INFLUENCE OF SANDING SPEED AND GRIT SIZES IN THE CYLINDRICAL SANDING PROCESS

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Abstract. *The sanding process is very much in demand in various stages of industrialization of the wood, where there is a need for a better quality surface finish. With the process of sanding the machined surface with fewer imperfections resulting in a better quality product or facilitating the application of paints and varnishes. The objective was to analyze the influence of cutting speed and grit size in surface finish of parts of Eucalyptus grandis processed through cylindrical sanding. We used four cutting speeds (19.5, 22.7, 26 and 28.1 m / s), feedrate of 16 m / min and three combination of grit size (80-100, 80-120 and 100-120) being one for thinning and another for finishing, respectively. A central data acquisition system was made to capture the variables (cutting power, acoustic emission and vibration) in real time. The greatest power sanding was found with the cutting speed of 28.1 m / s. With the cutting speed of 28.1 m / s was obtained at higher acoustic emission compared with the other three speeds analyzed. The cutting speed of 19.5 m / s produced the highest vibration. 100-120 sandpapers resulted in lower roughness.*

Keywords*: Sanding, Cylindrical Sanding, Eucalyptus grandis wood, sanding speed, grit size.*

1. INTRODUCTION

Timber originating from planted forests (reforestation), such as eucalyptus and pine, have been replacing wood that comes from natural forests in various segments of the timber industry, as in the furniture industry, manufacturing of wood panels, timber frame industries and construction Precisely by the rapid growth of these species and the growing industrial demand for forest resources. The use of wood-based products has grown tremendously in recent years in search of a more rational use of raw materials. Unlike other materials, wood properties vary among different species in a given species and in the same log. Moreover, the properties are strongly influenced by chemical, physical and anatomical wood. Since it shows the need for research involving these many variables, to enable a better understanding of the material contributing to greater efficiency of industrial processes that use wood as the main raw material.

Currently, the eucalyptus is planted in almost all the world, being a genre that species possess readily adaptable to various climatic conditions. Most species planted in Brazil is growing rapidly, a result of high quality genetic material. The production of wood and its derivatives are largely due to the large demand for wood in the forest Brazilian market (Malinovsky, 2002).

According to Gonçalves (2000), in wood, sanding becomes necessary when the cut is made perpendicular to the fibers, because these are broken harming the finish.

Little is known about the sanding of wood and because of this it’s used still many practical concepts without even having sought to study the best conditions for the process. This paper seeks to contribute to a better understanding of both the existing variables and how these variables influence the machining of wood, more precisely, sanding tubular Eucalyptus grandis.

Gonçalves (2000) also states that there are several factors that interfere with the forces and power of the different machining operations, cutting the wood affect the performance of cutting tools, such as moisture, density and direction of the fibers (corresponding timber) and slice thickness, cutting speed and tool geometry (referring to the process).

The sanding process can be divided into two stages of work. The first step is the processes that are performed to prepare the wood more or less reducing the surface roughness of the work piece. In the second stage has the process of sanding to prepare the wood for subsequent application of finishing materials. These two steps are known as roughing and finishing (KOCH, 1964).

According to Saloni (2007), sanding process is difficult to characterize. The randomness in the distribution of the mineral on the abrasive belt and the shape of the mineral, large amount of variables to considered that effect the process and the wide variety of minerals, backing and coats combinations make the process difficult to model and predict mathematically where additionally variety increase when the material to be processed is wood.

For Bianchi (1999) cutting forces in abrasive processes are important because they influence the quality of geometric, dimensional and surface finish, tool life and finally the execution time of the cutting process. The average values of cutting forces to be employed during machining are also important because they determine the power required for the sanding machine, as well as its structural needs.

