CHEMICAL TREATMENT OF TIMBER, A NOVEL METHOD

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ABSTRACT:

Dwindling resources of quality timber made manufacturers to look for alternatives. Species such as Rubber -"Hevea brasiliensis" were found to be good alternatives once treated against "Borer" attack. While expensive "Vacuum-Pressure Impregnation" provides total impregnation, cheaper methods such as "Dip" or "Spray" provides only a superficial treatment which may be removed during steps involved in furniture manufacture and similar processes. Analysis of "Mechanism of Impregnation in Vacuum-Pressure Process" indicate several short comings in the common explanation available. A new hypothesis suggested was verified with experimentation. Based on this explanation a "Novel Method", which uses simple equipment, yet ensuring total and perfect impregnation, though at a slightly lower rate, was developed. In this process the timber, immediately after sawing, is stacked in a tank (or a pit) to which the chemical solution pumped to completely submerge the timber. After the lapse of a specified period of time solution is pumped to a similar tank located adjoining (or close by) which too has a similar load of timber. While one tank is filled with chemical solution air is blown through the timber stacks of the dry tank. A spray of steam, if available, will be advantageous. While laboratory tests have proved the efficiency of the process field tests have proved the consistency of the process and durability of treated items. Cost analysis shows that the novel process is a very economical alternative, particularly attractive to Medium and Small Scale Industries.

INTRODUCTION:

With dwindling resources of quality timber the furniture and similar manufacturing industries, were forced to look for alternatives. Certain cheaper and abundant varieties while having most of the requirements such as strength, appearance, workability etc., were not durable due mainly to susceptibility to insect and fungal attacks. These then could be treated against such attacks and used as attractive alternatives to traditional high quality varieties.

Hevea basiliensis, commonly known as "Rubber Timber" is one such variety [1]. It's strength, nail holding and other physical properties are comparable with many quality varieties [2] such as Teak *(Tectona randis)*, Beech *(Fagus sylvatia)*, Light and Red Meranti (*Shorea leprosula* and *Shorea hemsleyane*) etc., [3],[4] , but attracts borers very quickly. This is a common problem with many species where sapwood and heartwood cannot be easily separated or distinguished, as the insects are attracted to the "food" available in the sap [5]. Heartwood which actually consists of dead cells has no attraction for insects. Boron Treatment, which is basically impregnation of timber with Boron in the form of a mixture of Boric acid and Borax [6] to form a neutral solution, is particularly effective against borer attack [7]. This combined with a suitable fungicide makes such timbers very attractive alternatives to traditional "quality" timber in the furniture and related industries [8].

Surface treatment may be sufficient for certain applications such as handicrafts which are painted or protected by other means almost immediately after working [8]. However, steps such as band sawing, turning, or heavy planing involved in furniture manufacture may remove the surface layer and / or cut across the cross-section. Therefore, total impregnation is important to ensure durability of furniture [9]. While total impregnation could be achieved with "Vacuum- Pressure treatment", processes such as "Dip" or "Spray" treatment [10] often carried out with "Rubber" timber provides only a superficial protection [7]. Further while Vacuum-pressure impregnation can be carried out within a few hours [8][11], Dip and Spray treatments take several weeks.

However, Vacuum-Pressure impregnation plants are very expensive needing equipment including Pressure Chambers, Vacuum and Transfer Pumps, Valves, Solenoids and Controls etc. Further, it was observed that hardly any industry which has this facility is using it on a 24 hour basis. Operation of the plant around 4 to 6 hours a day is usually sufficient to treat the total needs of most of these industries. Thus a cheaper method, yet providing total impregnation, though perhaps at a little slower rate than Vacuum-pressure impregnation would be very attractive for furniture manufacturing and similar industries, particularly those of medium and small scale.

MECHANISM OF IMPREGNATION

All the analysis and experimentation described below were carried out with Rubber timber and Boron treatment. Same results may be applicable to other chemicals and species as well. However, they were not yet experimentally verified.

