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THE EFFECT OF HIGH PRESSURE WATER JET ON THE SURFACE QUALITY OF WOOD

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Abstract

The wood surfaces under outdoor conditions are degraded by the weather influences (rain, UV/IR radiation, wind, biological organisms etc.). For the renovation of the degraded wood surfaces the upper layer has to be removed. Sand blasting and high pressure water jet are often used for the cleaning of the outdoor surfaces. High pressure water jet is especially interesting, because nowadays a lot of households have such a device, thus it is possible to do this cleaning method at home as well. Usually, wood surfaces are protected during outdoor utilization. Beside the use of different coating methods, heat treated materials are also often used outdoors. The main goal of the investigation was to determine the abrasion effect of the high pressure water jet on normal and heat treated scots pine and larch surfaces. Surface hardness and abrasion resistance were investigated to characterize the physical changes of the surface.

Key words: *heat treatment; surface hardness; abrasion resistance; surface degradation.*

INTRODUCTION

With high pressure water it is possible to impart high energy to the surface which results in the change of the surface. These changes are depending on the water pressure, the distance from the surface, the angle between the water jet and the surface, the contamination of the water (abrasive particles), etc. The theoretical background of the effect of high pressure water is discussed long ago. The importances of the several parameters are well described in earlier publications (Momber et al. 1995, Birtu et al. 2012, Shahverdi et al. 2012).

The utilization of the high pressure water jet for cutting in the wood industry is also known. In this case it is possible to cut optional shapes from thin plates. The cutting quality is hardly influenced by the thickness of the plate. Another technology is to use the water jet for the debarking of the logs before sawing. However, during the debarking process the surface quality is not important.

During the investigation of the effect of water jet on wood surface it was stated, that wood species is an important influencing factor (Ganne-Chédeville et al. 2010).

OBJECTIVE

The goal of our investigation was to describe the effect of high pressure water jet on the surface properties of heat treated scots pine and larch wood.

METHOD

Two wood species were investigated, namely scots pine (*Pinus sylvestris*) and larch (*Larix decidua*). Three different treatment temperatures were used: 180, 200 and 212°C with 10 hours treatment time. An oxidative athmosphere (air) was used.

Equilibrium moisture content (EMC), density, surface hardness and abrasion resistance were investigated.

For the determination of the EMC and density, samples with the dimensions of 20×20×30mm were used. Samples were climatized under 20°C and 65% relative humidity. Investigations were carried out according to the standards MSZ 6786-2/1988 and MSZ 6786-3/1988.

The surface hardness was determined according to the Krippel-Pallay method. With this method a steel ball with the diameter of 31,834mm is pushed into the surface in 2mm depth. Thus, the diameter of the penetration is 15,958mm. This results in a penetration area of $2cm^2$. The advantage of this method is to measure the hardness near the surface only and because of the large penetration area it is less sensitive to the inhomogeneity of the wood (early- and latewood).

$$H_{K-P} = \frac{F}{200}; [N/mm^2] \qquad (1)$$

where: F – force needed to the 2 mm deep penetration of the steel ball [N]
200 – surface of the penetration area (spherical cap) $[mm^2]$

To determine the abrasion resistance a Taber-abrader was used according to the standard MSZ 6786-14/1982. The abrasion during 400 turns was determined with the depth and mass loss per 100 turns. The abrasion was determined after every 100 turns separated as well, to get more knowledge from the abrasion process.

The high pressure water jet was produced with a Kärcher K2.00 universal washing device (commonly available type). A Viber power spreading head was used, which spreads the water in plane. The spreading head was prepared in a distance of 10cm from the surface. The angle between the wood surface and the water jet was 70°. The abraded area was about 42 mm wide with these settings (Fig. 1.). 20mm thick samples were abraded with the water jet for 10, 20, 30 and 40 seconds. Wood samples were prepared with standing annual rings, thus abrasion occurred on the radial surfaces. The samples were cut in the plane of the abrasion after water jet and the cross section was scanned with high resolution. The loss of the cross section was determined from these pictures with the help of image analysing software.