According Gurau et al. (2005), wood surfaces have various irregularities caused by the machining process and wood anatomy. There is great difficulty to exclude anatomical roughness, due to the complexity and heterogeneity of the wood surface. Hendarto et al. (2006) claim that this complexity and heterogeneity affect your wood surface roughness profile, making the analysis of the surface quality of wood is very complicated. The standard filtration methods used do not present reliable results when analyzing the surface profile of wood. However, these methods based solely on the general comparison, average, or "rough" of the roughness profiles of wood are accepted and widely used, but characteristic and specific information on the wood surface are not yet quantified.

Works by Carrano (1997), Taylor et al. (1999), Ratnasingam et al. (2002), Saloni (2007), Fotin et al. (2008), Porankiewicz et. al (2010) try to understand the relationship between input on the output parameters in the sanding process and these authors established the standards for the wood industry around the world. The aim of this study was to examine the influence of cutting speed and grit size in finishing and sanding efforts of Eucalyptus grandis wood processed through tubular sanding.

2. METHODOLOGY

The specimens are made of *Eucalyptus grandis*, with a mean size of 35 and 1220 mm in diameter and length, respectively, and the parts were used of large trees, with a minimum diameter of 50 cm and advanced age (over 35 years) and mostly belonged to the core of this, which justifies the high density obtained (0.69 ± 0.09 g/cm3 at 12.49 ± 0.35% moisture).

The workpieces were classified diametrically (ranging from 34.4 to 35.5 mm) and standardized the length of the 600 mm.

Then it was sanded one end of the specimens in a flat sander, removing the song "live" at one end, so when subjected to sanding, it does not rupture the sandpaper. The next step was to submit the specimens in tubular sander with two sanding weight of 80 (roughing), for uniform surface characteristics before the merits of the tests. After performing all these steps described above, the specimens were with uniform dimensions and surface characteristics, ie available for the testing of sanding, as shown in Figure 1.

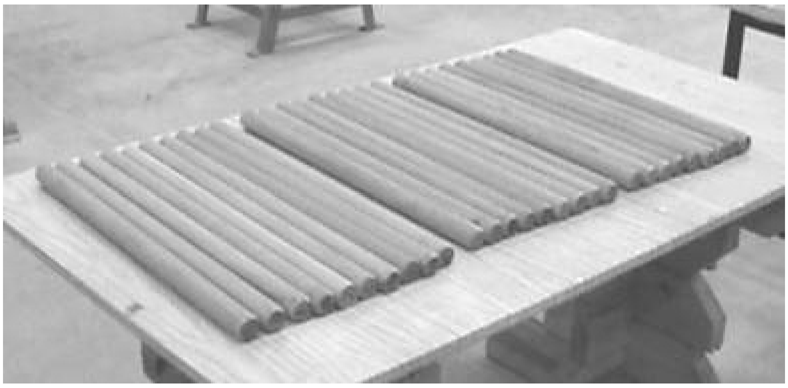

Figure 1- Workpieces.

The test bench was composed of a double belt sander vertical tubular (Eagle model LPD 3200), a steel cabinet to accommodate the components, the central data acquisition and control panel equipment, as shown in Figure 2.

Figure 2 - Test bench used

In the sanding operation were used sandpaper of the aluminum oxide abrasive with grit sizes 80, 100 and 120 mesh. These abrasives were positioned in the form of flat belt on wheels (upper and lower) and mechanically tensioned thread spindles square (stretchers). A third wheel (intermediate) was used for pressing the sandpaper on a cylindrical piece of wood, as shown in Figure 3. Pressing the idler pulley should be enough to get the sandpaper to act concurrently with the advancement of the workpiece, thus preventing burn marks on the wood. Figures 4a and 4b show in detail the system by pulling rubber mat (feed rate), the specimen positioned wheels of the first fixation of sandpaper (rough) and idler wheel.

The variation of cutting speed was achieved via a frequency inverter WEG brand, model 2008 CFW-25A, connected to the drive motor of sander, which was measured using an optical tachometer Dynapar brand, model HT 100. To acquire the data of cutting power, acoustic emission and vibration, we used a data acquisition system with data acquisition board mark National Instruments PCI-6220 model.

