

Set-Recovery of Heat Treated Maritime Pine Wood Prior and after Compression

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ABSTRACT

Pine (*Pinus pinaster*) wood samples were subjected to a combined densification and heat treatment process. Samples were densified before and after heat treatment. The heat treatment was carried out inside an oven at 190°C for 2 to 6 h and wood densification was performed in a hot press at around 48 bar pressure and at temperatures of between 160°C and 200°C for 30 min. Compression rate and density were determined after the treatment. Set recovery was determined by three cycles of water soaking followed by oven drying. The best results were attained when densification was done before heat treatment. The set recovery was less than 30% for the first two cycles and a little higher in the third cycle. For wood treated for 6 hours, the set recovery was less than 15%. Heat treatment before densification seems to be less effective than after densification to enable set-recovery.

INTRODUCTION

According to Morsing and Hoffmeyer (2000) the densification process can be divided into four steps, the first being softening or plasticization of the cell wall followed by compression perpendicular to the grain in the softened state, setting by cooling and drying in the deformed state and fixation of the deformed state. Springback when wood is re-moistened is one of the main problems with compressed wood. Morsing and Hoffmeyer, (2000) proposed three mechanisms to avoid springback, namely changing the hygroscopicity of the cell, forming covalent crosslinks between the wood components or releasing the elastic stresses and strains created during compression. Several authors have been testing the reduction in the hygroscopicity of the cell through heat treatment. For example Inoue *et al.* (1993, 2008) showed that it was possible to reduce springback by both dry heating and steam heating, although dry heating required 20 hours at 180°C to avoid recovery and 5-20 min are enough if steam heating is used. The intention of this work was to study differences between applying the heat treatment before or after compression.

EXPERIMENTAL

Pine wood (*Pinus pinaster*) from the Portuguese Viseu region was used in the tests. Sapwood samples with approximate dimensions of 145 mm x 145 mm x 32 mm (longitudinal x tangential x radial) were cut from a central board and placed in a controlled environment at 20°C and 65% relative humidity for two weeks. The samples were subjected to a combined treatment by densification and heat treatment. Samples were densified before and after heat treatment in accordance with the parameters shown in *Table 1* and the compressive set after the treatments was determined. The heat treatment was carried out inside an oven at 190°C for 2 to 6 h and wood densification was performed in a hot press at around 48 bar pressure and temperatures between 160°C and 200°C for 30 min. In order to determine the compressive set recovery, treated woods were subjected to three water soaking cycles followed by oven drying.

Table 1: Treatments

Sample	First treatment	Second Treatment
D160	Densification at 160°C, 180°C or 200°C	No treatment
D180		
D200		
DT1902	Densification at 160°C, 180°C or 200°C	Heat treatment at 190°C for 2h, 4h and 6h
DT1904		
DT1906		
T1902	Heat treatment at 190°C for 2h, 4h and 6h	No treatment
T1904		
T1906		
TD1902	Heat treatment	Densification at 160°C, 180°C or 200°C
TD1904		
TD1906		

RESULTS AND DISCUSSION

The compression set of untreated wood densified at 160-200°C ranged from 45.4% to 46.9%. Although compression set increases with the pressing temperature the differences were not significant (Table 2). In relation to samples that were heat treated before compression, the compression set was around 13%. This means that to attain a similar compression in samples heat treated prior to compression, a higher pressing pressure would be necessary. Although the decrease in the dimensions of samples that were only heat treated are presented here as compressive set, no compression was carried out. The decrease in the dimensions is only due to heat treatment.

The final density was around 1040 kg/m³ for densified wood corresponding to a 70% increase in relation to untreated wood. The density of samples that were heat treated after compression decreased with heat treatment, reaching a final density of around 980 kg/m³, representing a 62% increase in relation to untreated wood. For samples that were heat treated prior to compression, the maximum density obtained was around 630 kg/m³ which mean that the final density represents just a 3% increase in relation to the initial

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state of the wood. The density of the samples that were only heat treated decreased by about 6% (Table 2).

Table 2: Compression set and final density

Sample	Compression set (%)	Final Density (kg/m ³)
D160	45.4	1048
D180	45.9	1031
D200	46.9	1041
DT1902	46.5	988
DT1904	45.7	973
DT1906	46.3	1002
T1902	2.2	577
T1904	2.4	569
T1906	2.8	562
TD1902	12.7	627
TD1904	12.8	633
TD1906	13.0	619
Untreated		531

Figure 1 presents the water soaking followed by oven drying cycles for treated and untreated samples. These tests showed that the set recovery of densified wood without heat treatment was around 80%, regardless of the pressing temperature. Almost all of the set recovery was obtained after the first wetting cycle. Even though after the third cycle the set recovery is slightly higher, the samples have a lot of checks due to the wetting/drying cycles which increases the radial dimension. The set recovery of heat treated wood before densification depends on the time of treatment. With a higher treatment time the set recovery is smaller. After the second cycle the recovery was about 70% for wood treated at 190 °C for 2h whilst for 4h treatment the recovery reduced to 57% and for 6h to about 50%. In the third cycle the set recovery increased for all the treatments although there was already some damage in the samples due to the wetting/drying cycles.

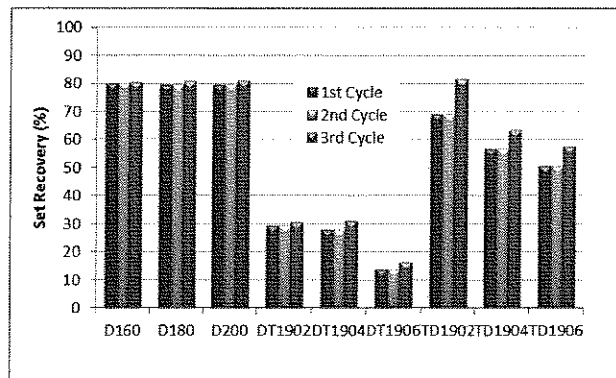


Figure 1: Set recovery after three wetting cycles

The best treatment was obtained when densification was followed by heat treatment. The set recovery was less than 30% for the first two cycles and a little higher in the third cycle. For wood treated for 6 hours, the set recovery was less than 15%. Heat treatment

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before densification seems to be less effective than after densification in reducing set-recovery. Nevertheless we have to take into account that the compression rate for heat treated wood is smaller. Tests are underway to try to obtain a similar compression rate on heat treated wood.

CONCLUSIONS

In conclusion to achieve the best results, densification must be done before heat treatment. The set recovery was less than 30% for the first two cycles and a little higher in the third cycle. For wood treated for 6 hours the set recovery was less than 15%. Heat treatment before densification seems to be less effective than after densification to reduce set-recovery.

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