OIL HEAT TREATMENT OF WOOD

Sidorova, K.[1]

ABSTRACT

The investigation of thermal treatment of wood has led to the improvement of heat treatment with vegetable oils. The aim of this work has been to study the oil absorption of wood during the process of oil heat treatment. This work has included the heat treatment of spruce, pine (heartwood and sapwood) and aspen in rape seed oil. The heat treatment was performed in the deep fryer at 180, 210 and 240°C during 30, 60 and 120 minutes. Two sets of samples were run, the first one was heat treated and left to cool in the air, the second one was heat treated and directly cooled in the oil bath for 1 hour. At 180°C there was a trend of increasing oil absorption during the heat treatment with the increasing the treatment time for all species. At 210°C the percentage of mass growth was reducing with increasing the time of the process. At 240°C all species lost the weight and the percentage of weight loss was increasing proportionally with increasing heat treatment time. During the heat treatment aspen had the highest mass increase and pine heartwood had the lowest. Results showed that wood absorbed significantly more oil in the stage of cooling in oil than during heat treatment. All species had a tendency to have approximately the same oil pick up during storing in the oil bath after the heat treatment at one temperature, so the heat treatment time did not have an effect on the oil absorption in the stage of cooling. The oil pick up during the stage of cooling had the lowest values for all species treated at 240°, because all the species lost the mass during the heat treatment at 240°. The colour changed during heat treatment and depended mainly on the heat treatment temperature. The darkness was increasing proportionally with increasing the thermal treatment temperature. The colour varied among the species.

Key words: oil heat treatment, pine, spruce, aspen, oil absorption

INTRODUCTION

The thermal modification of wood has been known as a process enhancing wood properties by reducing moisture absorption, improving dimensional stability and biological durability [12,11,3,5]. In recent years the heat treatment industrial processes have been developed successfully in Europe. These processes use air steam, nitrogen or oil as the heat transfer and include the Finnish ThermoWood [13] and Dutch PlatoWood [2] using steam, French Retification using nitrogen [4], German OHT-Process using oil [8].

---

[1]MSc Student in Wood Technology, Research Engineer, Division of Wood Physics, Luleå University of Technology, Skellefteå, Sweden, Tel.: +46 738 275 525, E-mail: katerina.sidorova@ltu.se

The treatments using air or nitrogen demand accurate control of high temperatures for the planned process time to enhance wood properties [14]. Hot oil provides fast and equal heat transfer to the wood and the same conditions all over the whole vessel; also oil serves as a perfect separation of oxygen from wood [8]. It was found that the hydrophobic properties and resistance against biological attack of oil-heat treated wood not only benefit from the heat treatment, but also from the shell formed by water-repellent oil during the process [14]. At the same time oil heat treatment reduces nail holding resistance significantly as well as the heat treatment in gaseous atmosphere. The colour resistance to weathering is not improved in the case of oil-heat treatment. So, special surface treatments and coating systems should be developed for oil heat treated wood for the outdoor exposure. Also oil thermally modified wood is not recommended in the structural uses where the strength properties are critical [14].

The purpose of this paper is to investigate the oil absorption of three wood species, pine, spruce and aspen, heat treated at different temperatures, 180, 210 and 240°C, and different time intervals, 30, 60 and 120 min, during the process of oil heat treatment. The importance of the knowledge about the oil penetration into wood during the process is evident, because the next step for this work is to enhance the properties of oil heat treated wood by adding chemical compounds into the oil.

MATERIALS AND METHODS

Materials

Rape seed oil was used for the wood treatment. For each time interval and heat treatment temperature five samples of spruce, pine heartwood, pine sapwood and aspen were prepared. The test samples of the sizes 150x20x20 mm were predried before heat treatment.

Treatment process

Deep-fryer Frifri Basic 411 (Switzerland) was used for the oil heat treatment. The wood was treated at 180, 210 and 240°C during 30, 60 and 120 minutes. Two sets of samples were run, the first one was heat treated and left to cool in the air, the second one was heat treated and directly cooled in the oil bath for 1 hour. The mass increase during heat treatment and during heat treatment with cooling in the oil bath was calculated (Eq. 1).

$M = (m2 – m1)/m1 \times 100\%$ (1)

m1 – mass before the heat treatment,

m2 – mass after the process.

