

The Effect of Wood Specimen Length on the Proportional Saturation of Preservative Fluid in Sitka Spruce (*Picea sitchensis* (Bong.) Carr.) and Corsican Pine (*Pinus nigra* var. *mantima*)

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Abstract: In this study, the proportional saturation and the fluid uptake of preservative liquid (that was) applied under the same pressure was investigated comparatively on the various longitudinal length of wood specimens in the two softwood species. Wood specimens of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and Corsican pine (*Pinus nigra* var. *mantima*) representative of two different permeability classifications, cut into five different lengths were treated with tanalith-C using the full-cell process under the same conditions. It appeared that longitudinal fluid flow decreased with increased specimen lengths. The shorter lengths were saturated effectively due to the shorter flow paths, and their retentions were higher than longer lengths. This decrease in permeability was attributed to more blockages in pit pores. According to this findings, it may be said that if the applied pressure is not modified, the void volume of wood on the various longitudinal length of the specimens (that were) treated under the same conditions would be filled in different amount of the preservative liquid.

Key Words: Softwood, Anatomy, Preservation, Longitudinal Flow, Full Cell, Proportional saturation.

Sitka Ladini (*Picea sitchensis* (Bong.) Carr.) ve Korsika Çamı (*Pinus nigra* var. *mantima*) Türlerinde Ağaç Malzeme Örnek Uzunluğunun Sıvı Emprenye Maddesi İçerme Oranına Etkisi

Özet: Bu çalışmada, aynı basınç altında uygulanan sıvı emprenye maddesinin farklı uzunluklardaki ağaç malzemenin boyuna akış yönünde gerçekleşen hacimsel ıslatma oranı ve içerilme miktarı iğne yapraklı iki ağaç türü üzerinde karşılaştırmalı olarak araştırıldı. İki farklı emprenye sınıflandırmasında bulunan Sitka Ladini (*Picea sitchensis* (Bong.) Carr.) ve Korsika Çamı (*Pinus nigra* var. *mantima*) türlerinden seçilen deneysel ağaç malzeme, beş farklı uzunlukta hazırlanarak aynı koruma işlemi koşullarında tanalith-C maddesi ile dolu hücre yöntemine göre emprenye edildi. Boyuna sıvı alımının her iki türde de örnek uzunluğu arttıkça azaldığı görüldü. Kısa örnekler koruyucu sıvı ile etkin bir şekilde dolarken, doluluk oranı uzun örnekler göre oldukça yüksek bir düzeyde oluştu. uzun örneklerin koruyucu sıvı alımlarının düşük düzeyde kalması, tracheidler arasında sıvı iletimini sağlayan geçit ağız açıklıklarının tıkanıklık oranına bağlandı. Elde edilen bu bulgulara göre, uygulanan basınç değeri değiştirilmedikçe aynı ortamda emprenye edilen farklı uzunluklardaki ağaç malzemenin içerisindeki mevcut boşluk hacminin yapısal özelliklere bağlı olarak farklı düzeylerde koruyucu sıvı ile dolacağı söylenebilir.

Anahtar Sözcükler: İğne Yapraklı Ağaç, Anatomi, Koruma, Boyuna Akış, Dolu Hücre, İçerme Oranı.

Introduction

Treatment of wood with liquids such as preservatives, fire retardants, dimensional stabilisation agents, and pulping liquids is associated with the transport of liquids in wood. Thus, fluid movement in wood is a very important process in wood products industries (1). Longitudinal flow becomes important, particularly in specimens having a low ratio of length to diameter, because of the high ratio of longitudinal to transverse permeability (2).

Longitudinal permeability was found to be dependent upon specimen length in the flow direction (3), i.e. the decrease of specimen length appears result in greater

permeability in less permeable species. For example, Sebastian et al. (4) found that the permeability of white spruce decreased with increasing specimen length. Bramhall (5) observed a negative relationship between the gas permeability and the lengths of Douglas fir specimens ranging from 0.5-3.5 cm. Siau (6) also reported similar results for Douglas fir and loblolly pine specimens of 2-30 cm in length.

Banks (7) described that (due to decreased permeability with increases in specimen length) some flow paths may remain unchanged as length is increased while others may totally be blocked with a wide variation in pore diameter. Liquid, therefore, penetrates into some

flow paths more rapidly than others, giving rise to the occurrence of surface forces resisting penetration with both wetting and non wetting liquids.