Fig. 1.
Sample set of the water jet abrasion

RESULTS & DISCUSSION

With the increasing of the treatment temperature, the EMC decreased. EMC of larch was nearly 20% lower at higher treatment temperatures (200, 212 °C) compared to scots pine, and 50% compared to the control samples (Fig. 2.). This means, that wood species is an important factor in terms of the changes in EMC as a result of heat treatment.

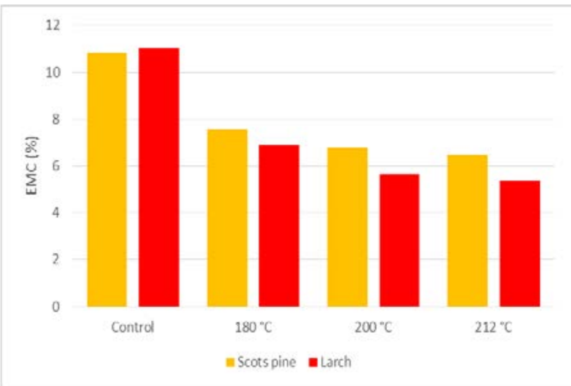

Fig. 2.
Equilibrium moisture content of heat treated and control samples (t=20°C, rh = 65%)

Airdry density of larch was 20% higher compared to the scots pine. Treatment temperature did not influence the airdry density of scots pine. However, the density of larch decreased slightly with the increasing treatment temperature (Fig. 3.).

Fig. 3.
Airdry density of heat treated and control samples

Krippel-Pallay hardness of larch was slightly higher compared to scots pine. Hardness of scots pine increased until 200°C treatment temperature compared to the control. However, the hardness of the samples after 212°C treatment temperature was the same as the hardness of the control samples (Fig. 4.). Larch did not show a clear tendency. The surface hardness of control samples was equal to the hardness of the 200°C heat treated samples, while samples after 212°C heat treatment showed 15% higher and after 180°C 40% higher values. The standard deviations are increasing with the treatment temperature in case of both wood species. In case of scots pine, the standard deviation became doubled, while in case of larch quadruplicated compared to the controls. Thus, the differences can be large in the surface hardness as a result of the heat treatment.

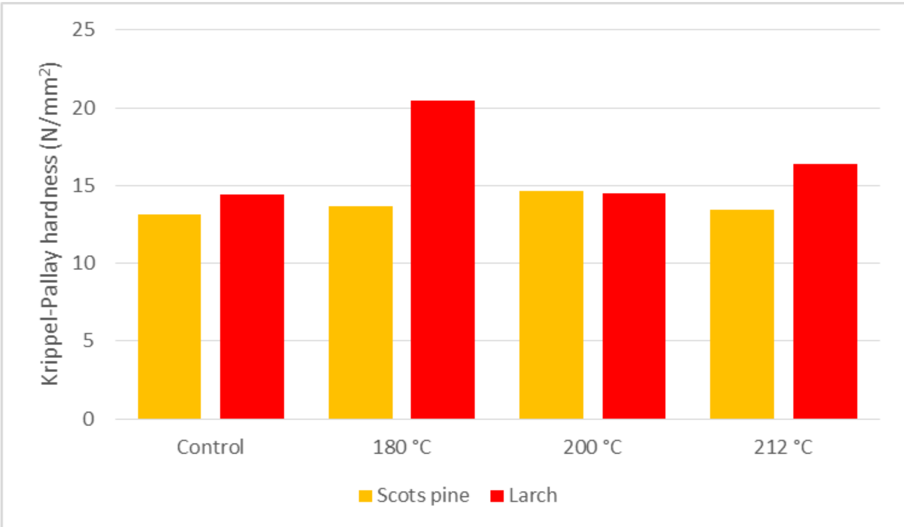

Fig. 4.
Changes in the surface hardness (side) as a result of heat treatment

Abrasion resistance was described with both the thickness and the mass loss during the abrasion (Fig. 5.). According to the mean abrasion for 100 turns, scots pine samples showed higher abrasion values compared to larch. Depth of abrasion and mass loss during abrasion increased significantly with the treatment temperature. This result shows that the abrasion resistance decreased as a result of heat treatment. Abrasion resistance showed higher percentage decrease with the depth of abrasion compared to the mass loss during abrasion. This result shows that the abrasion is nut equal in the whole abraded surface. It is higher in the middle and getting less on the edges of the abraded surface.