RESULTS AND DISCUSSION

The results for the mass changes during heat treatment are displayed in the Table 1. At 180° there was a trend of increasing oil absorption with the increasing the heat treatment time for all species (see also Fig. 2:1). At 210°C the percentage of mass growth was reducing with increasing the time of the process (see also Fig. 2:2); pine heartwood lost its weight already at 210°C because heartwood contains a lot of extractives which are evaporated during heat treatment process. The decrease in mass growth for the samples treated at 210°C can be explained by the fact that the wood having reached 200°C changes its properties rapidly because of the degradation of its components; after 200°C lignin starts to decrease [1,7]. At 240° all species lost the weight and the percentage of weight loss was increasing proportionally with increasing heat treatment time (see also Fig. 2:3). After 240°C the cellulose can start to degrade as well, because the decomposition temperature for cellulose is about 240–350°C [7].

Table 1: Mass increase during heat treatment (M – mass increase, St D – standard deviation)

Temperature, °C	Heat treatment time, min	Spruce		Pine (heartwood)		Pine (sapwood)		Aspen	
		M, %	St D, %	M, %	St D, %	M, %	St D, %	M, %	St D, %
180	30	**3,19**	1,12	**1,39**	0,87	**3,61**	0,23	**10,84**	3,1
	60	**3,47**	0,25	**1,98**	0,99	**5,72**	1,28	**12,8**	5,33
	120	**6,18**	0,65	**2,99**	0,48	**6,99**	1,28	**19,79**	11,22
210	30	**3,52**	0,87	**-4,03**	1,31	**3,76**	1,21	**10,27**	3,49
	60	**1,66**	0,66	**-4,45**	1,74	**2,58**	0,93	**7,07**	0,81
	120	**0,09**	1,13	**-4,6**	2,28	**2,34**	0,41	**6,83**	0,4
240	30	**-1,52**	0,35	**-8,72**	2,94	**-0,76**	0,33	**-3,92**	0,93
	60	**-3,88**	0,39	**-15,04**	4,99	**-2,89**	0,74	**-5,5**	1,79
	120	**-5,42**	0,39	**-16,17**	2,17	**-3,43**	0,76	**-6,23**	7,51

According to the results from Table 1 the species have different changes in mass after treatment. It can be explained by the difference in the anatomical structure. Aspen had the highest mass increase. Aspen is hardwood which is known to have much wider cells (vessel elements) than softwood [9]. Thus it makes the aspen easier to penetrate.

Pine sapwood has higher mass increase than spruce, because of the difference in the connections between longitudinal tracheids and horizontal parenchyma cells in rays [10]. Looking at the radial view it can be seen that pine has a large pit (fenestriform pit) and thin membrane between adjacent cells. Spruce has a number of small *piceoid* or *cupressoid* pits in the membrane (Fig. 1) [10].

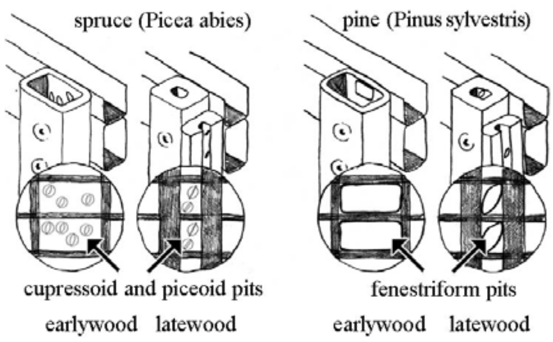


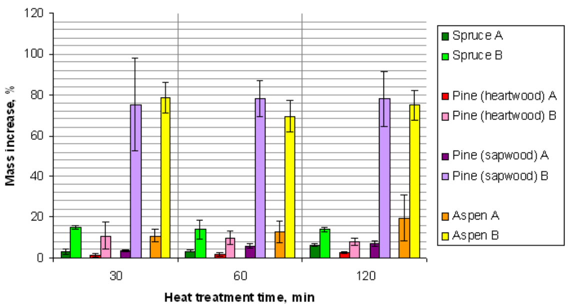
Fig. 1: Interconnecting pits between ray parenchyma and vertical tracheids in pine and spruce, earlywood and latewood [10]

The results for the mass increase during heat treatment and direct cooling in the oil are displayed in the Table 2. Oil pick up occurred for all species, because the wood absorbed tremendously more oil in the stage of cooling (Fig. 2) and started to sink after laying in the cool oil bath. The reason for the higher oil absorption in the stage of cooling is that there is an internal pressure in the wood during heating and low pressure during soaking [6] since the pressure and volume of the gases which are present in the wood cells are directly proportional to the temperature. All species had a tendency to have approximately the same oil pick up during the heat treatment at one temperature and storing in the oil bath, so the heat treatment time did not have an effect on the oil absorption in the stage of cooling (see also Fig. 2). Pine heartwood had the lowest oil pick up (Fig. 2) because it had the lowest values for mass increase in the stage of heating. Pine sapwood had the highest oil pick up in comparison with other species (Fig. 2). The oil pick up during the stage of cooling had the lowest values for all species treated at 240°, because all the species lost the mass during the heat treatment at 240°C (Table 1, Fig. 2:3).

