

## DRYING TIME AND QUALITY OF EDS-TREATED COMPARED TO UNTREATED BEECH WOOD (*Fagus japonica*)

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### Abstract

The paper presents the results of an experimental study performed with Japanese beech timber heat-treated by the EDS method (Japanese patent) and then dried in order to evaluate the effects of this treatment upon the drying rate and the drying uniformity. The obtained results demonstrate benefitting effects of the EDS treatment both upon the drying time and the drying quality. The drying rate of EDS-treated beech wood is by 29% higher in the case of wood without red heart and by 11% higher in the case of wood with red heart. As far as the drying uniformity is concerned, the minimum moisture content gradient across the 50mm thickness of the timber boards was recorded for the EDS-treated beech wood with red heart ( $\Delta MC=1.66$ ), by 21.7% lower than in the case of untreated beech wood with red heart.

**Key words:** EDS treatment, beech wood, drying rate, drying uniformity, drying stresses.

### INTRODUCTION

EDS company was founded in 1984 as a timber manufacturer. Its main concern is directed towards the protection of the natural environment in all its richness, especially towards the protection of forests. This strategy was put into practice by developing several solutions for the more rational use of wood, the valorization of inferior wooden resources and cellulosic plants which were not targeted for industrial uses until now, as well as a recycling-oriented use of wooden resources.

One of the main contributions of EDS company is an innovative technique (Ishii 1991) of heat-treating wood as a log in order to change, by means of high temperature (70-200°C) and smoke, its chemical composition so as to improve some of its properties.

The technique has proven its efficiency on low-value species from Asia (e.g. *Acacia mangium*, *Albizia falcataria*, palm wood, rubber tree wood, bamboo, coconut timber) (<http://www.eds-lab.jp/english/jyumoku.html>). The present research, in frame of a contract concluded between Transilvania University in Brasov and EDS Laboratory, pursues the effects of the EDS treatment upon Japanese beech wood (*Fagus japonica*), envisaging in case of positive results, a potential valorization of this technique on European beech (*Fagus sylvatica* L.) as well.

### OBJECTIVE

The main objective of the study presented in this paper was to evaluate the drying time and drying quality of Japanese beech wood (*Fagus japonica*), with and without red heart, after being treated by the EDS method (Ishii 1991), comparatively to untreated wood originating from the same tree. The influence of the red heart presence was also pursued.

### MATERIAL, METHOD, EQUIPMENT

The wooden material used within the experiments consisted of 50mm thick timber pieces originating from two logs of Japanese beech: one with red heart (average oven-dry density: 640kg/m<sup>3</sup>), the other one without red heart (average oven-dry density: 626kg/m<sup>3</sup>).

Half of the timber pieces from each log were first heat-treated by the EDS method in the EDS kiln (Fig. 1) at Maebashi-shi (Japan). The maximum temperature inside the kiln during the treating process was

150°C. The temperature inside wood was monitored continuously. It was raised up to 80°C and then maintained at this level for 72 hours, then cooled down to 50°C for further 48 hours.



**Fig. 1.**

**EDS kiln (<http://www.eds-lab.jp/english/puranto.html>)**

Afterwards, all pieces were conditioned for 2 months under constant parameters, at 20°C and 55% RH and then shipped to Romania.

As soon as they arrived at the University in Brasov, the moisture content of the timber pieces was measured by means of a Brookhuis capacitive moisture meter, in six positions, as shown in Fig. 2, to cover as best as possible the timber length, but also to take into consideration the differences that may appear between the centre and the exterior part of the timber board.

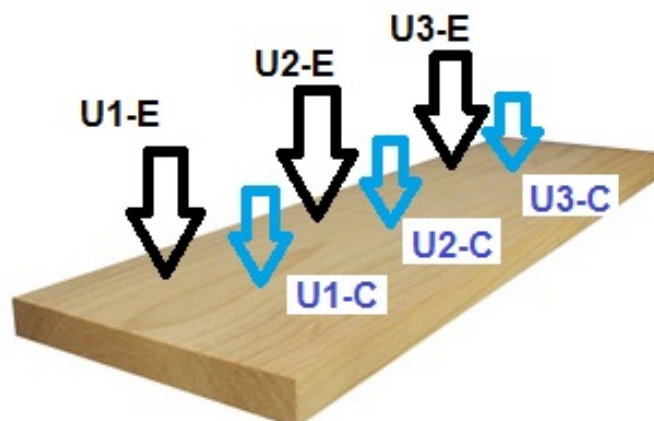


**Fig. 2.**

**Assessing the moisture content of the timber boards, as average of six values, measured over timber length (1-2-3), in central part (C) and exterior part (E) of the board.**

