The Effect of Hygrothermal Treatment on The Transversal Deformation and End Cracks of Hornbeam Logs

Abdollah Hoseinzadeh[1], kazem Doosthoseini[2], ali akbar Enayati[2] and habib Khademi-eslam[3]

[1]Islamic Azad University, Chalous, Iran [abdollah279@yahoo.com]

[2]Faculty of Natural Resource, University of Tehran, Iran

[3]Islamic Azad University, Tehran, Iran

Key words: *Carpinus betulus*, elastic deformation, heat treatment, hygrothermal deformation, longest crack relative factor, log waste percent, mean cracks length

ABSTRACT

In plywood industries, the transversal hygrothermal deformation of wood has an important role in log end cracks extension. In this survey, the tangential deformation of wood in five different temperatures (20, 40, 60, 80 and 100 ◦c) and the log end cracks of hornbeam (*Carpinus betulus* lipsky) in three different selected temperatures (40, 60 and 80oc), were studied. Twenty seven hornbeam trees in three diametric classes were cut down at the "Kheyroodkenar forest" in Nowshahr. From each tree, one log and one disk in diameter at breast height (d.b.h.), were cut. By a specified method (V-cutting), the tangential elastic and hygrothermal deformation of disks were measured. Furthermore, all log end cracks were measured before and after the hygrothermal treatment in a hot steam pool and data were statistically analyzed. The results indicated that by increasing the heat treatment temperature, the mean cracks length, longest crack relative factor and the log waste percent increased due to the increased transversal deformation. However, the transversal deformation varies among the diametric classes of hornbeam logs without following any specific patterns. Among the diametric classes, there were little changes in the longest crack relative factor and log waste percent.

INTRODUCTION

In plywood production process, in order to cut easier the dense wood species, the materials must be softened in hot water or steam. Regardless to be useful, when the green wood is heated, it expands tangentially and it slightly contracts radially. This phenomenon is called the hygrothermal recovery (Baldwin 1995). These changes in the dimensions accompanied by relief of the residual growth stresses, called elastic recovery (Dunich 2005), may cause the expansion of log end cracks and increase the log waste percent (LWP) in peeling process. Therefore, the transversal deformation (TD) in logs as an effective factor on end cracks expansion is considerable.

The results of a study on beech (F*agus orientalis L.*) wood showed that by increasing the heat treatment temperature, the hygrothermal deformation and length of log end splits increased too (Khademieslam 2003). In another survey, the log end cracks formation quality in oak (*Quercus sp*.) was studied and it showed that by increasing the time period and temperature of heat treatment would cause, the formation of cracks and this is the main reason for the hygrothermal deformation (Fonti *et al.* 2001).

In a study it is reported that the thermal treatment causes the expansion and increase in wood volume, and it can be due to the extent of lignin softening. These abnormal

thermal strains result from the viscoelastic recovery of the growth stresses (Grill and Thibaut 1994). The relaxation of transversal growth stresses arising from the wood thermal treatment is one of the reasons of radial cracks formation on the log ends (Fonti *et al.* 2001).
It is mentioned in an analysis that the prolonged hygrothermal treatment causes the depolymerisation of xylan and then its network becomes loose. As a result, the lignin softens and the tangential compressive growth stress is released (Nogi *et al.* 2003). The aim of this study was to investigate how TD effects on the log end cracks extension and consequently increases the waste of hornbeam logs in peeling process. The *Carpinus Betulus* Lipsky, with a considerable availability in Hyrcanian forests (the north of Iran) and with a suitable potential for the consumption in plywood production industries, was chosen in this study.