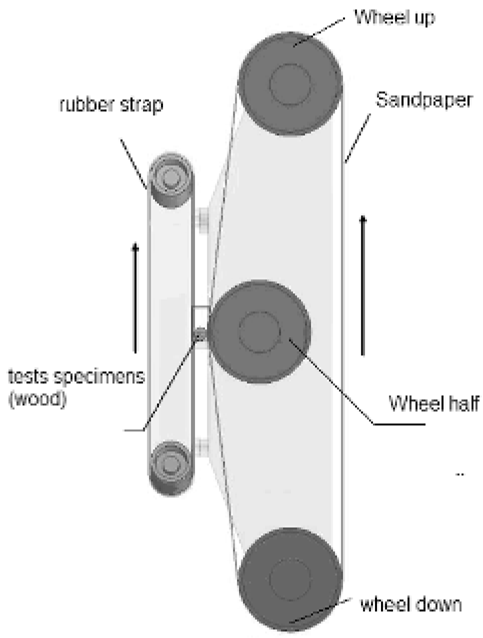

Figure 3 – Cylindrical sanding process.

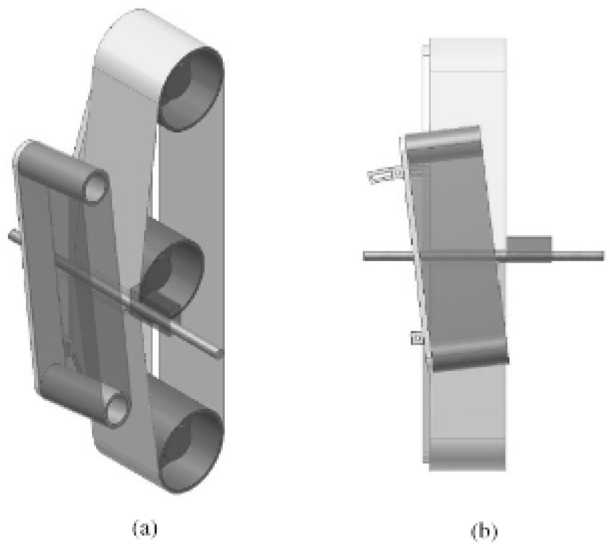

Figure 4 - (a) Cylindrical sanding process with perspective view, (b) side view (Tiburcio,2009)

The cutting power was obtained through of the current consumed using sensor Ward model TRX-I / U, whose signal was captured by the data acquisition board and saved during the tests.

Vibration analysis was obtained through the vibration sensor (Vibro Control TV-100). The vibration sensor was connected to the data acquisition board so that all data collected during testing were stored for later analysis.

The acoustic emission was obtained by an acoustic emission sensor and an acoustic emission module of the Physical Acoustics model 1272. The module presents acoustic emission analog output (RMS).

Data acquisition was performed using LabView ® software version 7.1 and process data from experiments were performed with programs of the Matlab ® version 6.5. With the test bench mounted, first, some preliminary tests were conducted for calibration of equipment, establishment of conditions for sanding and to learn about how the test bench.

The experimental design was completely randomized in a 4 x 3 x 3 (cutting speeds x grit sizes sets x repetitions). For the variables captured in real time were acquired 200 points per second, where they were stored in data files generated by LabView ® software and processed by handlers through the programs of the Matlab ®.

Cutting speeds used were 19.5, 22.7, 26 and 28.1 m/s, respectively. The feed rate used was 16 m / min and measured by an optical tachometer.

As the particle sizes of sanding, we used three combinations (80:100, 80:120 and 100:120), where, for each of these combinations, had a rough sandpaper (grain size smaller) followed by a sandpaper finish (the larger particle size). For each of the tests were performed three repetitions, totaling 36 trials. The average depth of cut used was 0.4 mm

After the tests, test specimens were sectioned for physical and surface quality (roughness). Of each specimen were taken three core samples where these two were for analysis of bulk density and moisture and a measurement of roughness.

