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EFFECTS OF THERMAL TREATMENTS OF WOOD IN THE GRINDING PROCESS OF *CORYMBIA CITRIODORA*

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Abstract. *The effect of heat treatment in the sanding process of wood was observed when comparing timber only sanded with other sanded and heat treated by analyzing the roughness and acoustic emissions of the parts. 36 species of Corymbia citriodora was used in the thermal treatments, and the temperatures were 120, 160 and 200 ° C. The grinding process was used with sanding horizontal plane cut parallel to the fibers, with aluminum oxide as abrasive material and two different particle sizes (P80 and P120). 12 samples only sanded were used as witnesses (12% of moisture content) at environment temperature (± 25 ° C). For each condition were performed 6 repetitions totaling 48 sampling units. During the abrasive process were also analyzed the relationship between roughness (Ra) with the acoustic emission produced. With heat treatments there was a significant decrease in roughness, and there was not relationship between roughness (Ra) parameter with the acoustic emission produced.*

Keywords: *Surface quality, humidity, sandpaper.*

1. INTRODUCTION

The heating of the wood is an ancient process, easy to perform and inexpensive that is pointed to by many researchers as beneficial to various properties of this material. The various studies that treat termorretificação have sought to understand the influence of this treatment on various wood properties such as shear strength, parallel compression and bending, tensile normal and perpendicular, Janka hardness, adhesion, wettability, hygroscopicity, aging, varnishing, colorimetry, rot, dimensional stability, weight loss, basic density, shrinkage and appearance.

However, little is known about the effects of these treatments on the processes of machining and finishing. Some rare studies indicate that the surface quality of machined parts changes when the material to be machined is heat treated.

The objectives of this study were to analyze the effects of thermal treatments of wood *Corymbia citriodora* in the process of sanding parallel to the fibers through the values of roughness and acoustic emission produced during the machining process.

2. THEORETICAL RATIONALE

Wood can be heat treated in various ways, such as in the presence of moisture or moisture followed by compression. The effects of the heating process will depend on what kind of treatment was given to the material. All thermally treated wood can be glued or painted and may also be used in furniture, flooring, doors, windows and other components (IBACH, 2001).

The heat supplied in the treatment causes chemical changes in the wood that are not much studied. Some of these reactions produce hydroxyl groups, which later will react with acids formed during degradation of hemicellulose through heat treatment. These-OH groups reacted with the acids formed will give rise to ester groups. As a result of these reactions is the reduction of water uptake of wood (BULIAN; GRAYSTONE 2009).

The thermal treatments change many properties in the wood. This process reduces the hygroscopicity and increase the dimensional stability and resistance to mold the material. However, these processes also increase the fragility of the wood, thus reducing some of its mechanical properties (ESTEVES; PEREIRA, 2009).

However, it is not so known about the effects of these treatments on the processes of machining and finishing of wood. Thus it becomes important to study this variable in the process of sanding of the wood.

The grinding (machining of grit) is one of the most expensive processes in the timber industry. This process is difficult to be characterized and analyzed because of the random nature and distribution of the grains in the sandpaper.

In the case of sanding heterogeneous materials such as wood, increases the complexity of the process and many variations are to be considered (SALONI *et al*. 2010).

Saloni (2007) developed a system to monitor and control the life of the abrasive using various types of sensors. The objective was to design, develop and evaluate a system for control and monitoring of the process of machining by abrasive for wood and wood products.

Relating the sanding process with subsequent coating parts of *Eucalyptus grandis*, Silva *et al*. (2010) conducted a study which shows that the coating quality is related to the surface and the product used. They emphasize that the quality surfaces must have low roughness, few defects and no impurities, which can be obtained by grinding. In their work they used sandpaper grain size 100-150-220, and posterior nitrocellulose lacquer coating which showed good performance in relation to the grip.

Santiago (2011) made a study in order to understand the interaction of input variables such as particle size sanding, cutting speed and pressure on some variables in the output plane grinding: material removal rate, temperature, roughness, power consumed, cutting force, acoustic emission and surface integrity, using the wood *Pinus elliottii*, processed in parallel to the fibers. And the rate of material removal was observed that the particle size, pressure and shear rate, significantly affected. For surface finish, just sanding grain size significantly influenced roughness.