Then the boards were stacked in order to be dried in a conventional kiln with automatic kiln control. Eight boards (two of each assortment) were selected and introduced in rows 4 and 11, so as to have one piece of each assortment in comparable positions within the stack (Fig. 3). The moisture content of wood was monitored in these eight pieces, by means of resistive V2A sensors.

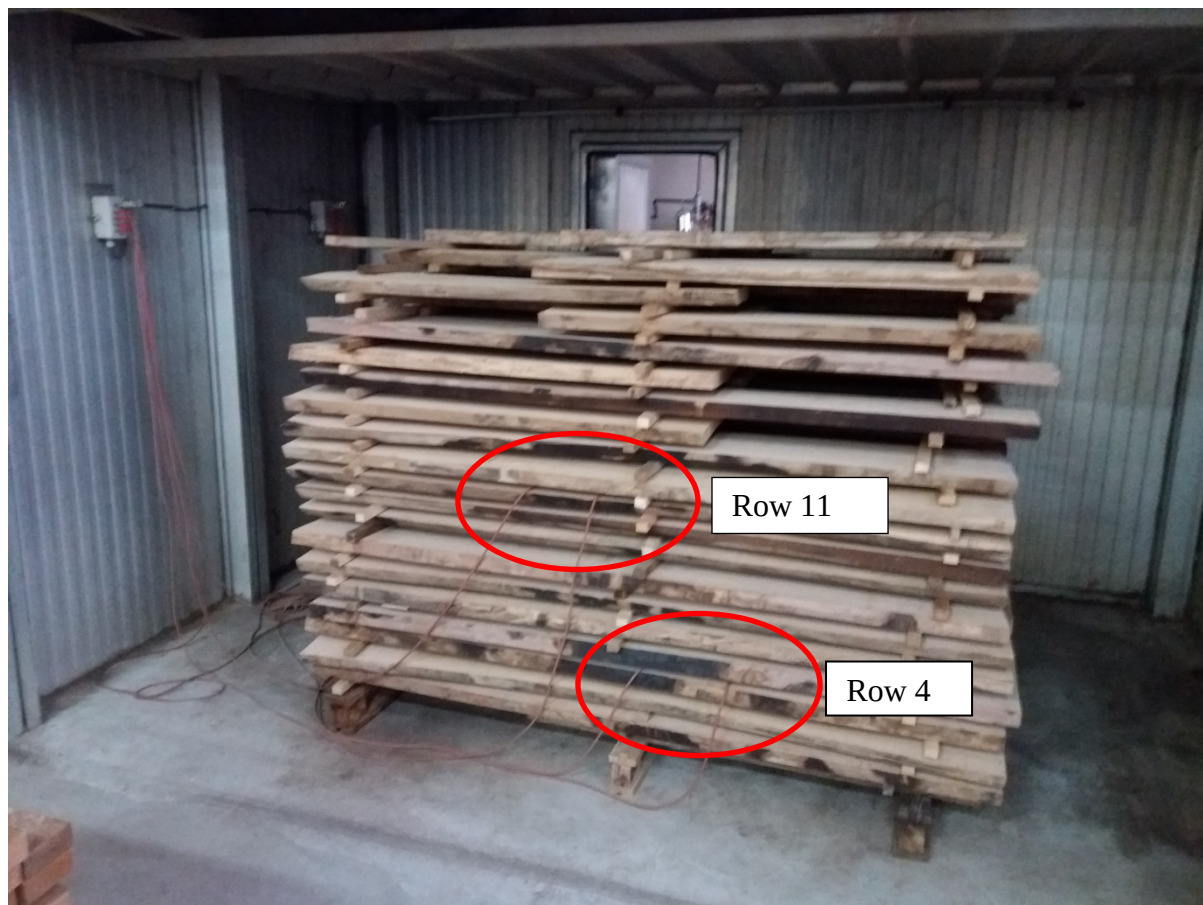


**Fig. 3.**  
**Positioning of wood moisture content monitoring sensors within the stack.**

The applied drying schedule is presented in Table 1.