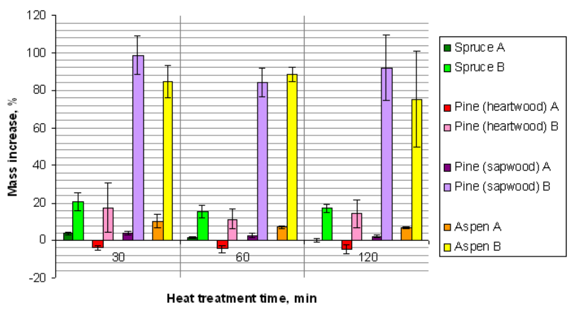
Analyzing the oil pick in the stage of cooling (Table 2), it is possible to see the trend for every species: the oil pick up is higher during the treatment at 210°C than at 180°C; and at 240°C the oil pick up is lower than at 210°C.

Table 2: Mass increase during heat treatment and cooling in the oil bath

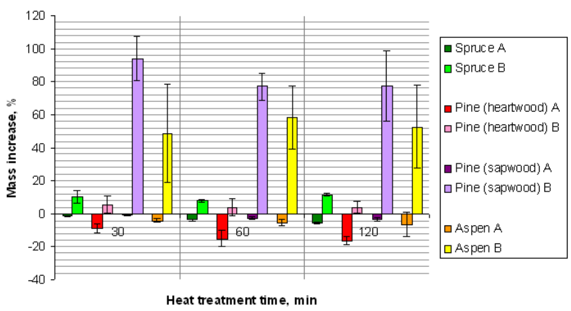
Temperature, °C	**Heat treatment time, min**	**Spruce**		**Pine (heartwood)**		**Pine (sapwood)**		**Aspen**	
		M, %	St D, %	M, %	St D, %	M, %	St D, %	M, %	St D, %
180	30	**14,99**	1	**10,87**	6,72	**75,15**	22,8	**78,53**	7,61
	60	**13,98**	4,8	**9,65**	3,25	**77,95**	8,67	**69,21**	7,71
	120	**13,8**	1,14	**7,89**	1,72	**77,99**	13,61	**74,98**	7,34
210	30	**20,61**	4,64	**17,43**	12,95	**98,54**	10,09	**84,58**	8,49
	60	**15,27**	3,65	**11,55**	5,45	**84,33**	7,57	**88,55**	3,89
	120	**17,24**	2,35	**14,18**	7,49	**91,93**	17,3	**75,25**	25,66
240	30	**10,14**	3,87	**5,67**	5,12	**94,19**	13,31	**48,64**	29,71
	60	**7,81**	0,8	**3,82**	5,15	**77,1**	8,37	**58,09**	19,06
	120	**11,69**	0,88	**3,99**	3,37	**77,29**	21,53	**52,63**	25,09



1



2



3

Fig. 2: Mass increase during heat treatment and direct cooling in the oil bath (1 - Heat treatment at 180°C, 2 - 210°C, 3 - 240°C. Spruce A, Pine A, Aspen A – samples cooled in the air after heat treatment; Spruce B, Pine B, Aspen B – samples cooled in the oil bath after heat treatment).

The colour changed during heat treatment and depended mainly on the heat treatment temperature. The darkness was increasing proportionally with increasing the thermal treatment temperature (Fig. 3). The colour varied among the species. After heat treatment pine (especially heartwood) was darker than spruce, aspen was the darkest and gained a sombre brown colour during treatment at 240°C.