In both Dip and Spray treatments Boron ions are **"diffused"** into the cells of the **"wet"** timber. This is a very slow process [2]. The exact "Mechanism of Impregnation" during Vacuum-pressure treatment is also not fully established. It is presumed that during the vacuum cycle a part of the liquid (juices) in the cells (and lignin) is sucked out which then gets partly filled with chemical (boron) mixture during the pressure cycle. Next vacuum cycle removes a part of the chemicals and juice mixture from the cells replacing them with more chemicals during the next pressure cycle. This leads to increase of concentration, and thus the depth of penetration, of boron in to the cells during each cycle leading to substantial depth of penetration on repeating the process for a number of cycles. However, this mechanism is not fully established (to the best knowledge of author) theoretically or practically [7],[8] [and personal discussions with author of reference 7].
[Certain literature says that for vacuum-pressure impregnation to be effective the moisture content of the starting material should be less than 20% to 25 % [7]. However in practice in treatment of Rubber timber with Boron, unlike other species with other chemicals, sawn timber is put in to the impregnation plant as soon as possible [8] with the only delay perhaps being collecting sufficient quantity to fill the plant. Timber is not stacked for air drying as it may then be attacked by borer, and

are usually not pre dried in kilns or by other means as they substantially add to the cost of treatment].

Is this the correct explanation of the process ? Can the same result(s) be achieved by some other method(s)? The question whether the application of a hydrostatic pressure be able to compress a practically incompressible fluid (juices in cells) sufficiently to enable pumping in of some more liquid (boron mixture), will then arise. Can these fluids be sucked out by a vacuum? Both these questions are not properly answered in the existing literature (to the best knowledge of the author). Then **what are the other possible explanations**?

Evaporation of liquid on the surface of timber due to low partial pressure created during vacuum cycle may dry the surface of the timber to a certain degree. This causes some of the liquid (juices) inside the cells to be sucked out to the surface due to capillary action and surface tension as happens during kilning. As the chemical mixture is pumped back and the timber gets totally immersed in chemical solution the fluid depleted cells and porous matrix sucks back some chemical to replenish what was sucked out during vacuum period. As the cells are still interconnected in sapwood (and in rubber), as was needed for conveying food, chemicals so sucked in can mix well with the juices in the cells. Part of this mixture, of cell juices and chemicals, is then sucked out during the next vacuum cycle and penetrated during soaking. Thus a repetition of this process will gradually increase the concentration and thus the depth of penetration of chemicals.

This hypothesis could well be one possible explanation. If it is so even if a vacuum is not created, partial sucking out of the juices may be accomplished by drying the surface by any other means. If the surface is now fully soaked, or totally surrounded, with chemical solution suction of the chemical in to the liquid depleted cells should occur. This hypothesis could well be experimentally verified. Accordingly a set of experiments were designed and carried out.

EXPERIMENTATION:

Experiment 1.

Four pieces of 1" thick, 6" wide and 4' long planks of Rubber timber were prepared from timber sawn a day before. Out of these one piece was put into a vacuum-pressure impregnation plant while the other three pieces were treated as below.

a) Pieces were first exposed to a hot air draft around 50 °C in a drying kiln, for a sufficient time so that the surface felt dry to hand.

b) All the planks were then immersed in a bath of chemical (Boron mixture) that was being used for impregnation in the Vacuum-pressure chamber use with sample 1. Left for about 20 minutes.

c) A 6" long piece was cut from one plank for testing and the balance were again dried, and immersed in chemicals.

d) Cut piece was tested for depth of penetration with the standard Turmeric test. Measurement was carried out with instruments marked to 1/16" accuracy, and the variation over the cross section averaged to 1/32".

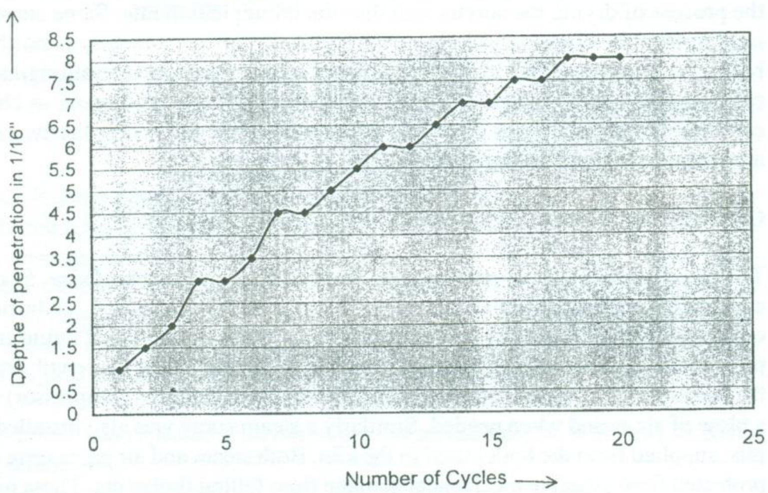
e) This process was repeated for 24 cycles.