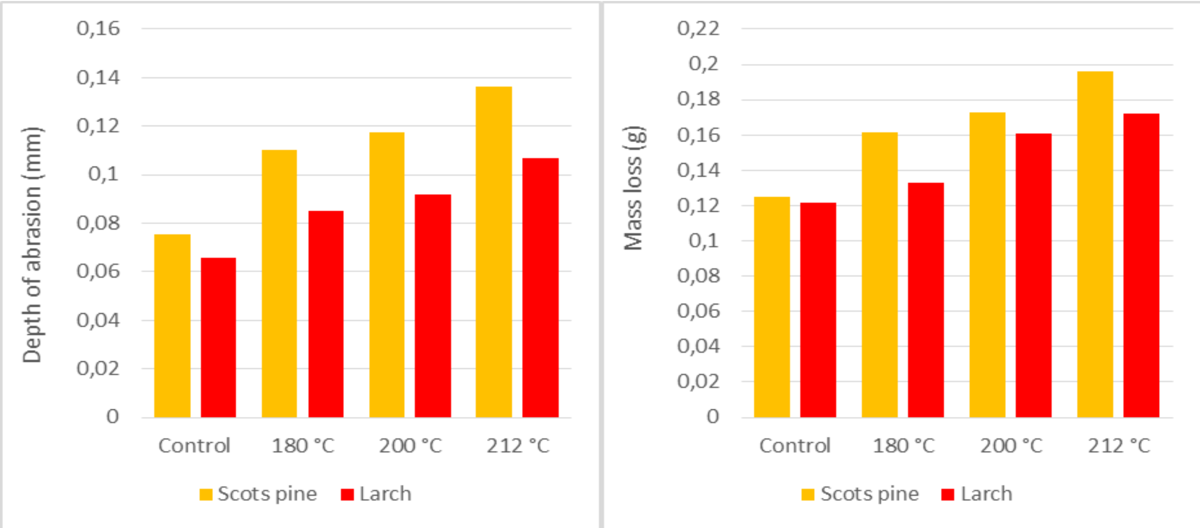

Fig. 5.
Changes in the mean Taber abrasion for 100 turns as a result of heat treatment

By analysing the each 100 turns of abrasion separated the results showed that the abrasion is significantly the highest during the first 100 turns of the Taber-abrader and it decreased continuously after that (Fig. 6.). The abrasion during the first 100 turns increased as a result of the heat treatment. This result shows that the differences between the upper layer of the wood material and the underlying parts are higher in case of heat treated wood compared to the control. The distribution of the heat in wood during the termal modification was investigated by Cearmak et al 2013.

