WOOD RESEARCH
60 (5): 2015
823-832

MITIGATION OF END SHAKES ON OAK SAW TIMBER AS A RESULT OF STORAGE BY APPLYING ENVIRONMENT-FRIENDLY METHODS

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(Received June 2015)

ABSTRACT

The mitigation of the damages occurring during the storage of saw timber can be solved – based on the current requirements – exclusively by applying environment-friendly methods. The chemical methods has negative effect on the environment, and due to water wastage and the water irrigation works has also negative impact. For this purpose diverse end grain sealers are available. Their efficiency in case of saw timber protection is however generally unknown or only little information is available for the users. The selection of the appropriate sealer can be performed only within the frame of a complex research program. The research involved the study of four commercially available end grain sealers of different base. The change in the moisture content of the timbers and the visible shakes appearing on the end grain surfaces of the timbers with their end pointing to the four cardinal points have been continuously observed for a period of seven months. The research has shown that after the cutting there is a possibility to reduce the dimension and quantity of end shakes during storage, and as the result of the proper storage the fungi and insect damage can be prevented. From this point of view the East-West-oriented stacking system prove to be the most effective. The research supports the idea that the use of the appropriate end grain sealer may significantly mitigate desorption through the end grain surface, which may also have beneficial impact on the number and depth of end shakes.

KEYWORDS: End grain sealing, end-shake, yield, orientation of timber.

INTRODUCTION

Regarding the activities and economic efficiency of wood-processing businesses, yield is of extreme importance. Within the activities performed in sawmills, the storage of delivered timbers

is the first phase of operation where yield can be improved. The quality of the sawmill timber, so the character and quantity of the wood defects in the timber play a very important role in the development of the yield percentage. Following logging, changes may tend to appear on saw timbers as a result of external abiotic and biotic factors. The more efficient the mitigation process is to treat such changes, the higher extent the quality of saw timber can be preserved.

The growing and vital functions of living trees need water, so it is natural, that the fresh logged timber contains significant amount of moisture. Affected by the shape and dimensions of the body it will be equilibrated with its environment only after several months. The equilibrium moisture content of timber is basically determined by the air temperature and relative humidity. As soon as any of these factors changes, these alterations are followed also by the moisture content of timbers. Several environmental effects affect the ambient temperature and the relative humidity of course; among others weather components such as sunshine, precipitation, wind, but also storage conditions, e.g. orientation of timbers or topographic relations (valley, hillside, etc.) have influence on moisture content.

When a tree is felled and every time a log is docked, the end grain of the log is exposed to the air and begins to dry. Exposed end grain dries quickly and, as it does, it shrinks. However, the timber further into the log's core doesn't dry and does not shrink. With the end of the log shrinking on this stable core, tension develops in the end grain of the log and radial end checks occur. These can form within half an hour of a cross cut being made. They grow as the log continues to dry and new end checks can develop between the initial ones (Nolan et al. 2003).

The period and the circumstances of storage play a significant role in the subsequent formation of end shakes on saw timber. End shakes, ripping, lathe checks can easily develop and in this context fungoid and insect pests can appear. There are several methods for mitigation, a part of which can be considered as traditional (e.g. storage in water, spraying, end grain surface shielding). The importance of end-grain sealing on moisture protection has been addressed (Miller and Boxall 1984, 1987; Miller et al. 1987; Raaschou Nielsen and Lindberg 1987; Lawther et al. 1992, Pranamornkith 2014). Different environment conditions such as temperature, relative humidity, air flow rate or solar radiation significantly affect end shakes (Yang and Normand 2012). With professional decisions made as to the place of storage, and by taking orientation into consideration, timber quality can be efficiently preserved. According to Shupe and Mills (1997) the East-West orientation is more advantageous due to the stronger solar radiation on the Southern side, however for the mitigation of end shakes different individual protective devices, such as treatment of the end grain surfaces are available. The end-coating reduces the loss of water and the end-cracks.

In total the collective application of these methods will provide us with the optimal solution.

End grain sealing is a very popular method in the preservation of quality. The end-shakes arising on the saw timber are frequent and important timber defects of sawmills processing broad-leaf trees (Wilhelmsen 1969), for this reason it is of great importance primarily in the protection of the finished and semi-finished products issued by sawmill industry, but prospectively its application will be emphasized in the preservation of saw timbers as well.

The end shakes develop as result of the rapid drying. Because these end-shakes open and close during the drying process, it is occasionally complicated to detect them (Murray 2014).