*Table 1*

**Drying schedule**

| Phase         | Wood moisture content, %                      | Air temperature, °C      | Equilibrium moisture content, % |
|---------------|-----------------------------------------------|--------------------------|---------------------------------|
| Warming-up    | MC <sub>initial</sub>                         | 30°C                     | 14%                             |
| Actual drying | MC <sub>initial</sub> ... MC <sub>final</sub> | gradual raise up to 52°C | Gradual decrease down to 2.7%   |
| Cooling       | MC <sub>final</sub>                           | -                        | -                               |

Based on the difference between the initial moisture content (before drying) and the final moisture content (after drying), the drying rate (*w*) was calculated for each monitored board:

$$w = \frac{MC_i - MC_f}{D} \quad [\% / h] \quad (1)$$

where:

MC<sub>i</sub> – moisture content of the board at the beginning of actual drying, in %;

MC<sub>f</sub> – moisture content of the board at the end of actual drying, in %;

D – duration of actual drying.

Hereinafter, the timber pieces were subjected to the final quality control. Establishing the moisture gradient over the timber thickness (by means of layer-samples) and also the level of inner stresses (by means of fork-samples)(Fig. 4) were the main envisaged tasks.

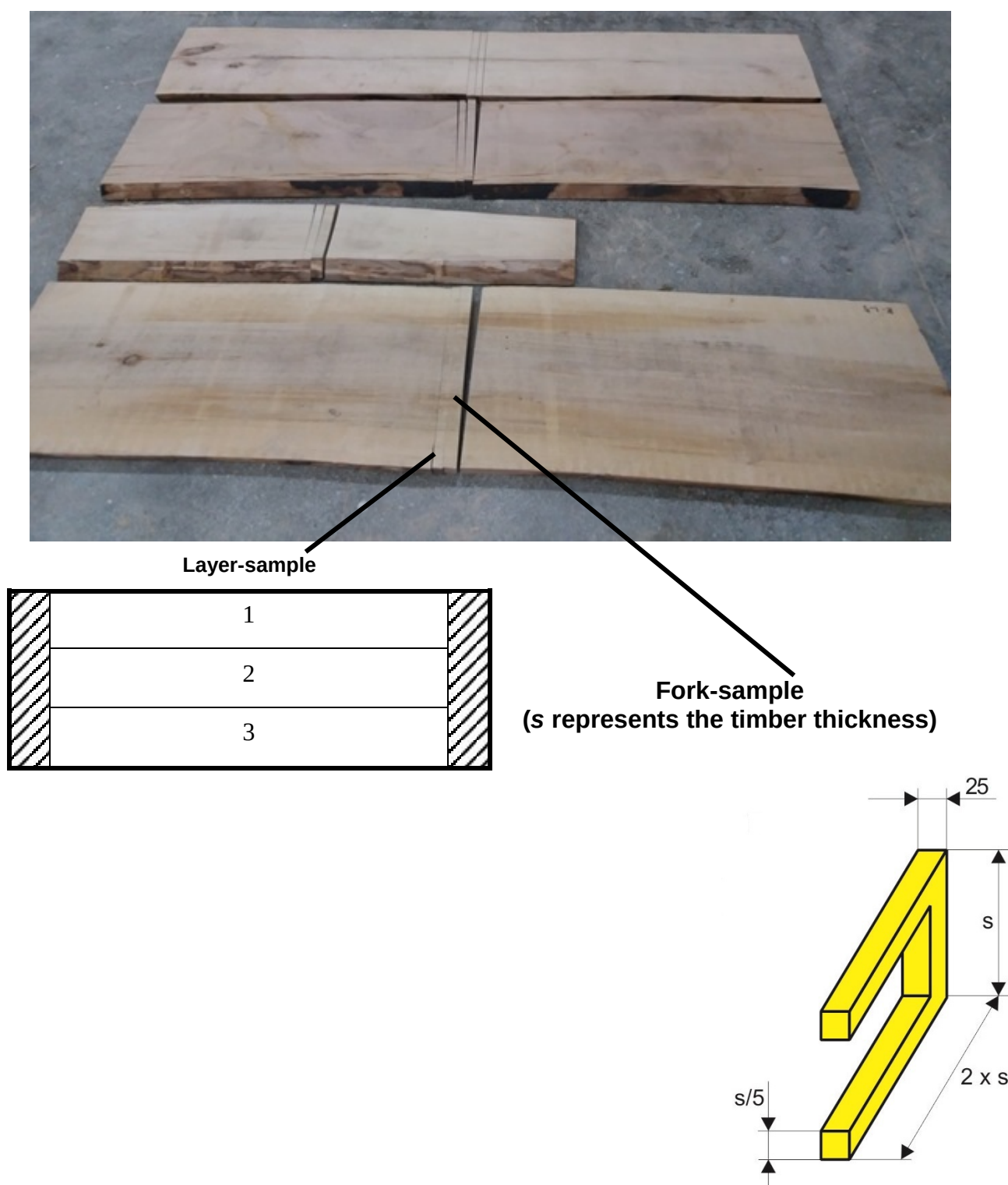


**Fig. 4.**  
*Layer-sample and fork-sample used within the quality control after the drying process for the determination of the moisture content uniformity over the timber thickness and of the internal stresses due to drying.*

The layers (1-2-3) were weighed first right after drying ( $m$ ), then again after oven-drying at 103°C ( $m_0$ ). An electronic scale by KERN with a precision of 0.001g and an electric oven by BINDER were used to this purpose. The moisture content of each layer was calculated according to the relation:

$$MC = \frac{m - m_0}{m_0} \cdot 100 \text{ [%]} \quad (2)$$

Then the moisture content gradient ( $\Delta MC$ ) across the timber thickness was calculated as difference between the highest and the lowest value obtained from each sample:

$$\Delta MC = MC_{max} - MC_{min} \text{ [%]} \quad (3)$$

$\Delta MC$  represents a valuable indicator of drying quality: values higher than 5%, indicate a high level of internal stresses, and thus, high risk of checking.

In order to determine the level of internal stresses, the fork samples cut according to the dimensions indicated in Fig. 4 were placed on an evaluation jig (Trübswetter 2006)(Fig. 5).

