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INFLUENCE OF CUTTING SPEED, SANDING BELT GRANULOMETRY AND SPECIFIC CUTTING PRESSURE ON THE SANDING OF EUCALYPTUS GRANDIS WOOD

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Abstract. *The sanding process is highly relevant to the quality of wood products. Sanding reduces imperfections in wood surfaces and it is important both for the end product and for the application of paints or varnishes. Few studies about sanding variables are available in the literature, which is why sanding ends up being performed empirically. To improve the process, the relationships between the variables of the process and the cutting quality and forces must be known. In this context, an analysis was made on the influence of the cutting speed, sandpaper grit size and load applied in the sanding process of Eucalyptus grandis cut across the grain. The tests were performed with 3 types of sanding belts (80, 100 and 120 grit), at 3 speeds (10, 11 and 12 m/s) and 2 variations of specific pressure (219.89 and 283.44 g/cm²). The surface quality was analyzed based on roughness measurements , (Ra). Sanding efforts were analyzed by cutting force and power sanding. It was found that the 100-grit sanding belt provided the lowest sanding force. Cutting speed, specific pressure (loads) and granulometry influences the surface quality and efforts to sanding. The best surface finishingss were obtained in tests with higher loads.*

Keywords*: Sanding, Eucalyptus grandis, Roughness, Sanding force, Sanding pressure*

1. INTRODUCTION

The world today is facing the challenge of sustainability, leading to a considerable increase in the use of products from more easily renewable resources. In the search for renewability, the forest products industry has invested in the quality and production of reforested wood. In Brazil, the area occupied by reforestation has grown considerably since 2000, and the species covering most of this reforested area is eucalyptus.

The use of this type fo raw material makes it extremely important to know its characteristics of workability. Because wood is a material whose properties vary from species to another and according to several other factors, it is crucial to know how the material will behave during its machining and finishing.

The sanding process is fundamental to achieve the surface quality required in the wood finishing for several uses. Therefore, it is essential to know and align this process to the desired characteristics of the end product. Innumerable influencing variables must be considered when sanding wood, such as the wood moisture content, species, sanding direction, cutting speed, the density of the wood, sandpaper grit size and others.

The most important parameter measured after sanding is surface roughness, which will indicate if the surface is ready for the next stage or if the final quality of the product has been reached. An adequate roughness will result in the desired final standards and an improvement of the surface to receive products such as sealants, paints and varnishes.

Wood should always be sanded along the grain to prevent damaging its fibers and impairing the process. Because sanding across the grain is much more difficult, it should be done extra carefully to avoid scratching the wood.

Several variables should be controlled, such as the sanding direction, sanding speed and pressure, and the product moisture content and cleaning after the sanding operation. Precautions regarding these variables aim not only to improve the quality of sanding, but also to extend the service life of the sanding cloth.

After the sanding process, the resulting product is expected to show good surface quality to facilitate the subsequent processes. A good finish implies low values of roughness parameters.

The sanding process can be divided into two classes of tasks. The first type involves the processes that are carried out to prepare the wood and reduce its initial surface roughness. The second class of tasks involves the sanding processes that prepare the wood for the subsequent application of finishing materials (Koch, 1964).

Due to the high variation in the direction of the grain from one wood species to another, it is necessary to be very familiar with the sanding belts to be used, since the use of the wrong grit may lead to problems during the sanding process. It is therefore necessary to know the best abrasive material and the size of grains of the sanding belt in order to mitigate the sanding process. According to Bianchi et al.(1999), it is also very important to know the speed and forces that act in the process. For Bianchi et al.(1999), the cutting forces in abrasive processes influence the geometric quality, dimensional and surface finishing, tool life and execution time of the cutting process. It also determine the necessary power and structure for machine.

The purpose of this study was to devise a new way to analyze results by means of a data acquisition system to study the relationships between cutting speed, sanding pressure, sanding force, sanding power, sandpaper grit size and surface quality based on roughness measurements. Sanding process is influenced by these important variables that are rarely studied.

According Gurau et al.(2005), sanded wood surface has different irregularities caused by machining and wood anatomy.

Saloni et al.(2005) using different pressures, wood species, types and cutting speeds, observed that the material removal rate can change with variation of pressure, abrasive type, size and speed of sanding and that sanding power increased linearly with increasing pressure. In most cases a higher speed of sanding produced a better surface finish.

According to Gonçalves (2000), the cutting performance of tools in wood machining processes can be indicated by the consumption of energy required for cutting in trimming operations or by the surface quality attained in finishing processes.

Javorek et al.(2006) found that pressure had a significant effect on power consumption and cutting force in sanding process. He noted influence of pressure, cutting direction and cutting speed on the sanding force and sanding power consumed.

Porankiewicz et al.(2010) showed that the resistance of the sandpaper is changed depending on the specific pressure. The variation of particle size influence the resistance of the sandpaper.