3. EXPERIMENTAL SECTION

3.1. Preparation of samples

The wood species were *Corymbia citriodora* in the form of plates, and were then transformed into sampling units with dimensions of 54 mm length, 30 mm width and 23 mm in thickness as shown in Figure 1. The specimens were manufactured at the Laboratory of Wood Processing of the Experimental Campus of UNESP Itapeva. The preparation conditions of the samples were identical so as not to influence the sanding process.

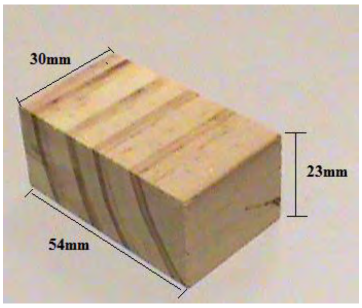

Figure 1 - Dimensions of the specimens.

3.2. Conducting the tests

Initially 36 samples of wood species *Corymbia citriodora* were placed in an oven Climatizer to stabilize its moisture content to 12%, and then taken to the greenhouse for them suffering heat treatment process. Were heated 12 specimens separately to each temperature (120, 160 and 180 ° C) for a period of 2 hours. With the heat treated samples, assays were performed sanding the pieces, which were ground parallel to the fibers plane Sander Model Mark Baldan LFH-2 using automatic feed rate (Figure 2b), two abrasive particle size (P80 and P100) and checked the influence of the temperature of the wood in the same finishing process. 12 samples only sanded were used as witnesses (to 12% of moisture content) at environment temperature (± 25 º C). After sanding, the surfaces of the sample pieces were evaluated by measuring 6 times the variable roughness Ra in the direction perpendicular to the fibers with a Taylor Hobson profilometer mark 25 + (Figure 2a). The adopted sampling length was 2.5 mm (cut-off), according to the value suggested by NBR 6405 (ABNT, 1988). The length measurement (lm) is 2.5 mm cut-off was 12.5 mm, resulting in an average of five values obtained by measurement. The range in the adopted rugosimeter was 300 mm and the adopted filter was a Gaussian one.

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Figure 2 (a) Surface Roughness Tester used to determine the roughness of the sanded surfaces
(b) flat Sander Brand Baldan Model LFH-2 with automatic advance.

For the acquisition of acoustic emission was used a module composed for an acoustic emission sensor (piezoelectric) and a signal amplifier with electrical output rectified RMS (root mean square), brand PHYSICAL ACOUSTICS CORPORATION Model R15A sensor, amp model signal 1272-1000 (Figure 3).

Figure 3 - Module Acoustic emission (1) sensor (2) and amplifier (3).

This corresponds to the rectified electrical signal VDC unit and is widely used to express the greatness that acoustic emission, with no changes to other units.

The data acquisition was performed using LabView™ software, version 7.1, and the data processing obtained in the tests was performed with Matlab™ software, version 6.5.

For the treatment of the data, was used the statistical program R, version 2.11.1, which were made in the analysis of variance (ANOVA) and multiple comparison test of Tukey, with a significance level of 5% ($\alpha = 0.05$).

4. RESULTS AND DISCUSSIONS

Figure 4 shows the average roughness as a function of temperature for each abrasive particle size, heat treated samples compared to samples containing only sanded at room temperature (25 ° C), in the sanding *Corymbia citriodora.*

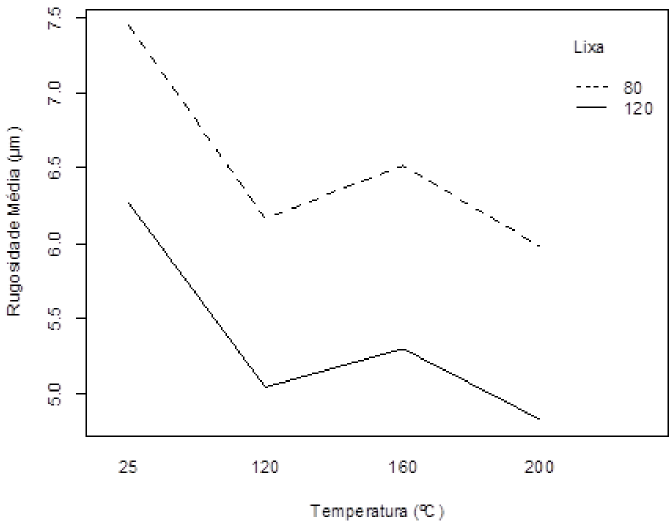

Figure 4 - Graph of the roughness average (Ra) as a function of temperature for each abrasive particle in the samples heat treated and control samples (25 ° C), in the sanding of *Corymbia citriodora.*

There was significant differences between the sandpaper ($F_{1, 43} = 67.12$, P-value <5%) and among temperatures ($F_{3, 43} = 20.33$, P-value <5%) (Table 1).