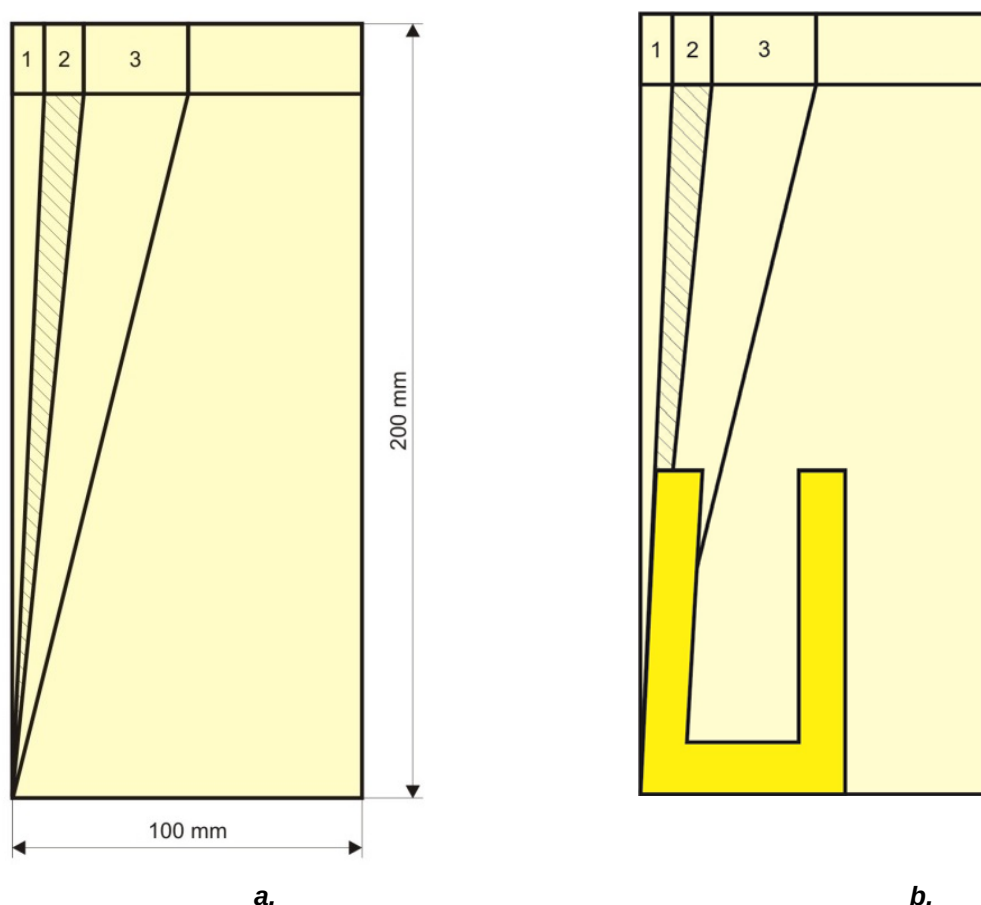


**Fig. 5.**

**Determination by means of fork-samples of the internal stresses caused by drying:**  
**a – evaluation jig; b – correct positioning of the fork-sample on the jig.**

The average curving degree of the two teeth, placed at turn in the corner of the jig determine the gravity of the stress degree: 0...1-very low stress; 1...2-normal stress; 2...3-high stress; >3-very high stress.

## RESULTS AND DISCUSSION

The results concerning the drying rate of EDS-treated and untreated Japanese beech with and without red heart are presented in Table 2.

Table 2

*Drying rate values for Japanese beech timber*

| Wood type /<br>MC sensor (row)      | Initial MC,<br>% | Final MC,<br>% | Drying rate<br>per sample,<br>%/h | Average<br>drying rate<br>per wood<br>type, %/h |
|-------------------------------------|------------------|----------------|-----------------------------------|-------------------------------------------------|
| Untreated wood, without red heart   |                  |                |                                   |                                                 |
| S2 (row 4)                          | 9.4              | 7.5            | 0.026                             | 0.038                                           |
| S6 (row 11)                         | 11.8             | 8.2            | 0.050                             |                                                 |
| EDS-treated wood, without red heart |                  |                |                                   |                                                 |
| S4 (row 4)                          | 10.5             | 8.2            | 0.032                             | 0.049                                           |
| S5 (row 11)                         | 12.6             | 7.8            | 0.067                             |                                                 |
| Untreated wood, with red heart      |                  |                |                                   |                                                 |
| S3 (row 4)                          | 9.3              | 7.3            | 0.028                             | 0.036                                           |
| S7(row 11)                          | 10.7             | 7.5            | 0.044                             |                                                 |
| EDS-treated wood, with red heart    |                  |                |                                   |                                                 |
| S1 (row 4)                          | 10.0             | 7.6            | 0.033                             | 0.040                                           |
| S8 (row 11)                         | 10.8             | 7.5            | 0.046                             |                                                 |

It can be noticed that, in all cases, the drying rate recorded for the samples in row 11 was higher (almost twice) than of those of the same wood type, but situated in row 4. The average values per wood type clearly show that EDS-treated wood dries faster than untreated wood. The drying rate is by 29% higher in the case of wood without red heart and by 11% higher in the case of wood with red heart.

Table 3 presents the results concerning the moisture gradient over the timber thickness.

Table 3

*Moisture gradient across the timber thickness, after drying*

| Wood type                              | Mass of each<br>layer right after<br>cutting, before<br>oven-drying, g | Oven-dry<br>mass of each<br>layer, g | Moisture content of<br>each layer after the<br>drying process, % | Moisture content<br>gradient across<br>timber thickness<br>( $\Delta U$ ), % |