The bulk density of the specimens was determined according to NBR 7190 (ABNT, 1990). The moisture content of samples was determined according to NBR 9656 (ABNT, 1986) in an oven at 103 ± 2 º C.

The samples for roughness measurement were carefully handled during sectioning, in order to not affect the results beats and roughness after sanding. Were subjected to measurement of surface roughness by a roughness meter mark of the Robson Taylor Surtronic model 25 +.

The roughness used was the average roughness "Ra" for best fit to the studies of surface finishing of wood in order that the sanding process does not produce periodic markings as in conventional machining processes (turning, milling, etc.). The sample length was set at 2.5 mm (cut-off), the second value suggested by the NBR 6405 (ABNT, 1988). The measurement distance (lm) cut-off 2.5 mm is 12.5 mm, resulting in an average of 5 values obtained by measurement. The range adopted in roughness meter was 300 μm and the Gaussian filter was adopted.

In preliminary tests were tested 2CR and Gaussian filters and do not show significant differences in surface profile, we adopted the Gaussian filter, just by being the most used filter in the measurement of roughness profiles in wood.

For each specimen were made 8 measurements of roughness, symmetrically along the perimeter of central face of the specimen at random. Were then calculated for each of the 12 trials, the mean and standard deviation of 24 measurements (8 measurements for each of the three specimens). The roughness of the specimens was measured prior to the testing of sanding for analysis of the improvement in surface finish of the samples after sanding. The roughness data were subjected to analysis of variance.

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3. RESULTS AND DISCUSSION

The results of sanding power, vibration, acoustic emission and surface roughness are shown in Figures 5-14. The results of sanding power are shown in Figures 5, 6 and 7.

The two highest cutting speeds (26 and 28.1 m/s) consumed more power to cut the three sets of sandpaper analyzed. The cutting speed of 22.7 m / s consumed less power among the velocities analyzed for three sets of sandpaper evaluated.

According to Figure 7, the combination of sandpapers 100-120 showed lower power consumption (maximum 1700 W), compared with the other sets of sandpaper analyzed (maximum consumption around 2300 W). This is associated with a lower rate of material that the set of sandpaper removes 100-120, compared to other sets of sandpaper, just by having smaller abrasive grains.

As the shape of the lines of the graphics cutting power, it is worth noting that the lower peak (in the range of point 20) refers to the power consumed by the first set of sandpaper, that is, sandpaper rough. The highest peak generated refers to the power consumed when the two set of sandpaper were in contact with the body of evidence (in the range of point 40). The third peak generated (in the range of point 60) refers to the power consumed by the second set of sandpaper, that is, sandpaper finish. This is smaller than the first peak, exactly because of completion of sandpaper to remove less material of the specimen than sandpaper thinning, or create less grip and lower cutting forces during sanding.

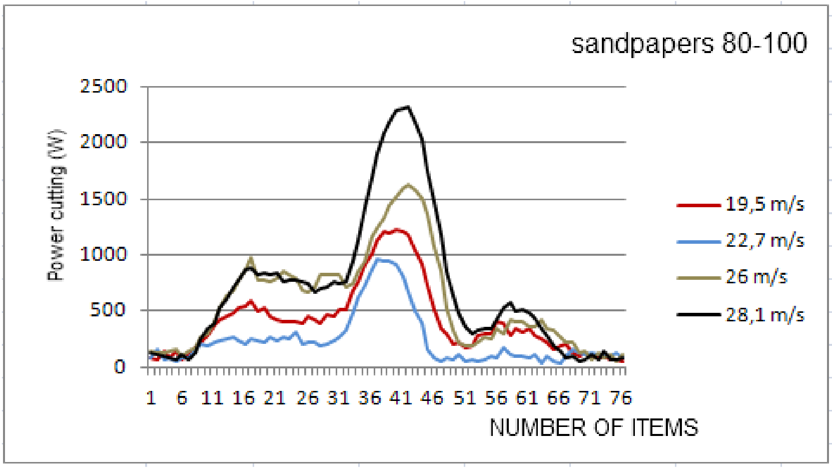

Figure 5- Cutting power in four cutting speeds of sanding with sandpapers 80-100.