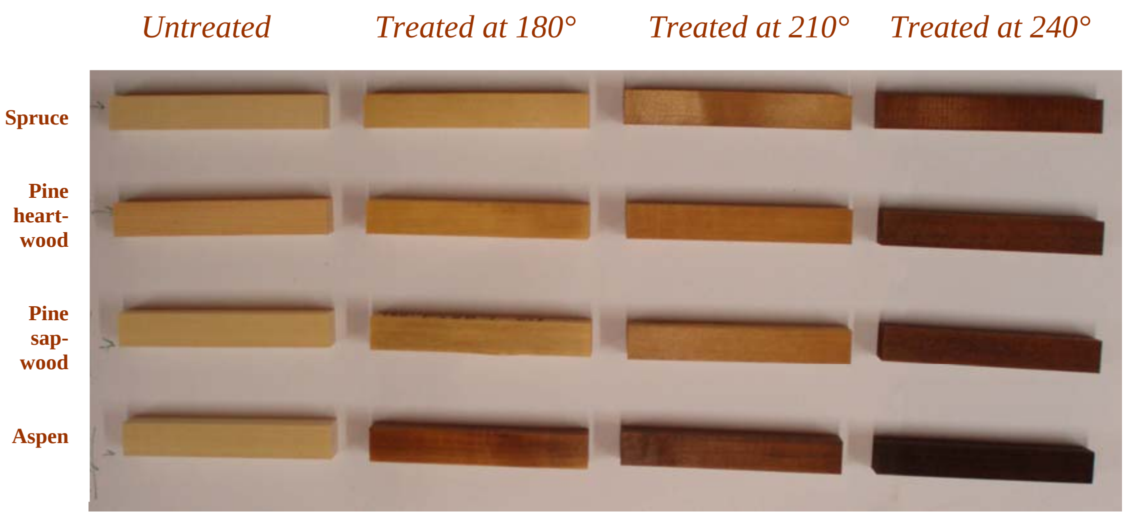


Fig. 3: Samples before and after heat treatment

CONCLUSIONS

According to the results obtained during oil heat treatment process the following conclusions were made:

The degradation processes within the wood during oil heat treatment are similar to the heat treatment in the gaseous atmosphere. The variations in colour are significant between samples of different species and samples treated at different temperatures.

The percentage of oil pick up during heat treatment is not major. The wood absorbs the highest percentage of oil during the stage of cooling. The heat treatment time did not have an effect on the oil absorption in the stage of cooling.

The species have different oil pick up for the reason of the differences on the anatomical level, variations in porosity and permeability, heartwood content

REFERENCES

1. Beall FC, Eickner HW (1970) Thermal degradation of wood components: a review of literature. USDA Forest service research paper. US Department of Agriculture. Forest Products Laboratory. Madison, USA.
2. Boonstra MJ, Tjeerdsma BF, Groeneveld HAC (1998) Thermal modification of non-durable wood species. 1. The Plato technology: Thermal modification of wood. IRG/WP 98-40123, IRG Secretariat, Stockholm, Sweden.
3. Burmester A (1973) Effect of heat-pressure-treatment of semi-dry wood on its dimensional stability. Holz als Roh und Werkstoff, Germany.
4. Dirol D, Guyonnet R (1993) The improvement of wood durability by retification process. The international research group on wood preservation, IRG/WP 93–40015, IRG Secretariat, Stockholm, Sweden.
5. Giebeler E (1983) Dimensional stabilization of wood by moisture-heat-pressure-treatment. Holz als Roh und Werkstoff, Germany.
6. Grenier D, Baillères H, Méot JM, Langbour P, Lanvin JD (2003) Oil absorption during oleothermic treatment of wood. In: The First European Conference on Wood Modification ECWM 2003, Ghent, Belgium, 3-4 April 2003.
7. Finnish Thermowood Association (2003) ThermoWood® Handbook. ThermoWood: Homepage, http://www.thermowood.fi/, 1/10 2008.
8. Rapp AO, Sailer M (2001) Oil heat treatment of wood in Germany – State of the art. In: Review on heat treatments of wood. COST Action E22, Environmental optimisation of wood protection. Proceedings of the special seminar held in Antibes, France, on 9 February 2001, Forestry and Forestry Products, France.
9. Rowell R (1984) The chemistry of solid wood. American Chemical Society, Washington, USA.
10. Sehlstedt-Persson M, Johansson D, Morén T (2006) Effect of Heat Treatment on the Microstructure of Pine, Spruce and Birch and the Influence on Capillary Absorption. In: Proceedings of The 5th International IUFRO Symposium Wood Structure and Properties. 3-4 September, Sliač - Sielnica, Slovakia.
11. Stamm AJ (1964) Wood and Cellulose Science. Ronald Press, New York, USA.
12. Stamm AJ, Hansen LA (1937) Minimizing wood shrinkage and swelling: Effect of heating in various gases. In: Industrial and Engineering Chemistry, US Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, USA.
13. Syrjänen T, Kangas E (2000) Heat treated timber in Finland. The international research group on wood preservation, IRG/WP 00–40158, IRG Secretariat, Stockholm, Sweden.
14. Wang J (2007) Initiating evaluation of thermal-oil treatment for post-MPB lodgepole pine. Forintek Canada Corp., Vancouver BC, Canada.