|----------------------------------------|------------------------------------------------------------------------|--------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------------------|
| Untreated wood,<br>without red heart   | 43.72                                                                  | 39.91                                | 9.55                                                             | 2.07                                                                         |
|                                        | 41.55                                                                  | 37.47                                | 10.89                                                            |                                                                              |
|                                        | 38.50                                                                  | 35.38                                | 8.82                                                             |                                                                              |
| EDS-treated wood,<br>without red heart | 31.41                                                                  | 28.93                                | 8.57                                                             | 1.78                                                                         |
|                                        | 28.78                                                                  | 26.18                                | 9.93                                                             |                                                                              |
|                                        | 26.26                                                                  | 24.28                                | 8.15                                                             |                                                                              |
| Untreated wood,<br>with red heart      | 56.78                                                                  | 51.67                                | 9.89                                                             | 2.12                                                                         |
|                                        | 63.19                                                                  | 56.64                                | 11.56                                                            |                                                                              |
|                                        | 49.94                                                                  | 45.63                                | 9.45                                                             |                                                                              |
| EDS-treated wood,<br>with red heart    | 52.90                                                                  | 48.48                                | 9.12                                                             | 1.66                                                                         |
|                                        | 53.73                                                                  | 48.55                                | 10.67                                                            |                                                                              |
|                                        | 45.84                                                                  | 42.05                                | 9.01                                                             |                                                                              |