Made by Tukey test can be observed that the temperature 25 ° C was the one that had significant difference between the temperatures.

TABLE 1 - Means of average roughness (um) for the eight conditions of sanding.

	T=25 ºC	T =120 ºC	T=160ºC	T = 200 ºC	Average of Sandpaper
Sandpaper P80	7,5	6,2	6,5	6,0	6,6 a
Sandpaper P120	6,3	5,1	5,3	4,8	5,4 b
Average of Temperature	6,9 A*	5,6 B	5,9 B	5,4 B	

* Means followed by the same letters (lowercase and uppercase letters in rows in columns) show no statistical difference (Tukey, $\alpha = 0.05$).

When analyzing the results of roughness was observed that heat treatments were beneficial to the surfaces of the pieces, as they had average roughness smaller than woods that were sanded without first going through the process of thermal treatment. However, there was no significant difference between the temperatures of heat treatments, which proved not to be necessary to spend so much energy in the process, as the effect of the highest temperature was the same as the lowest one.

There was significant difference between the sandpapers, in which the grain P120 afforded the lowest roughness to the parts giving them better finishes, such as results obtained by Moura and Brito (2008) that studied the effects of thermal treatments in the species *Pinus caribaea. hondurensis* and *Eucalyptus grandis* in the presence and absence of oxygen.

The graph in Figure 5 shows the linear regression line fitted on the results of the relation between the average roughness to the acoustic emission, in the sanding of *Corymbia citriodora*.

The model had a coefficient of determination adjusted $R^2 = 0.02$, which implies that the model can not be used to represent the data. And the analysis of variance of the regression ($F_{1, 65} = 1.32$, P-value> 5%) at a significance level of 5%, showed no relationship between the average roughness with acoustic emission.

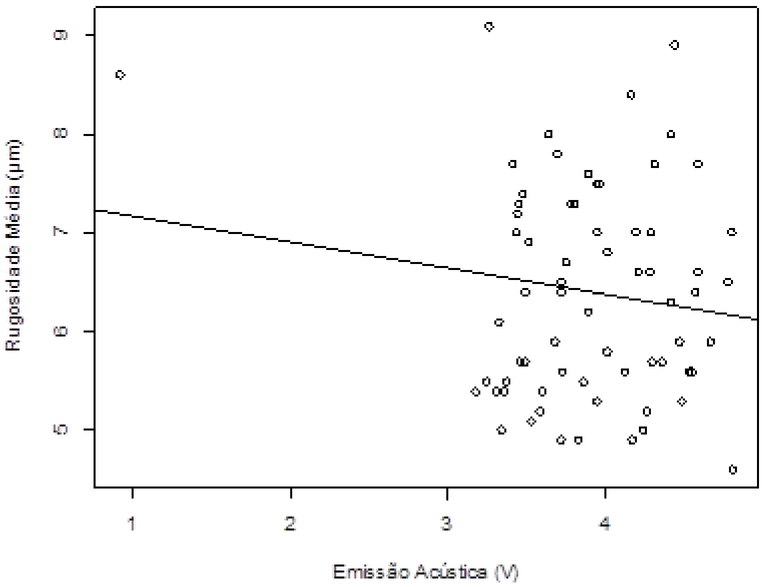

Figure 5 - Graph of linear regression for the average roughness (Ra) as a function of acoustic emission in the sanding of *Corymbia citriodora.*

Relating the acoustic emission with the roughness average (Ra) was found no linear relationship, as the statistical tests denied dependence of these variables, in addition to extremely low coefficient of determination adjusted for this species ($R^2 = 0.02$).

Similar results were found by Souto *et al*. (2004), which studied the relationship of the roughness parameters Ra and Rk with the emitted acoustic emission part turning cylindrical steel. At the work they observed that the Ra parameter has no direct correlation with acoustic emission, however the parameter Rk correlated with the levels of acoustic emissions produced during the machining of parts.

5. ACKNOWLEDGEMENTS

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