MATERIALS AND METHODS

Twenty seven hornbeam trees in three diameters (30 to 40, 40 to 50 and 50 to 60 cm) classes were cut down at Kheyroodkenar forest in Nowshahr (the north of Iran). From each tree, one green log (2.6 m long with bark) and one disk with a thickness of 3 cm in diameter at breast height were prepared. By the V-cutting method (Jullien 1993), first the tangential elastic deformation and after the hygrothermal treatment in five temperature levels (20, 40, 60, 80, and 100^{o}c) in a steam bath with a controlled temperature, the hygrothermal deformation was measured on the disk samples.
The TD was obtained by adding up the tangential elastic and hygrothermal deformations. The green logs were treated hygrothermally in three different selected temperatures (40, 60 and 80^{o}c) in a steam pool with the controlled temperature. All log end radial cracks were measured before and after the treatment. then the mean of cracks length (MCL) was calculated by dividing the total cracks length to number of cracks, the longest crack relative factor (LCF) and the log waste percent (LWP) (Eq. 1 and 2).

$$LCF(\%) = (L_c / L_r) \times 100 \quad (1)$$

$$LWP(\%) = (R_c / L_d) \times 100 \quad (2)$$

Where L_c , L_r , R_c and L_d are the log end longest crack, log radius, peeling residue core and the log diameter respectively. Then the data were statistically analyzed.

RESULTS

Table 1 shows the wood transversal deformation with the different heat temperatures (20 to 100^{o}c) of the disk samples. The results show that there is an exponential correlation between temperature degrees and TD (Fig. 1) so that by increasing heat treatment temperature, the TD increases. The effect of diametric classes on TD is shown in figure 2.

Table 1: TD due to the hygrothermal treatment (measured on the disk samples)

Hygrothermal temperature levels (^{o}c)									
20		40		60		80		100	
MD*	**CV(%)****	**MD**	**CV(%)**	**MD**	**CV(%)**	**MD**	**CV(%)**	**MD**	**CV(%)**
0.216	15.90	0.261	14.30	0.358	17.80	0.552	14.90	0.75	12

**: the means of deformation , **: the coefficient of variation*

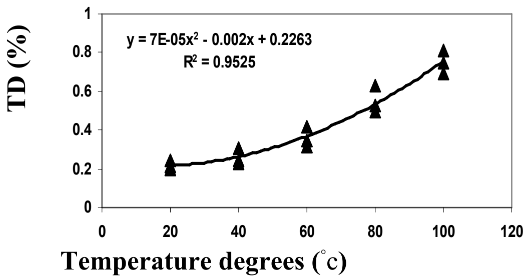

Figure1: Correlation between temperature degrees and TD

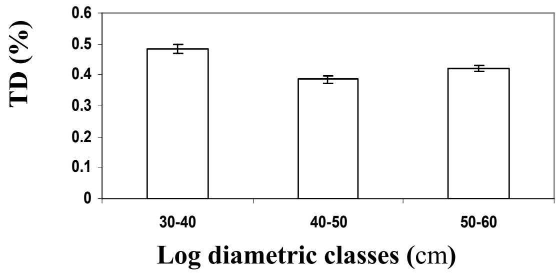

Figure2: TD in different log diametric classes

According to figure 2, TD varies among diametric classes of hornbeam logs without following any specific patterns. However, the highest values of TD were observed in 30 to 40 cm diametric class but in others the increase of diameter resulted in the TD increase.

Table 2 shows the MCL, LCF and LWP within the different selected temperatures (40, 60 and 80°c) heated logs. The results showed that by increasing of heat temperature, the MCL, LCF and LWP increased. However, among the diametric classes, there were little changes in the LCF and LWP.

The correlation between TD and LCF; LCF and residue core and LWP (Fig. 3 to 5) show when TD increases, the LCF increases too; consequently residue core and LWP increase.

Table 2: The values of MCL, LCF and LWP (measured before and after hygrothermal treatment)

Before treatment				**After treatment**					
MCL(mm)		**LCF**(%)		**MCL**(mm)		**LCF**(%)		**LWP**(%)	
Value	**Cv**(%)	**Value**	**Cv**(%)	**Value**	**Cv**(%)	**Value**	**Cv**(%)	**Value**	**Cv**(%)
100.70	19	65.30	15	148.01	16	87.90	12	81.29	16