This was compared with the sample, which was put into the vacuum-pressure impregnation plant and treated for approximately 4 hr and 30 minutes with alternate 15 minutes each vacuum and pressure cycles.

Results:

a). Vacuum-pressure impregnated plank had total penetration

b). The graph shows the depth of penetration of the test samples. It was observed that total penetration was achieved in about 18 to 20 cycles.



Discussion and Inferences:

The proposed hypothesis is valid, proved by the total penetration achieved.

Porosity of timber means presence of pores. These pores may be holding a small percentage of air or gasses. Application of pressure may compress these gasses, while the vacuum will expand them, thus accelerating the penetration process. This may explain the shorter time of impregnation observed with vacuum-pressure process.

Pre-drying may increase the amount of gasses in pores and thus the rate of impregnation. This may explain the faster rate of impregnation with pre-dried timber as given in certain literature [7],[8].

INDUSTRIAL UNIT WITH THE NOVEL PROCESS:

Encouraged by above results a low cost industrial process was developed with a plant constructed at the factory of a leading furniture manufacturer. Obtaining a hot air blast needs heat exchangers which in turn escalate the cost of the plant. Considering financial constraints it was decided, therefore, to use an air blast for surface drying, with intermittent steam blast to raise the temperature of the surface of the timber thereby assisting the drying process. As this factory already has a waste wood fired boiler used with the seasoning plant (kiln), like in most of the medium scale wood working factories, and as the quantity of steam generated can be easily increased merely by increasing the fire (waste) wood fed to the boiler, steam in this instance is virtually free. Hardly any oil fired boilers are used in timber industry and therefore the cost of steam is minimal in most of the cases. Evaporation of fluids may cool the surface of timber due to latent heat and therefore heating the surface would accelerate the process of drying the surface and thus the impregnation rate. Same steam line is used to heat the chemical solution when needed. (In case a factory is not having a boiler the process may be carried out without steam. The total operation time in that case may have to be increased). Two pits (tanks) were decided upon, as chemicals can then be pumped from one tank to the other thus subjecting the two tanks to alternating cycles of drying and soaking.

CONSTRUCTION OF PLANT

The plant consists of two parallel steel lined concrete pits each of size 5' x 6' x 22' constructed 6 ft apart with a centre pit to accommodate a pump. Both pits were connected with 4" diameter pipes and valves to enable pumping of liquid from one pit (chamber) to the other. Pipes with small holes drilled along the length and laid at the bottom of the pits, and connected to an air blower fan (not a compressor) supplies a blow of air as and when needed. Similarly a steam spray was also installed at both pits, supplied from the boiler used in the kiln. Both steam and air pipes were suitably protected from possible mechanical damage from falling timber etc. These pits could take about 250 to 300 cu ft of timber each. (fig 1)

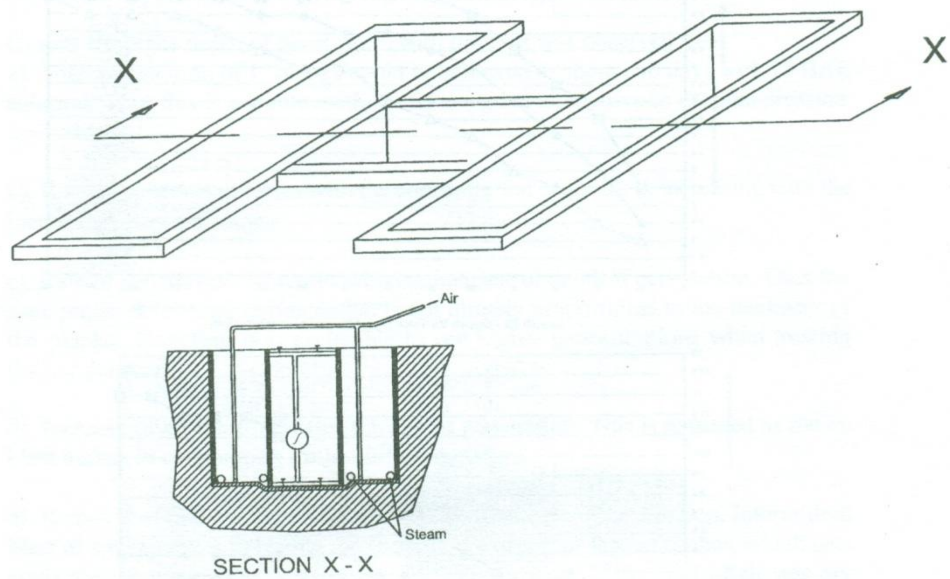


Fig. 1 - SKETCH OF TREAMENT PLANT

EXPERIMENT 2:

i). 1" thick Rubber planks were stacked with stickers as usual on both pits. An air blast with steam was sent to one of the pits for some time. Then it was filled up with 28 BAE neutral solution of Boric acid and Borax, while the air blasts with intermittent steaming was directed to the other pit. After about 2 hours chemical solution was pumped from first pit to the second pit and air blast re-directed to the first. This process was repeated. Samples were taken out after each cycle, ie; every 4 hrs (2 hrs drying and 2 hrs soaking), and tested for depth of penetration.

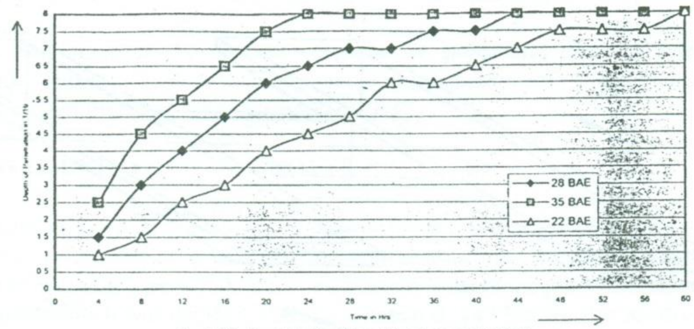
ii). Experiment was repeated with two more concentrations, 22 BAE and 35 BAE, with 1" planks.

iii). Experiment was repeated with 3/4" and 1 1/2" thick planks using 28 BAE solution.

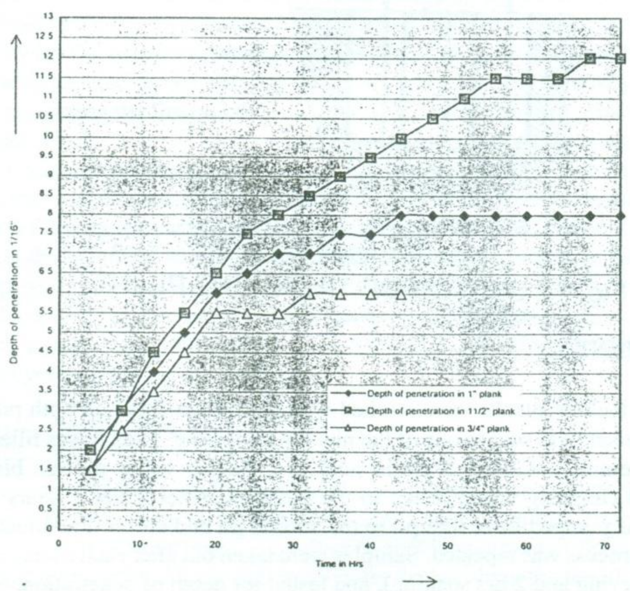
iv). Experiment was repeated with 28 BAE solution and 1" planks with increased air blast with intermittent steam, b) with air only (no steaming),

v). Experiment was repeated with 1" plank and 28 BAE solution withthe temperature of the solution raised to about 45 °C

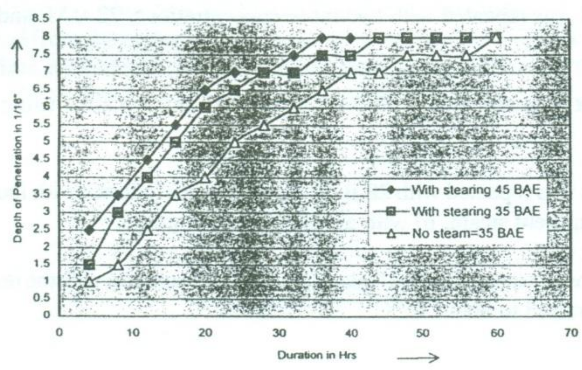
Accuracy of measurements approximately 1/16", variations averaged to 1/32"