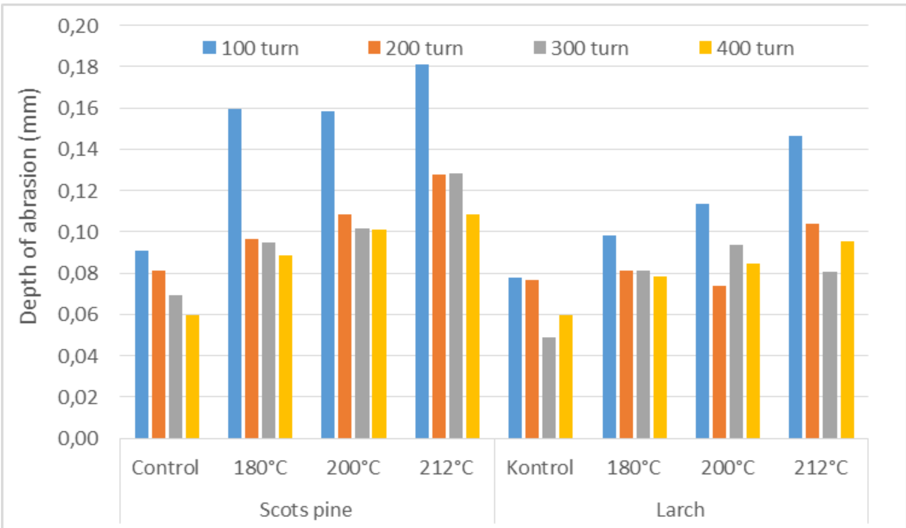

Fig. 6.
Changes in the Taber abrasion per each 100 turns during abrasion as a result of heat treatment

The abrasion (material loss measured on the cross section of the abraded surface) as a result of the high pressure water jet was higher in case of larch compared to scots pine (Fig. 7.). The difference between the two wood species was the highest at the controls and the 180°C heat treated samples. However, these differences decreased with the increasing treatment temperature. Abrasion increased with the time of the abrasion and with the increasing of the treatment temperature as well.

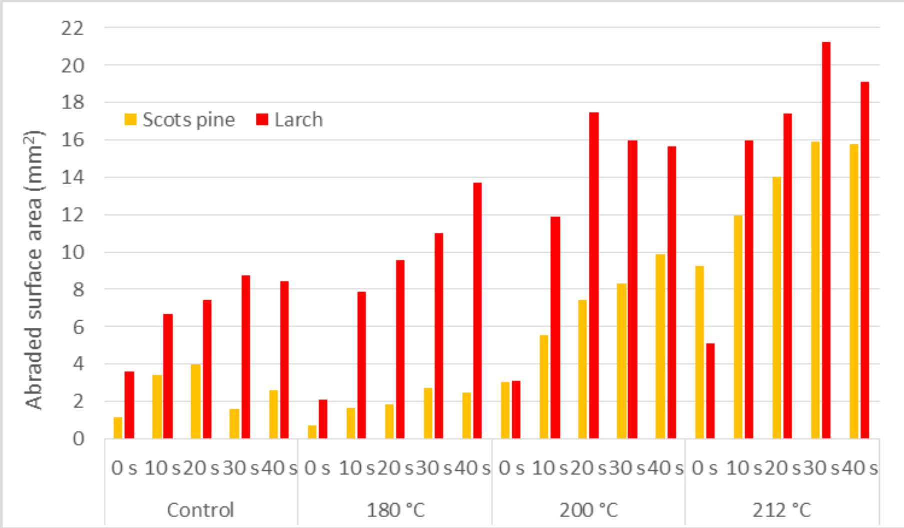

Fig. 7.
Changes in the abraded (water jet) surface as a result of wood species and heat treatment temperature

By taking an average (of the control and the 3 different treatments) of the abrasions with the water jet as a function of time the results showed that larch was abraded in a higher extent compared to scots pine. The abrasion was the highest in the beginning, and the intensity of the abrasion decreased with the time (Fig. 8.).. The last tendency is similar to the results gained by Taber abrasion test.