The sealers can be applied cold or warm onto the material to be protected. Cold applicable sealers can be applied easily, while warm applicable sealers can be applied difficult – in case of timber – onto the surface. (McMillen 1961)

The different oak types are of significant importance both in silviculture and in timber-industry. The "production" of high-quality plate and sawmill timbers is significant for silviculture

and timber-industry respectively. It is reasonable to start the quality improvement as soon as possible – already on the log yard. The preservative end-coating is still not spread in timber preservation everywhere, so the basic objective of the research was to propose appropriate technology and preservative for the storage of the high-value chestnut oak (*Quercus petrarea* Liebl.) timber. In our research work the efficiency of four different end grain sealers was determined.

MATERIAL AND METHODS

During the research series of almost 7 months we have continuously investigated the alteration of the moisture content and end shakes of the timber and we have searched for the answer, whether the orientation of the saw timber during storage affects the tendency to end shakes. As base material of the research project 50 pcs. Sessile oaksaw timbers were available. The length of the timber was 2.1 m, diameter between 25-50 cm. For the end grain sealing of sawmill materials several end grain sealers are available. Among them we have selected preservatives for the elaboration of the research program, the purchase of which is not complicated on the timber preservative market. For this reason we have considered four different end grain sealers: aqueous paraffin, water based-I, alcohol based and water based-II.

Establishment of research stacks

On the asphalted log yard of a North-East-Hungarian sawmill two research stacks consisting of 25 pcs. each was established. Within the stacks the timber were placed in two rows on each other. Accordingly one stack was located in North-South orientation and the other in East-West. The end grain surfaces of the timber were coated with four different end grain sealers. Within the 25-pcs-stacks the oak trunks were arranged by fives. To measure the efficiency of the four preservatives a fifth group – control group – was established, where the investigation was performed without end-coating. The meterological data published by the Hungarian Meteorological Service were used during the monitored period.

Condition survey

The occurrence of end shakes can be observed mainly on timber felled between April and October, for this reason logging work is recommended for winter (Yang and Beauregard 2001). The alterations arising at the timber ends (end shakes, colouration etc.) were recorded by means of pictures about the end grain surfaces beginning from the establishment of the stacks up to breaking-down. The condition surveys were carried out between April and October, approximately in every 1.5 month, totally 5-times.

For the evaluation of end shakes we worked a methodology, by the help of which based on the pictures (Fig. 1) made during the condition surveys the alterations can be numbered, excluding subjective judgements. The objective evaluation method is based on an image analyzing program. It displays diagrams which are showing the distribution of image tints, alias histograms.

The end-shakes appear on the cross-section of the timber in a darker tone (Fig. 1), so they can be clearly separated by an image analyzing program (Photoshop CS6, Adobe Systems, USA). The program establishes a divalent black-and-white image from the photographs (Fig. 2) by means of a limit value correction, in order to have only two tones – black and white – on the histogram received. The limit value shall be selected in a manner, that every end shake becomes black and the body white. Then the percentual value of the end shakes can be read from the statistic data of the histogram.

Fig. 1: End grain surface for examination.

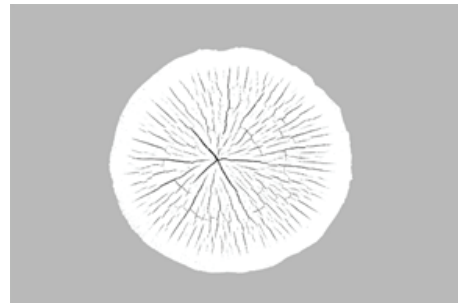

Fig. 2: Result of the image conversion.

Alteration of the moisture content

The alteration of the net moisture content of timber was registered by instrumental measuring (Hydromette M 4050, Gann, Germany) on every single experimental timber. The measuring was performed 30 and 60 cm from both ends of the saw timber and in the middle respectively with 70 mm long teflon insulated stainless steel drive-in electrodes, so the alteration of moisture content could be observed on the entire length of the timber. The measuring of the water content alterations has coincided with the occasion of making photographs about the end-shakes.

RESULTS AND DISCUSSION

During the evaluation of the results the external effects on the timber during the experiment shall be considered in any case. The weather – sunshine, precipitation quantity – affects directly the alteration of moisture content and the cracks and damages respectively. Three seasons – spring, summer and autumn – fell into the examined seven-month-period. The different seasonal effects deviating from the particular year can probably modify the results received to a certain extent. In the year of the investigation the weather of the region has deviated from the previously usual. The real long-lasting warm period has started only at the end of the summer, while the beginning of autumn earlier with more precipitation in this year has brought drought and higher temperature than usual (Fig. 3).

