

The effect of a constant immersion time of 60 minutes on different thicknesses was compared. While 2 cm thick specimens had a net retention of 0.85 per cent BAE, 3 cm thick specimens had 0.42 per cent BAE and 5 cm thick specimens had 0.16 per cent BAE.

The constant of proportionality was calculated from the average loading of chemicals using the following empirical equation,

$$\frac{\text{conc. of sol.}(\%\text{BAE}) \times \sqrt{\text{time (hr)}}}{\text{loading } (\%\text{BAE}) \times \text{thickness (cm)}} = \text{K(const)},$$

and values are recorded in Table 1. Low value of K for 2 cm thick specimens suggests that the diffusion takes place at a faster rate. This is understandable because the ratio of surface area to area of cross-section is higher. For 2.5 cm and 3 cm thick specimens, K-value ranges from 6.9 to 8.3. A K-value of 7.5 to 8 can predict approximately the immersion time required to give a net average loading of 0.4 per cent BAE up to 3 cm thickwood. For higher thicknesses, immersion time can be calculated assuming a K value of 8 and after analysing chemically the actual net dry salt retention, the immersion time can be suitably modified. Harrow (1952) showed that the diffusion process was particularly suitable for 2.5 cm boards, though could be used for wood up to 7.5 cm thick. For higher thickness, diffusion rate will be dependent on many factors besides concentration of the solution and time of immersion.

Assuming K to be 8 for rubber wood and to a get a net average loading of 0.4 per cent BAE, the immersion time needed can be calculated from the following formula:

$$\text{Immersion time (hr)} = \left\{\frac{8 \times 0.4 \times \text{thickness (cm)}}{\text{concentration of solution (\% BAE)}}\right\}^2$$

This can also be written as,

$$T = \left(\frac{3.2\,t}{C}\right)^2$$

where T = immersion time, hr
t = thickness, cm
C = concentration of solution % BAE

If experiments with different concentrations of solution are also carried out, the value of K for rubber wood can be further refined.

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