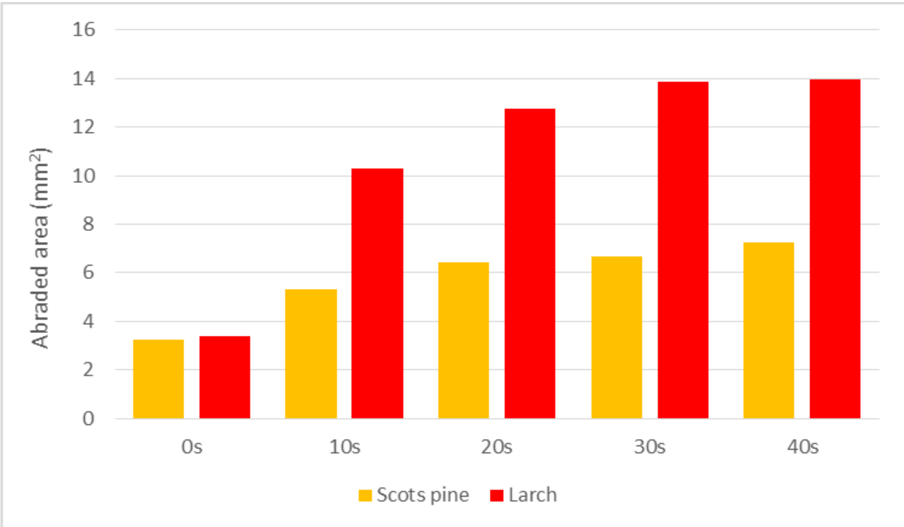

Fig. 8.
Effect of time of the high pressure water jet on the abraded surface area (0 sec. means surface roughness).

By taking an average of the abrasions with the water jet as a function of heat treatment temperature the results showed that larch was abraded in a higher extent compared to scots pine, but tendencies are different (Fig. 9.). In case of larch the value of the control samples is the lowest and the increase of the abraded surface area as a result of the high pressure water jet is continuous. In case of scots pine no significant difference could be found between the control samples and the samples heat treated at 180°C. However, as a result of higher treatment temperatures than 180°C the abrasion increased more intensively compared to larch. This is well shown by the differences between the two wood species after different treatment temperatures, namely the water jet abrasion was fivefold in case of 180°C treated samples for larch compared to scots pine, while only 20% more in case of 212°C treated samples.

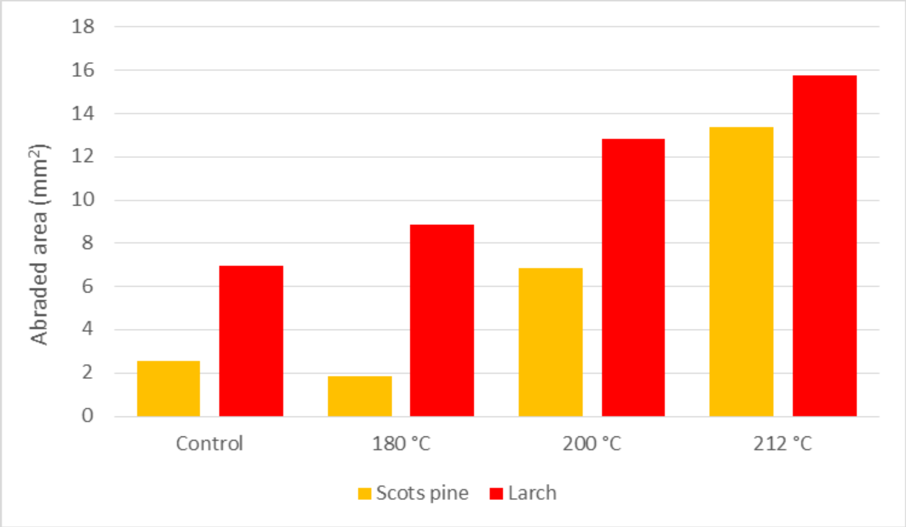

Fig. 9.
Effect of heat treatment temperature on the abraded surface area after high pressure water jet

The tendency of the abrasion of the Taber-abrader and the high pressure water jet was different. After the Taber-method the scots pine showed higher abrasion values, while as a result of high pressure water jet the larch showed higher abrasion values. On the one hand, during the Taber-method the surface takes the load nearly even, thus the earlywood and latewood are abraded more even. It resulted that the abrasion values were in correlation with the density, namely the material with higher density resulted in lower abrasion. On the other hand, in case of high pressure water jet abrasion the differences between the abrasion resistance of the earlywood and latewood are more important. The earlywood with lower density could be abraded more intensively compared to the latewood with much higher density. It is also an important factor, that the average annual ring thickness of larch was 40% higher compared to scots pine (Fig. 10-11.). This means also in a higher earlywood ratio of larch, which resulted in higher abraded surface area of larch during the abrasion with high pressure water jet. This is the main reason for the opposite results with the two investigated abrasion methods.