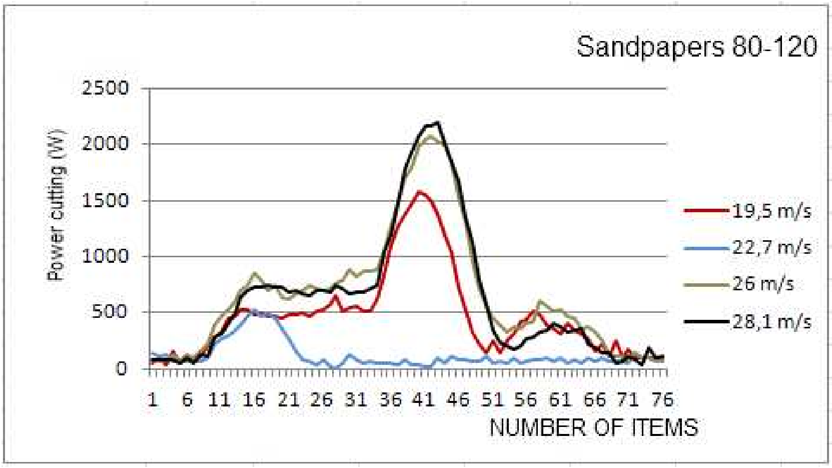

Figure 6- Cutting power in four cutting speeds of sanding with sandpapers 80-120.

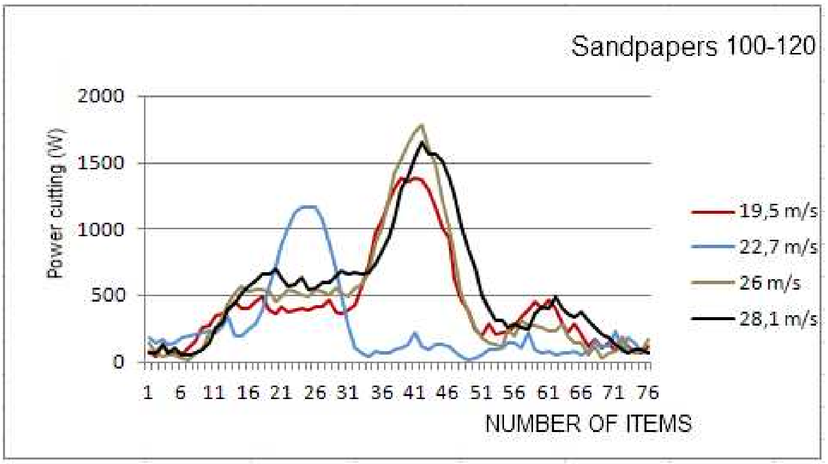

Figure 7 - Cutting power consumption in the 4-speed sanding with sandpapers 100-120.

The results of vibration are shown in Figures 8, 9 and 10. The higher speed sanding (28.1 m / s) generated less vibration in all the sanding done, as can be seen in Figures 8, 9 and 10. The lower cutting speed (19.5 m / s) generated the highest vibration in the sets of sandpapers 80-100 and 100-120. In the graphs of the vibration shape of the lines refers to the moment in which the abrasives were in contact with the specimen during sanding. The highest peak was generated at the instant when the two played simultaneously sanding the specimen, which consequently created a greater vibration sander.