The results presented in Table 3 confirm the fact that EDS-treated wood dried more uniform than untreated wood: the moisture gradient across timber thickness is by 14% lower in the case of EDS-treated beech wood without red heart and by 21.7% in the case of EDS-treated beech wood with red heart. Considering that beech wood with red heart is known as more unhomogenous, as also demonstrated in this study by the highest value obtained among the four wood types (Table 3), the benefit of the EDS treatment becomes more significant: EDS treatment succeeds in „calming down” red heart beech wood and to ensure

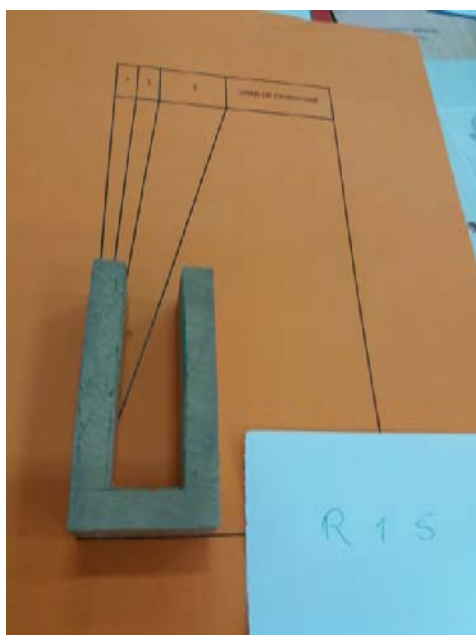
a uniform drying of this difficult wood type. This finding is also supported by the results obtained by means of the fork-samples (Fig. 6).



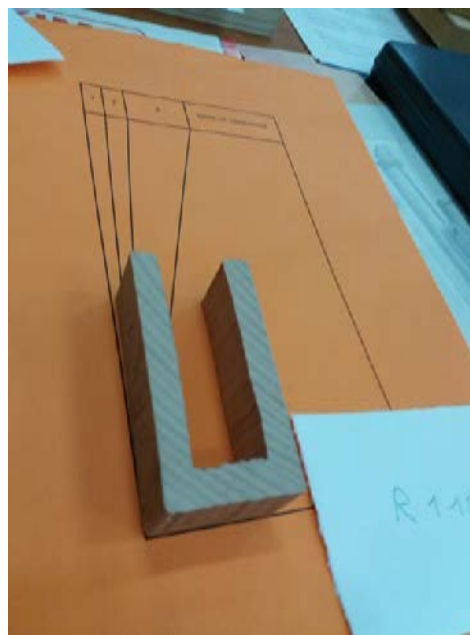
**Untreated wood without red heart: 1.1 / 1.0**  
(average = 1.05)



**EDS-treated wood without red heart: 0.8 / 0.5**  
(average = 0.65)



**Untreated wood with red heart: 0.1 / 1.1**  
(average = 0.6)



**EDS-treated wood with red heart: 0.4 / 0.5**  
(average = 0.45)

**Fig. 6.**  
**Experimental results regarding the internal stresses caused by the drying process,**  
**obtained with fork-samples.**

## CONCLUSIONS

According to the obtained results, the EDS treatment has benefitting effects both upon the drying time and the drying quality of Japanese beech wood. The effects are more visible in case of wood with red heart, which is normally more unhomogenous and more difficult to dry than beech wood without red heart. Under the effect of EDS treatment it dries faster than untreated wood without red heart and more uniform than all other considered wood types.

#### **ACKNOWLEDGEMENT**

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