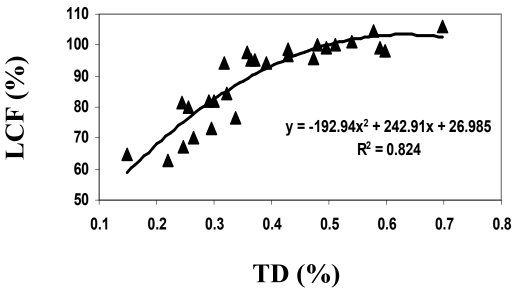

Figure 3: Correlation betweenTD and LCF

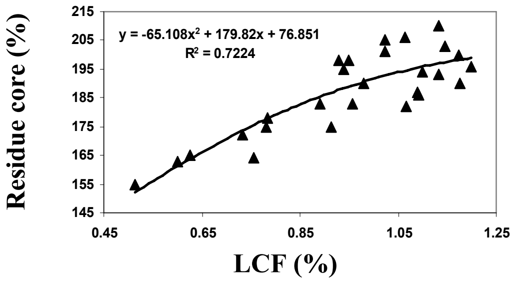

Figure 4: Correlation between LCF and residue core

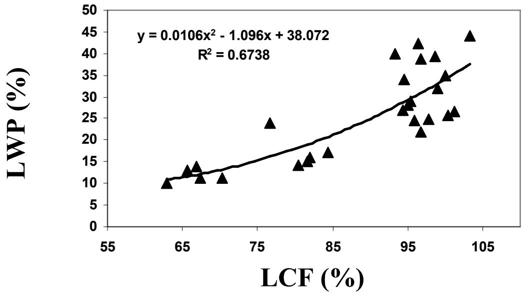

Figure 5: Correlation between LCF and LWP

CONCLUSIONS

The results of this study showed that TD in disk samples, generally, exhibited an increase BY increasing the hygrothermal treatment temperature levels (from 20 to 100^{o}c). This may be due to the release of growth strains that cause expansion tangentially and slightly contraction radially (Khademieslam 2003).
This phenomenon can be the main reason for the formation and extension of log end cracks (Dunich 2005). The results also showed that the primary log end cracks started to extend by the heat treatment and the increase of temperature (40 to 60^{o}c) increased it. Consequently the LCF, residue core and LWP increased.
Generally there is an agreement between cracking and deformation that proves that TD is the decisive cause of heat heart cracks and it determines their course.
According to the results, the highest values of TD were observed in 30 to 40 cm diametric class. These may be due to the greater proportions of juvenile wood, (including more reaction wood than mature wood) in this diametric class (Zobel 1989) which, due to greater residual growth stresses (nogi *et.al.* 2003), has the higher readiness for TD. But in other diametric classes, the results showed that by increasing the diameter, the TD increased. This can be due to the increase of the distribution of residual growth stresses in higher diameter trees (Nogi *et al.* 2003, Zobel 1989).

REFERENCES

Baldwin, R.F. (1995). Plywood and veneer-based products : Manufacturing practices. *Miller Freeman* Books.

Dunisch, O. and Ruhmann, O. (2005). Kinetics of cell formation and growth stress in the secondary xylem of *swietenia mahagoni (L.) jacq*. and *khaya ivorensis a. chev.* (*Meliaceae*). *Wood Science and Technology* (2006) **40**: 49-62.

Fonti, P., Machioni, N. and Thibaut, B. (2001). Ring shake in chestnut *(castsnea sativa mill .)*: State of the art. *Annals of Forest Science*, **59**, 129-140.

Grill, J. and Thibaut, B. (1994). Tree mechanics and wood mechanics: Relating hygrothermal recovery of green wood to the maturation process, *Annals of Forest Science* **51** , 329-338.

Jullien, D. (1993). Evaluer les deformations du bois dans le plan transveres: Validation d 'une method. Architecture, Struture, Mecanique De L arbre. *Sixieme seminaire interne, Montpellier.*

Khademieslam, H. (2003). Evaluation of log end cracks variations in beech wood and their effect on plywood manufacturing process. *Islamic azad university of Iran*, Journal: *Agricultural sciences*, no. 2, 95-107.

Nogi, M., Kanayama, K. and Yamamoto, H. (2003). Reduction of longitudinal and tangential growth stress in logs by heat treatment. *8th International IUFRO drying conference , 2003.*

Zobel, B.J. and Van Buijtenen, J.P. (1989). Wood variation, *Springer-verlag,* 363 p.