Pressure impregnation (PI) of timber using water-borne preservatives such as tanalith-C of copper chromium arsenic (CCA) by the full-cell process is an important method to increase the natural durability of wood against deteriorating organisms, and hence, increase its service life. Efficient penetration and uniform distribution of the preservative salt is achieved by PI as the preservative is driven via the wood capillary system. Factors of prime consideration governing the flow are the amount of pressure, fluid viscosity, solvent contact angle, wood pore radius, and wood capillary length (2).

This study was, therefore, concerned with the examination of the effect of specimen length on the longitudinal fluid uptake of two softwood species using tanalith-C in PI. For this purpose, Sitka spruce and Corsican pine, representative of the less and the more permeable species having values in the range of 0.1 to 1 cm³ (air)/(cm.atm.sec.), were particularly chosen.

Materials and Methods

A total of 60 specimens were cut from each of the wood species and 12 were cut to each of the five specimen length categories. The cross-sectional dimensions of the experimental specimens were 5 by 5 cm, and the lengths were 5, 15, 30, 45, and 60 cm. The experimental specimens were cut from the sapwood zone of air-dried and defectfree stakes of both Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and Corsican pine (*Pinus nigra* var. *maritima*). The grain orientation was very important in this investigation, thus the wood grain was arranged longitudinally without twisting.

The experimental specimens were initially weighed to obtain uncoated weight (1). All surfaces/ends, except the desired end for allowing the longitudinal penetration of the fluid, were double coated with ABS solvent cement to

prevent transverse flow. Thereafter, the specimens were re-weighed for sealed weight (2). Following the loading of the specimens into an impregnation cylinder, a full-cell process, similar to normal vacuum-pressure treatment as described in the literature (7-10) carried out under the conditions indicated in Table 1.

After the impregnation process was completed the treated specimens were taken out of the cylinder and weighed immediately for treated weight (3).

Thereafter, the fluid uptake (FU) and the proportional saturation (PS) were calculated using the following equations:

$$FU = [(3)-(2)]$$

$$PS = [FU/(1)] \times 100$$

Results and Discussion

A summary of the results for proportional saturation and fluid uptake, showing the averaged values, is given in Table 2. Data is also presented in Figure 1.

The experimental results generally showed that the fluid penetration (i.e. proportional saturation, %) decreased with increased specimen lengths, and the fluid uptake (g) increased as specimen length increased in both species. However, the rate of decrease in the proportional saturation (and also the change of increase in the fluid uptake) with increasing specimen length in each species. In this case, Sitka spruce was found to be slightly lower than Corsican pine in both data sets. As seen in Figure 1, proportional saturation of the experimental specimens decreased from 100 % to 41 % in Sitka spruce (SS), and to 52 % in Corsican pine (CP) as specimen length increased from 5 cm to 60 cm. On the otherhand, as also shown by Figure 1, the fluid uptake increased from 77 g to 345 g in SS, and from 72 g to 432 g in CP as specimen lengths increased.

The flow of preservatives along the wood capillary system decreased with increasing specimen length in both

Table 1. Experimental conditions.

parameters	stage 1		stage 2	
	vacuum (mmHg)	time (min)	pressure (bar)	time (min)
all the samples	640	5	6	5