Fig. 10.
Abraded surface of larch after 40 seconds high pressure water jet abrasion

Fig. 11.
Abraded surface of scots pine after 40 seconds high pressure water jet abrasion

CONCLUSIONS

Changes as a result of heat treatment in equilibrium moisture content and density values showed similar tendencies to other investigations known from the literature.

Krippel-Pallay hardness of larch was slightly higher compared to scots pine. Hardness of scots pine increased until 200°C treatment temperature compared to the control and decreased above this temperature. Larch did not show a significant tendency. In case of scots pine, the standard deviation became doubled, while in case of larch quadruplicated compared to the controls.

In case of the Taber-method the density correlated with the abrasion, thus scots pine showed higher abrasions compared to larch. Depth of abrasion and mass loss during abrasion increased continuously with the treatment temperature, thus the abrasion resistance decreased as a result of heat treatment in case of both wood species. By analysing the each 100 turns of abrasion separated the results showed that the abrasion is significantly the highest during the first 100 turns of the Taber-abrader and it decreased continuously after that. The abrasion during the first 100 turns increased as a result of the heat treatment. This result shows that the differences between the upper layer of the wood material and the underlying parts are higher in case of heat treated wood compared to the control.

Abrasion as a result of high pressure water jet increased with the time of the abrasion and with the increasing of the heat treatment temperature as well. Tendencies were different in case of the different wood species. In case of larch the value of the control samples is the lowest and the increase of the abraded surface area as a result of the high pressure water jet is continuous. In case of scots pine no significant difference could be found between the control samples and the samples heat treated at 180°C. However, as a result of higher treatment temperatures than 180°C the abrasion increased more intensively compared to larch. The abrasion was the highest in the beginning, and the intensity of the abrasion decreased with the time. It is the same result as in case of the Taber-method.

The results of the abrasion of the Taber-abrader and the high pressure water jet were different. After the Taber-method the scots pine showed higher abrasion values, while as a result of high pressure water jet the larch showed higher abrasion values. This phenomenon is explained by the differences in the anatomical structure of the investigated wood species and the different methods. These results show well the importance of the used method for the investigation of a material property, because the different factors and conditions can cause different results for the same materials. While in case of the Taber-method the density correlated well with the abrasion resistance, in case of the high pressure water jet abrader method the differences between the density of the earlywood and latewood and the annual ring width were the most important influencing factors.

According to our results it can be stated that it is possible to use a high pressure water jet cleaner for the cleaning of wooden surfaces, however in case of softwood surfaces it can happen that the surface will be drastically damaged. This method abrades the wooden parts with lower density more, thus the pattern of the surface (radial or tangential cut) can be an important factor during cleaning. This is especially valid in case of heat treated wood, because heat treated woods abrasion resistance is lower compared to the untreated.

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REFERENCES

Birtu C, Avramescu V (2012) Abrasive water jet cutting - technique, equipment, performances, Nonconventional Technologies Review, 16(1):40-46.

Cermak P, Horacek P, Rademacher P (2013) Heat distribution in thermally modified timber. European Journal of Wood and Wood Products, 71(6):827-830.

Ganne-Chédeville C (2010) Merkblatt zur Reinigung von unbehandelten Holzfassaden mit dem Hochdruckreiniger.

Momber AW, Kovacevic R (1995) Statistical character of the failure of multiphase materials due to high pressure water jet impingement. International journal of fracture, 71(1):1-14.

Shahverdi H, Zohoor M, Mousavi SM (2012) Numerical simulation of abrasive water jet cutting process using the SPH and ALE methods.International Journal of Advanced Design and Manufacturing Technology, 5(1):43-50.