Varanda et al. (2010), studying the influence of cutting speed and particle size of abrasives on the surface quality of Eucalyptus grandis wood, concluded that higher sanding speeds consume more power to different sandpaper analyzed. Also concluded that smaller abrasive grains produced better surface finishes.

Ratnasingam et al. (2002), concluded from studies with sanding of the Rubberwood (Hevea brasiliensis), that the reduction of particle size contributes to the surface finish.

Processing also exerts a strong influence on roughness. In machining by orthogonal cutting, the most important factors are cutting speed and blade sharpness, but the blade cutting angle, the angle between the cutting edge and the fibers and the amplitude of vibration of the machine also affect the surface roughness (Magoss & Sitkei, 2001). In machining by peripheral milling, the cutting speed and sharpness of the cutting edges strongly determine the roughness of the workpieces. In sanding, roughness is influenced by the cutting speed, advancing speed, grain size and abrasive grain wear. In all these processes, roughness can be influenced by wood defects such as pores, incrustations, cracks and others.

Saloni (2007) say that there is a significant effect of anatomical characteristics of wood on the sanding process influencing the result of sanding forces and quality of the sanded surface.

During the abrasive machining process, the abrasive grains wear out and their tips begin to lose their "edges", i.e., their sharpness, making the grains "blunt". The loss of sharpness of the grains causes an increase in the efforts of removal of the material, leading to deformations on the surface of the material instead of its effective removal. As these forces and deformations increase, there is an increase in the tangential cutting force in response to the higher attrition between the top of the abrasive grain and the surface of the material, generating higher temperatures in the process (Alves, 2005).

This study analyzed the influence of the cutting speed, sandpaper grit size and load applied in the plan sanding process of Eucalyptus grandis cut across the grain. The tests were performed with 3 types of sanding belts, at 3 cutting speeds and 2 variations of specific pressure.

2. METHODOLOGY

A data acquisition center was used to read and record the relevant data in the sanding process. This center consisted of three main pieces of equipment, shown in Fig. 1, namely a computer, a control panel and a data acquisition system.

The data acquisition system comprises a swinging support base to ensure perpendicularity in the tests, an adapted load cell, and a flat sanding machine.

Sixty test specimens (Fig. 2), with dimensions of 50mm x30mm x 21mm, were prepared from 3 bars with an initial length of 1400 mm and a rectangular 50 mm x 40mm section. These bars were first machined with a rough wood milling machine to ensure all their faces had the same dimensions. They were then cut into segments using a circular saw with cutting guide, thus ensuring that all the test specimens had the same size.

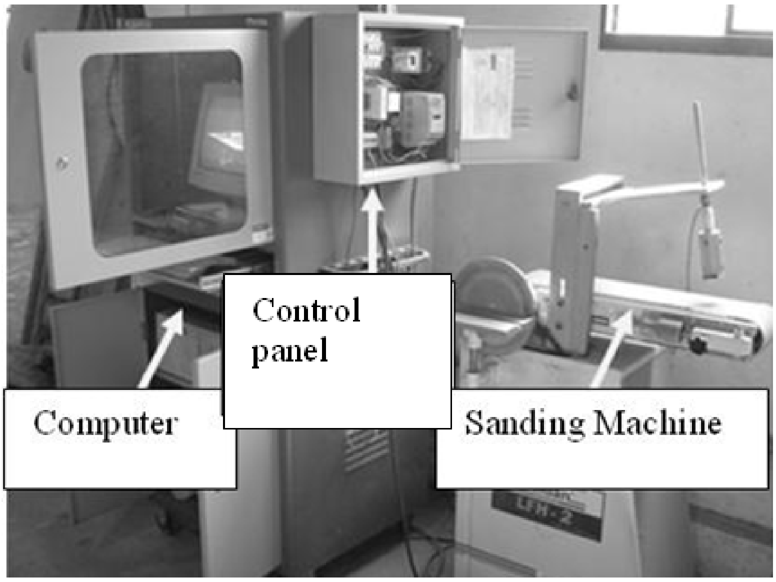

Figure 1. Data acquisition center and test specimen.

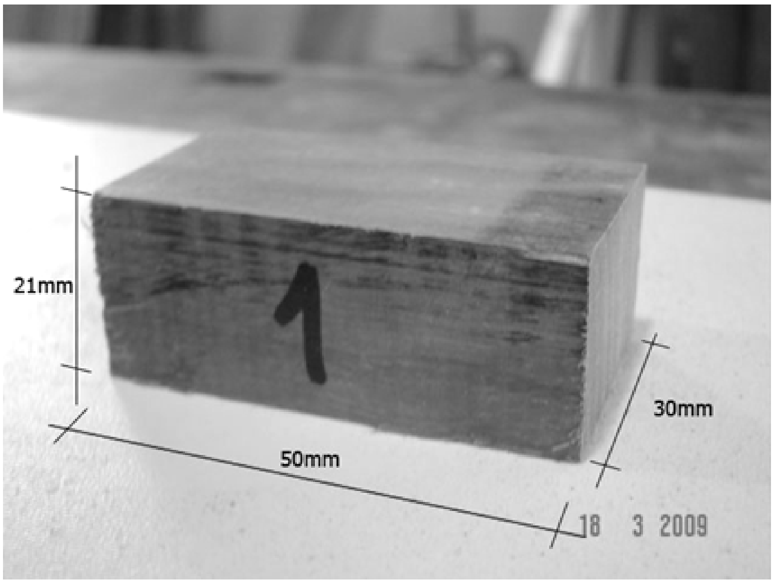

Figure 2. Test specimen.