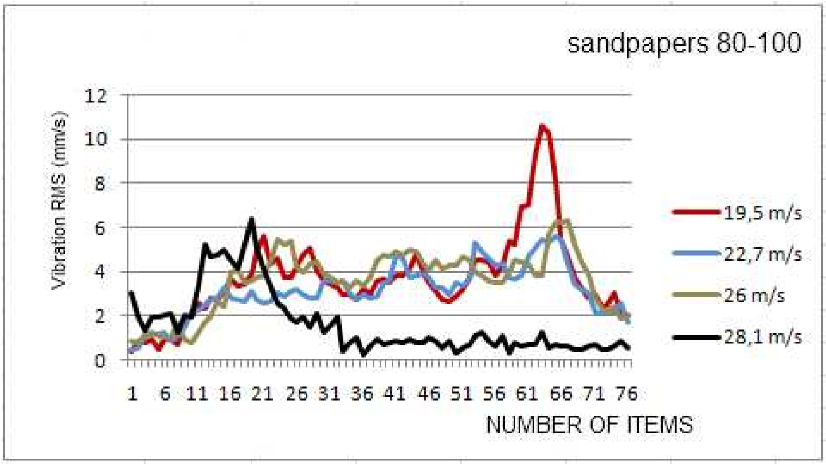

Figure 8 - Vibration generated in the 4-speed sanding with sandpapers 80-100.

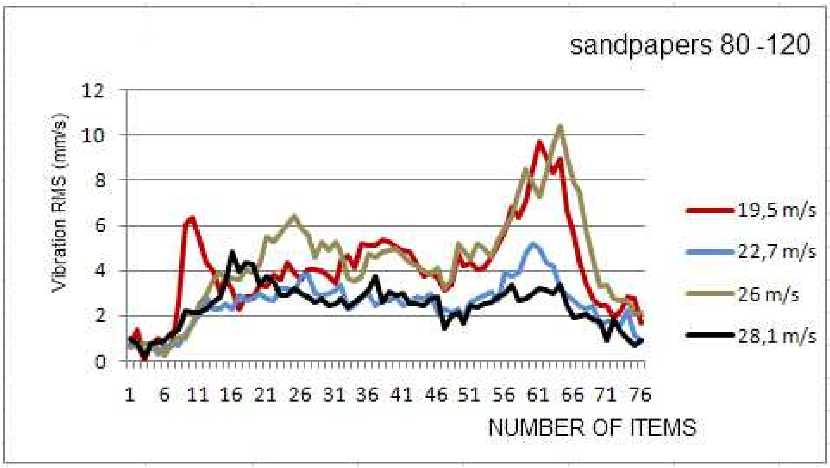

Figure 9 - Vibration generated by the 4-speed sanding with sandpapers 80-120.

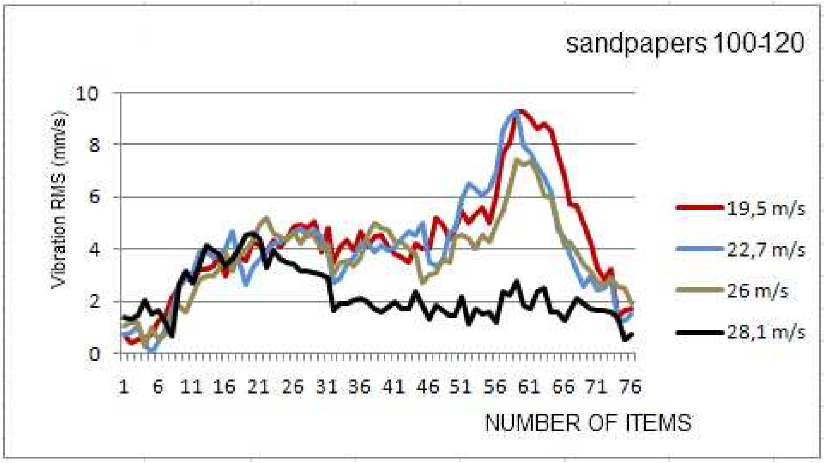

Figure 10 - Vibration generated by the 4-speed sanding with sandpapers 100-120.

For acoustic emission (Figures 11, 12 and 13), generated the highest peak is related to time of increased contact and greater efforts made in the sanding, that is, when the two sandpaper were simultaneously in contact with the specimen. The results of acoustic emission did not differ very precisely by the difficulty of fitting the acoustic emission sensor near the piece screwed.