Graph 02 - Depth Vs Time (for different concentration)



Graph 03 - Depth Vs Time (for different thickness)



Graph 04 - Depth Vs Time (with & without steam)

Observations and Discussion:

Graphs show the depth of penetration with time. It was observed that;

a). Total penetration of 1" planks could be achieved in about two days with 28 BAE solution. Thus this is a viable method and is a good alternative to vacuum-pressure treatment.

b). Rate of penetration varies with the concentration of solution, increasing with the increase of concentration.

c). Rate of penetration decreases with the increase of depth of penetration. Thus the time required for total impregnation is not directly proportional to the thickness of the planks. Therefore it is preferable to use higher concentrations when treating thicker planks.

d). Increase of air blast increases the rate of penetration. This is expected as the air blast assists in evaporation of the surface moisture.

e). Removal of intermittent steam blast reduces the rate of penetration. Intermittent blast of steam assists in raising the temperature of the surface of timber, which gets cools during evaporation of moisture due to latent heat. If the blast of air was dry (low R H) better results could have been expected. Thus, laying of an additional steam line to heat the blast of air, by blowing through it as in a kiln or any other suitable process, can be recommended when the additional expense can be afforded.

f). Increasing the temperature of the chemical solution increases the rate of penetration. However, use of steam blast to heat the bath dilutes the solution. An additional heat transfer arrangement as in "e", if available could be used for heating the bath as well.

COMMENTS:

This unit is in operation now for several years with very good results. The plant was continued to be supplied with steam as it can thus raise the temperature of the chemical solution, which was observed to have two additional advantages, viz; i). Chemical bath at a higher temperature accelerates the penetration, and ii). It prevents formation of fungus and bacteria in the bath thus preventing the severe pungent smell often observed with boron baths in vacuum-pressure plants. Need for frequent complete removal of liquor, which still contains a reasonable concentration of chemicals, from the bath replacing it with new chemicals, usually necessitated by this fungal formation in vacuum-pressure plants, thus is eliminated by the heating of the chemical bath with steam. It was found that replenishing the strength of the chemical, without disposing of the liquor, is sufficient and the same bath could be used for years.

As most of the medium scale timber working industries are having their own steam facility, cost of steam supply to the plant usually is only marginal. However, the process can be used even without steam where such facility is not available.

ECONOMICS OF PROCESS

The total construction cost of this plant was less than Rs 200,000/=. About 500 to 600 cuft of planks could be treated with these two baths alone in approximately two days. Capacity can easily be increased, if needed, simply by adding an additional pit. The cheapest Vacuum-Pressure impregnation plant available for the capacity requirements of this manufacturer was around Rs 7.5 million.
Operational costs of this plant are; a). Electricity for blower, b) cost of steam. At this unit, and at most of the medium industries, this is virtually nil as the only additional requirement is fire wood which is a waste from the saw mill. Hardly or no maintenance cost and need no skilled operators. Vacuum-pressure impregnation plants on the other hand consumes a considerable amount of electricity and needs skilled personnel for operation. Maintenance cost of valves, solenoids and controls involved too are considerable.

This amply demonstrate the economics of this process.

CONCLUSION:

1. In vacuum-pressure impregnation process, the suction of liquids from cells (and pores) may be due to capillary action (and surface tension) caused by the drying of the surface resulted by the evaporation of surface moisture due to reduced partial pressure.

2. Partial sucking in of chemicals to the cells is mainly due to replenishing of the fluid depleted cells when the surface is again soaked with chemicals. Application of pressure may be aiding this process.

3. The novel timber treatment plant and the Process described above ensures "total" and "complete" impregnation, though at a lower rate than with vacuum pressure plant.

4. The Plant is very simple and much cheaper, and therefore the process is much more economical, than using a Vacuum-Pressure impregnation plant of similar capacity. This process, therefore, would be particularly attractive to medium and small scale industries

5. Formation of bacteria which causes severe pungent smell, as often observed in vacuum-pressure impregnation plants, is eliminated with the heating of chemical bath with steam where available. Thus this saves chemicals by eliminating the need for frequent emptying of chemical baths.

6. Long term effectiveness of the process and the durability of the so treated products have already been proved in actual use.

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