DEVELOPMENT OF A PORTABLE HARDNESS TESTER FOR WOOD USING DISPLACEMENT TRANSDUCER

Adriano Ballarin¹, Albert Assis², Hernando Lara Palma³

ABSTRACT: Hardness is largely used in material specifications. Specifically for timber, Janka hardness is traditionally performed. More recently, international studies have reported the use of Brinell hardness for timber quality assessment in field conditions, especially due to the lower magnitude of the involved force. Two generation of portable equipment with these purposes were already developed by the Research Group on Forest Products from FCA/UNESP, Brazil for dynamic evaluation of hardness. This paper presents results obtained in the development of the third generation of this equipment, which uses displacement transducer in order to automate the indentation evaluation in wood. Functional tests of the equipment were carried out using seven species of Eucalyptus. Results already obtained revealed strong correlation to Janka hardness and confirmed the potential of the equipment in the classification of wood.

KEYWORDS: Janka Hardness, Brinell Hardness, portable equipment, displacement transducer

1 INTRODUCTION

Hardness is largely used in material specifications. Among the major strength properties of wood, hardness reveals its potentialities (good correlation to other mechanical properties and quickness of results) and can be used as a non-destructive tool in the characterization of species from reforestation [1,2].

For evaluation of hardness in wood, considering its viscoelastic properties, especially its resilience, and its low elastic modulus to yield stress ratio (E/Y) perpendicular to the grain, one can easily note greater appropriation of Janka hardness when compared to Brinell hardness. Despite the major appropriation of Janka hardness to wood measurements several researchers have suggested Brinell method for the evaluation of hardness in wood [3,4] in field condition, considering the lower magnitude of the forces involved in the indentation and the additional difficulty to control, the depth of the metal sphere indentation required on Janka hardness method.

Two generation of portable equipment with these purposes were developed by the Research Group on Forest Products - FCA/UNESP, Brazil for dynamic evaluation of hardness in wood - Portable Hardness Tester for wood - DPM.

This paper presents results obtained in the development of the third generation of this equipment – DPM 3 - which uses displacement transducer in order to automate the indentation evaluation in wood.

2 MATERIAL AND METHODS

The Portable Hardness Tester - DPM-3 (Figure 1) - patents pending - is an electro-mechanical equipment whose operating principle is similar to Brinell hardness test, i.e., a cap with spherical format and known diameter is indented into wood using a known energy. In this case, energy mobilized to promote indentation is obtained by the free fall of a mass and the hardness value is determined by the relationship between the energy used and the area of the spherical surface that will be printed on the material evaluated (indentation) according to the expression:

\[ H = \frac{E}{\pi.D.h} \]  

where H is hardness strength (kJ.m⁻³), E is the energy resulted from the fall of the mass (kJ), D is the diameter of the metal sphere (m) and h is the deep of the indentation (m).

The measurement of the indentation is made by a displacement transducer connected to an electronic circuit responsible for signal processing, calculation and immediate display of hardness. Seven species of eucalyptus were used to perform the experimental tests. Sixteen specimens (5cm x 5cm x 15cm) for each species were obtained, totalizing 112 specimens.

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The Janka hardness tests were performed in the direction perpendicular to the grain of wood on a universal testing machine EMIC, model DL 30000, following Brazilian Standards. Hardness \( H \) was estimated alternatively by the Portable Hardness Tester – DPM3 using Equation 1.

### 3 RESULTS AND DISCUSSION

Using the displacement transducer, the Portable Hardness Tester DPM-3 promoted fast and easy readings, revealing consistent values of indentation. Immediately after the indentation, the value of hardness \( H \) (Equation 1) provided by the software was displayed.

The indentation was determined under load (and not on unloading), avoiding the influence of the recovery. Furthermore, by measuring the indentation instead of the indented area, the DPM3 avoided “sinking in” phenomenon effects. Both, recovery and “sinking in” effects were reported by Doyle and Walker [5] as limitations of the conventional Brinell hardness tests for wood.

Table 1 presents descriptive statistics of the measurements of Janka and Portable Hardness Tester – DPM3 hardness. It is observed lower coefficient of variation (CV) of the results obtained from the Portable Hardness Tester (17.83).

<table>
<thead>
<tr>
<th>Descrip. Stat.</th>
<th>Hardness Janka (MPa)</th>
<th>( H ) – DPM 3 (kJ.m(^{-2}))</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>68.53</td>
<td>41.69</td>
<td></td>
</tr>
<tr>
<td>Sd</td>
<td>24.34</td>
<td>7.43</td>
<td></td>
</tr>
<tr>
<td>CV</td>
<td>35.53</td>
<td>17.83</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>112</td>
<td>112</td>
<td></td>
</tr>
</tbody>
</table>

The determination coefficient \( (R^2) \) in Figure 2 expressed moderate to strong association between hardness \( H \) (DPM3) and conventional hardness Janka.

Figure 2 shows a greater dispersion of the results for higher levels of hardness, that may be attributed to the rational function \( f(x) = k.x^{-1} \) that governs Brinell hardness and particularly the hardness \( H \) (Equation 1). In fact, for higher levels of hardness (lower indentations levels, in other words) minor variations in the indentation promote large variations in the hardness value.

### 4 CONCLUSIONS

The following main conclusions can be pointed:

- The Portable Hardness Tester – DPM3 promoted fast, easy and reliable readings of the indentation, as well as evaluation of hardness \( H \);
- Classical problems of Brinell hardness of the “sinking in” phenomenon and the recovery of indented area were solved by the equipment using under loading measurement of the indentation (and not of the indented area);
- Hardness \( H \) measured from the equipment revealed moderate to strong association to conventional Janka Hardness \( (R^2=0.86) \).

### REFERENCES