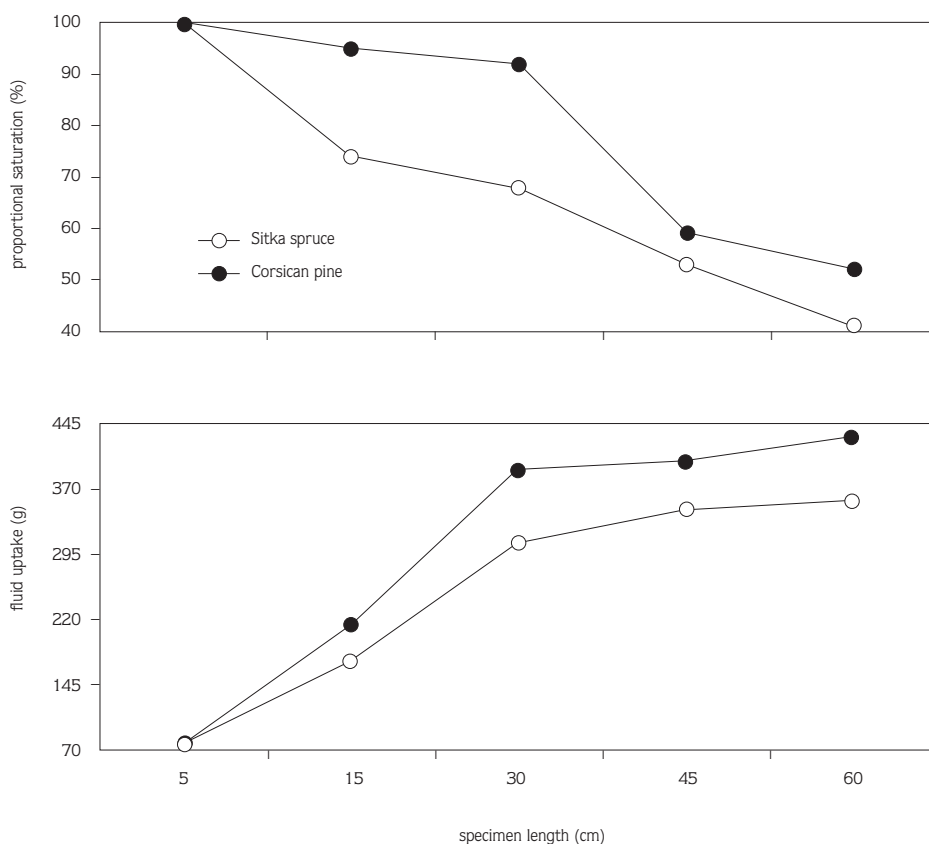


Fig. 1. Effect of specimen length on the proportional saturation (above), and the fluid uptake (below) for Sitka spruce and Corsican pine.

Sitka spruce and Corsican pine under the same treatment conditions i. e., 5 minutes vacuum and pressure period and maximum pressure of 6 bars. In each species, the shortest specimens (5 cm) were saturated more effectively than the longest specimens (60 cm) due to the length of the flow paths. That is, more void space was filled, and the higher retentions were achieved in shorter length specimens compared with longer length specimens. This is in agreement with previous experimental findings (2, 6, 7).

The amount of preservative allowed into the specimens, however, showed a dissimilar trend in that shorter specimens received much less fluid than the longer specimens. This could be explained by the amount of void space in the longer blocks compared with shorter blocks.

The one way analysis of variance (ANOVA) was applied to the results in Table 2 to evaluate the effect of specimen length upon the proportional saturation, and a significant difference was found between the proportional saturation and length for both species. It is clear from the

Table 2. Proportional saturation and fluid uptake of tanalith-C into the different specimen lengths of Sitka spruce and Corsican pine treated by a full-cell process.

specimen length (cm)	proportional saturation* (%)	fluid uptake (g)
Sitka spruce		
5	100 (2.01)a	77
15	74 (2.78)b	170
30	68 (1.12)b	310
45	53 (4.04)c	346
60	41 (3.36)d	358
Corsican pine		
5	100 (2.07)a	72
15	95 (2.13)b	213
30	92 (2.01)b	391
45	59 (1.90)c	403
60	52 (2.44)d	432

* Values are means of 12 replicates; figures in parenthesis are standard deviations. Values within a group followed by the same letter are not significantly different by Duncan's Modified Least Significant Difference Test ($\alpha=0.05$).

results that the proportional saturation of the 5 cm specimens was approximately two times greater than that of the 30 cm specimens in both species.

The change in the proportional saturation with length showed a low variation in Corsican pine with a slight systematic decrease the specimens of 5 cm and 30 cm, and also between 45 cm and 60 cm, whereas there was an abrupt drop in the 45 cm specimens where the percentage of the change was highest in some 33 %. Conversely, in Sitka spruce there was considerable variation compared with the specimens of Corsican pine. The greatest change in Sitka spruce was some 26 % between the specimens of 5 cm and 15 cm.

Conclusions

In this study, the effect of specimen length on longitudinal permeability was investigated for Sitka spruce (SS) and Corsican pine (CP). The experimental results showed a similar trend in both species in that the saturation of the specimen by preservatives decreased

from 100 % to 41 % in SS, and to 52 % in CP as specimen length increased from 5 cm to 60 cm.

The reason for decreased permeability with increased specimen length was due to the treatment time factor. If pressure application was prolonged, further movement and saturation occurred in longer blocks.

The shortest specimens (5 cm in length) of short flow pathways tended to be saturated more rapidly in a short period of pressure application than longest (60 cm in length) flow pathways. In addition, variability in wood capillary systems, to some extent, could also explain this phenomenon. For example, blockages of flow pathways by resins and by air embolism blockage could be more numerous in longer specimens than in shorter specimens on account of the dimensions of the specimen.

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