The higher cutting speed (28.1 m / s) generated the highest noise emission levels for all sets of sandpapers analyzed, as shown in Figures 11, 12 and 13. It is expected that higher speeds produce higher acoustic emission, just by increasing the adhesion between the sandpaper and surface to be sanded, remove more material and therefore generate greater acoustic emission.

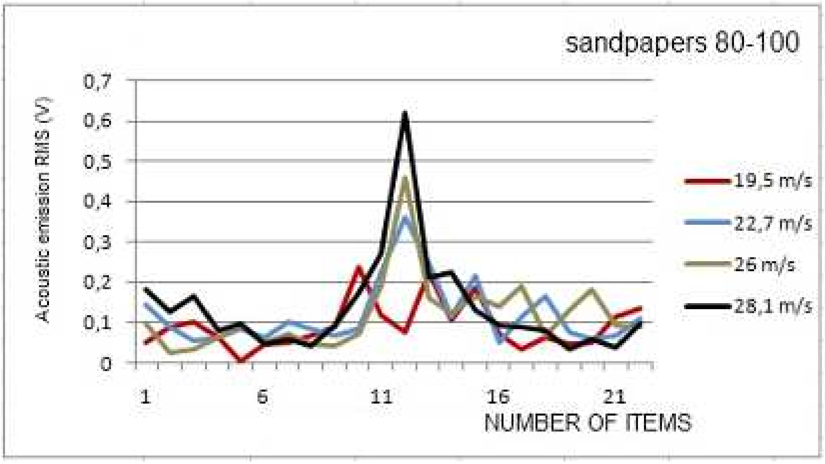

Figure 11- Acoustic emission generated in the four-speed sanding with sandpapers 80-100.

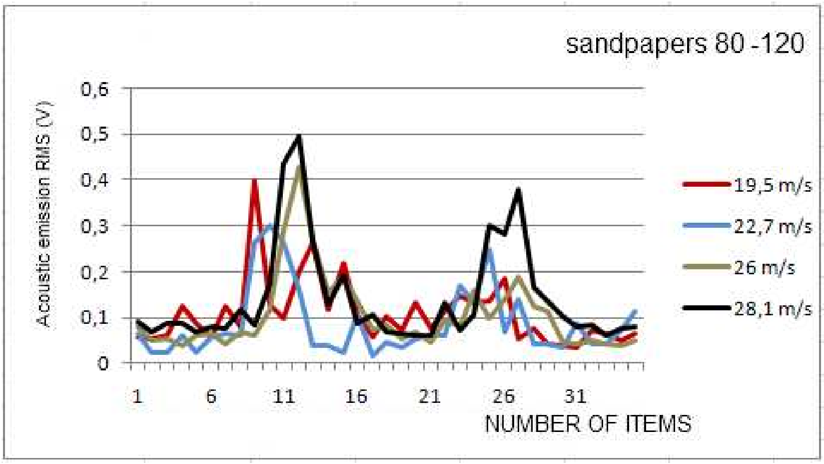

Figure 12- Acoustic emission generated in the four-speed sanding with sandpapers 80-120.

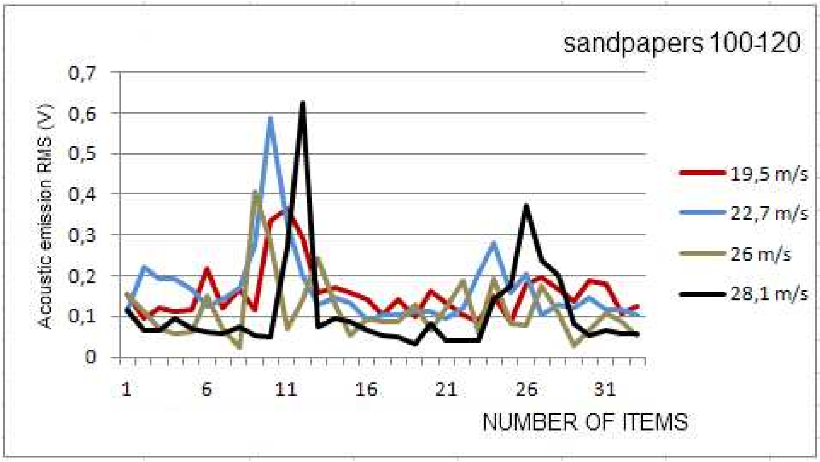

Figure 13 - Acoustic emission generated by the 4-speed sanding with sandpaper 100-120.