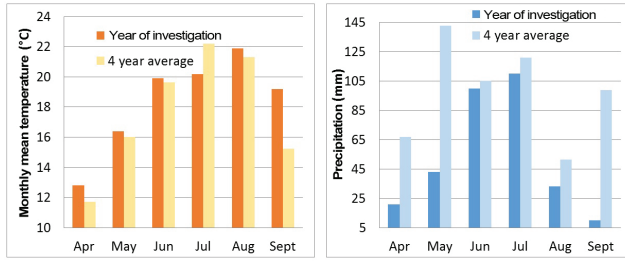

Fig. 3: Monthly mean temperature and precipitation in the year of investigation.

Moisture content

The chronological alteration of the average moisture content of the experimental items closely correlates with weather parameters (Fig. 4). There are no excessive deviations in the

moisture content of the control and the treated samples in the first three examinations. In this period of the year both the monthly mean temperature and the precipitation is increasing.

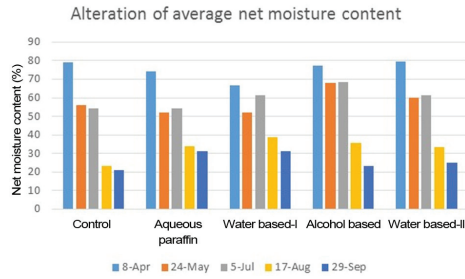

Fig. 4: Effect of the end grain sealer to the extent of the average desorption (N-S).

It can be observed that a moisture loss of higher extent occurred at the 4th measuring time. There is a difference in the moisture content of more than 10 % between the control and the treated samples, which reduces gradually with time. This period can be observed in the stage of summer, when there were also longer lasting warm periods and the precipitation quantity significantly decreased at the last indication the average moisture content was indicated between approx. 20 and 30 %. It can be also observed that each of the preservatives applied has reduced the extent of desorption, the coated timber have lost their water content more uniform, while the moisture content of the control pieces has fallen under 25 % already during the measuring in August. It is important because the fiber saturation point in case of oaks can be found at this value (Molnár 2004). Below this value the end shakes will appear increasingly. The most uniform desorption has taken place with the application of the preservative water based-I. The experimental timbers have shown almost similar results independent from the orientation.

Effect of orientation

For the examination of the desorption intensity the results of the measuring points indicated 30 cm from the ends were analyzed on the control timbers. Using these data – performing a functional analysis – information about the trend of desorption can be received and the extent of the effect of orientation can be indicated.

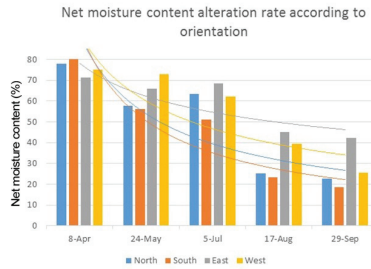

Fig. 5: Tendency of desorption depending on the cardinal points (control logs).

The extent and frequency of the end shakes of timber closely correlate with the amount and rate of desorption. The most favourable condition is provided, when both the reduction of water content and its rate are as low as possible. If the desorption rate is represented on a

graph and a trend line is put on it, the curve incline refers to the desorption rate. Based on the analysis of the function relationships it can be observed that the connection of the data sets can be optimally described by a power curve. The data and functional relationships of Fig. 5 express the information related to the characteristics of desorption on the side corresponding with the individual cardinal points. The value of the moisture content on the Northern, Southern and Western side has reduced under 25 % for the last measuring (18-25 %), on the contrary the Eastern end has shown a result above 40 %. In the foregoing measuring time the deviation of moisture content between the East-West and North-East side is around 20 % (45.1-39.4 % and 25.3-23.4 %) The desorption rate on the Eastern side has a more moderate curve.

The deviations between the incline of the curves of the diverse cardinal points can be well observed. In order to receive exact data of the desorption tendency; we have summarized the numeric results (Tab. 1) of the function analyses – the function-related coherences and the r^2 values – because their incline cannot be read from the trend lines of the figures.

Tab. 1: Result of the function analysis of desorption for every cardinal point.

		North	South	East	West
Control	**function**	$y = 118.32e^{-0,33x}$	$y = 124.23e^{-0,379x}$	$y = 88.041e^{-0,144x}$	$y = 117.26e^{-0,277x}$
	r^2	0.847	0.941	0.820	0.893

The high amount of the coefficients of determination refers to close fit for every cardinal point, based on which reliable conclusion can be drawn from the investigation results. From the point of view of the moisture content changes the most favourable value has come from the Eastern side, where the desorption rate was more moderate than on the other sides, so the probability of end shakes is lower. A significantly higher factor can be stated in the exponent of the curves equation than on the other sides, which effected higher rise so the tendency of desorption refers to a more intensive drying there, which shows the highest value on the Southern side. It corresponds with the preliminary expectations (Shupe and Mills 1997), according to which the intensive sunshine on the Southern side and the long-lasting strong solar radiation in the afternoon on the Western side can seriously damage the end grain surfaces through similarly more rapid desorption. The examination of the Northern side had an interesting result in the form of a similarly rapid desorption. It refers to the fact that the drying effect of another factor shall be considered, namely intensive desorption caused by windy weather.

End-shakes

The end shakes on the end grain surfaces were visible already during the establishment of the stacks, because the selected timbers were already logged. As the result of the drying their areal ratio has been ranged from 3 to 4 %. The further alterations were recorded with photographs made in different times. The end shakes occur due to the intensive desorption of the surfaces, where the moisture content can reach the hygroscopic limit directly on the surface and in its surroundings or even fall below. As a result of this the end shakes develop on account of the stresses arising in the timber. The hair-cracks at the end of materials drying outdoors can be even 30 cm or longer (Murray 2014), in our case we saw only 10 cm long cracks.

After the application of the end grain sealers the qualitative and quantitative alteration of end shakes has developed differently in both research stacks. On the Eastern side of the East-West-orientated timber the quantity of end shakes has barely deviated from the 2-5 % range, except the application of aqueous paraffin. After the application of aqueous paraffin the amount of end shakes has gradually increased as months gone by, which has almost reached 12 % by the end of

September? On the Western side similar results were recorded with the deviation that the amount of end shakes has increased after the application of alcohol based. In case of the application of both preservatives – with East-West orientation – the quantitative alteration of end shakes was not considerable against the control timber. This lower result can be also seen on the averaged end shake – area ratio diagram of the four cardinal points (Fig. 6). However it can be also observed that the increase of the end shakes does not coincide with the tendency of control timbers. Despite the relative uniform increase of the control timber the aqueous paraffin shows a higher increase only at the fourth measuring, while alcohol based only at the fifth measuring date.

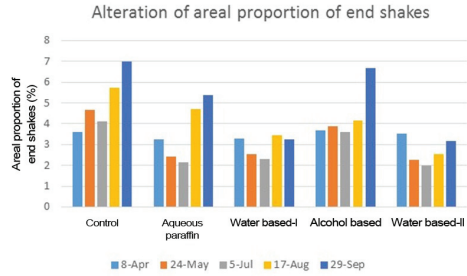

Fig. 6: Average areal proportion of the end-shakes additional to the application of individual sealers in average of cardinal points.

The end shake ratio has also significantly increased on the end grain surfaces of the North-West-orientated control timbers – almost to the double on the Northern side and with approx. 25 % on the Southern side compared to the starting condition. Further increase on the Northern side surfaces cannot be demonstrated with the application of preservatives, on the contrary on the Southern side the application of alcohol based did not have adequate result again. Despite the application of this sealer the quantity of end shakes – similar to the Western side – has increased.

Based on the evaluation of the end grain surfaces of the inspected timber – considering all 4 cardinal points – significant difference can be demonstrated among the applied sealers. As indicated in Fig. 6 every sealer has moderated the development of end-shakes, however not to the same extent. The end grain sealers water based-I and water based-II have reduced the quantity of the developing end-shakes in case of both orientations; accordingly their efficiency against the other two sealers can be well observed in the summarized diagram.

CONCLUSIONS

The stored timber suffer an intensive desorption during a relative short time, for this reason significant quality loss can be experienced – without end-coating -, which can result serious yield problems.

The orientation of the stored timber is a significant factor among the quality affecting factors. Based on the research work it is reasonable to apply an East-West-orientated stacking system, because desorption rate is more moderate on the end grain surfaces than in case of North-South-orientation.

The investigations support the fact that an appropriate preservative can significantly mitigate desorption through end grain surfaces, so it can favourably affect the amount and extent of the arising end shakes.

All of the end grain sealers applied during the research project has some kind of protective effect, however – based on the results received – significant quality difference can be demonstrated among them.

The application of the end grain sealers water based-I and water based-II has reached an excellent result in the reduction of intensive desorption and moderation of the arising end-shakes.

The end grain sealing ability of the popular aqueous paraffin and alcohol based fall behind the efficiency of the other two end grain sealers.

ACKNOWLEDGMENTS

This research - as a part of the Talentum Project for Science and Student Talent Fostering at WHU, TÁMOP-4. 2. 2. B - 15/1/KONV-2015-0005 - was sponsored by the EU/European Social Fund .The financial support is gratefully acknowledged.

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