Before sanding, the average roughness of the specimens was 13.36 ± 1.25 µm. After sanding, the average roughness of the specimens was 7.40 ± 1.26 µm. This shows the considerable reduction of the roughness of the specimens after the sanding operation, namely, the considerable improvement in surface finish of parts of *Eucalyptus grandis*. The set of sandpapers 100-120 resulted in lower value of average roughness for all cutting speed analyzed, as shown in Figure 14.

The set of sandpaper 80-100 gave higher values of average roughness for the sanding speeds analyzed, that is, the worse surface finish between the sets of sandpaper evaluated.

According to Kilic et al. (2005), surface quality of solid wood products is one of the most important properties influencing further manufacturing processes such as finishing or strength of adhesive joint, and it is a parameter that can be used to measure the quality of industrial process.

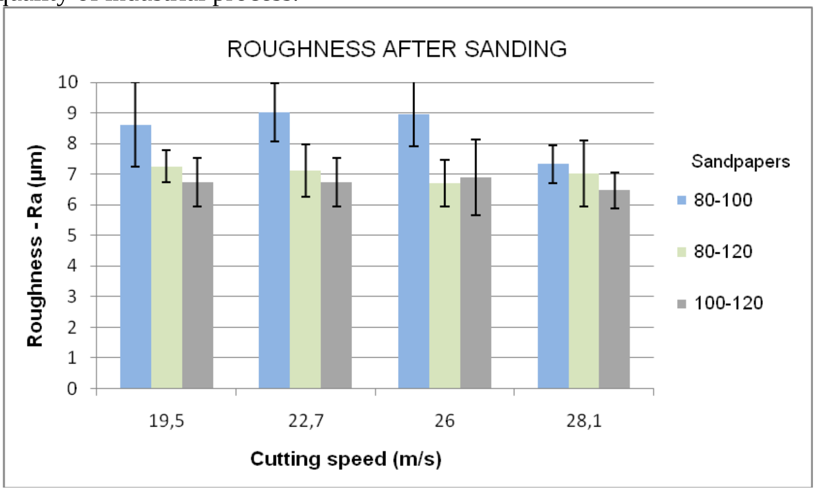

Figure 14 - Surface roughness of the work pieces after sanding.

In the analysis of variance, factor cutting speed had a significant effect on the roughness of the sanded parts with only the set of sandpapers 80-100, and ($F_{2,\ 276} = 101.02$ ($p < 0.05$)). However, for combinations of sandpapers 80-120 and 100-120, the speed factor was not significant in the roughness profile.

4. CONCLUSIONS

From the results it is concluded that:

The sanding speeds 26 and 28.1 m / s consumed greater cutting power for 3 sets of grit sizes analyzed and the speed sanding of 22.7 m / s consumed less power cutting in all sets of grit size used;

The greatest acoustic emission in all sets of grit sizes was generated with the cutting speed of 28.1 m / s and the fastest speed sanding (28.1 m / s) generated less vibration sander in all sets of abrasive papers used;

At all sanding speeds analyzed, the range of 100-120 sandpapers resulted in the lowest value of average roughness.

The factor cutting speed significantly influenced the finishing for only the set of grit sizes 80-100 mesh.

With the cutting speed of 28.1 m / s was obtained at higher acoustic emission compared with the other three speeds analyzed. The cutting speed of 19.5 m / s produced the highest vibration. 100-120 sandpapers resulted in lower roughness.

5. ACKNOWLEDGEMENTS

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