To capture all the signals, a bench was set up with a Siemens 110-220 VAC/24 VDC power supply, a TCA 500-2MV/V load cell transducer, and a Weg® µline frequency converter with 380V input and 3A output to control the speed of the sanding machine motor. These components were connected by means of an 8-input/output terminal.

During the sanding process, the motor power was measured with a WARD® series 90501 TRX-I/U current transducer with about 0.5% of uncertainty. This transducer captures the variation of the motor current and releases a proportional signal between 0 and 5 Vcc.

The data were captured using a National Instruments® BNC-2120 16-channel input module, and a PCI-6220 data acquisition board. The acquisition board and the channel module were connected by means of a National Instruments® SHC68-100 EPm shielded cable.

The input data were captured by LabView 7.1®, using a program adapted to the test performed here. These data were then analyzed and selected using Mathlab 6.5® software.

Prior to the tests, the test specimens were acclimatized to ensure uniform moisture content. The tests were performed with moisture content stabilized at 8%. The testing procedure consisted of turning on the data acquisition program, then the frequency converter, then the motor, and waiting for the power curve of the motor to normalize after starting, whereupon the test specimens were inserted and machined for one minute.

In tests using the 80-grit sanding belt, the machining time had to be reduced to 40 seconds to prevent wear of the load cell by the sander. All the sanding belts were composed of aluminum oxide grains.

Three repetitions were made in each test condition to avoid any possible anomaly. The tests were performed with 3 types of sanding belts (80, 100 and 120 grit), at 3 speeds (10, 11 and 12 m/s) and 2 variations of specific pressure (219.89 and 283.44 g/cm²).

The surface quality was evaluated using a Taylor Hobson Surtronic 25 surface roughness tester with a sampling length of 4mm, 0.8mm cut-off and 2CR filter. It was also evaluated the roughness Ra (roughness average). The roughness was measured in the direction perpendicular to the sanding.

3. RESULTS AND DISCUSSION

As it can be seen in Fig. 3, the lowest sanding force obtained with the 100-grit sanding belt, and the 80 and 120-grit sanding belts showed similar cutting forces. This figure also shows that the speed that provided smaller sanding forces was 10m/s. Better results in comparisons of speeds require higher variations of speeds among the tests. An analysis of the graphs indicates that the lowest sanding force was obtained at the highest speed, while the highest cutting forces occurred at the lowest speed.

Analyzing the Fig. 4 shows that the sanding power (power to sanding) increased with increasing cutting speed, with the exception only for the 80 grit size on the cutting speed of 10m/s. Power sanding is the total power minus the power required to keep the sander running (power idle).

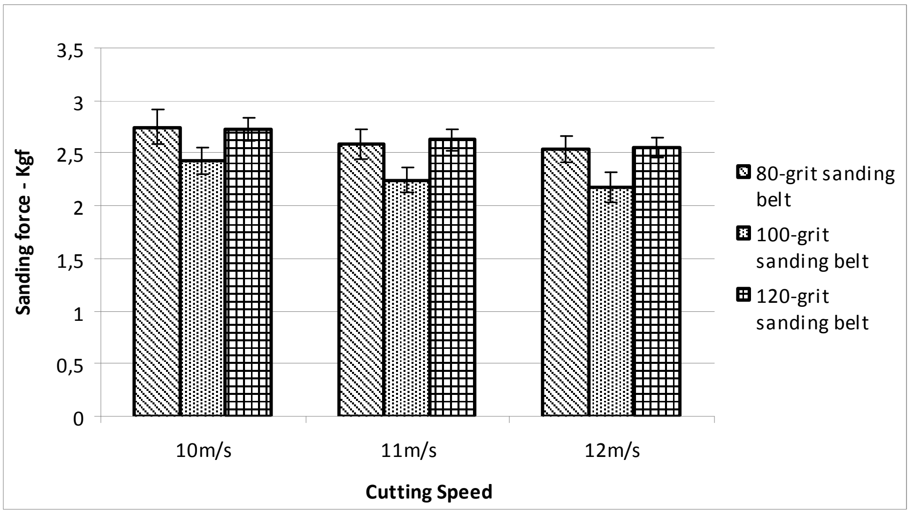

Figure 3 – Results of sanding force with 219.89 g/cm² pressure.

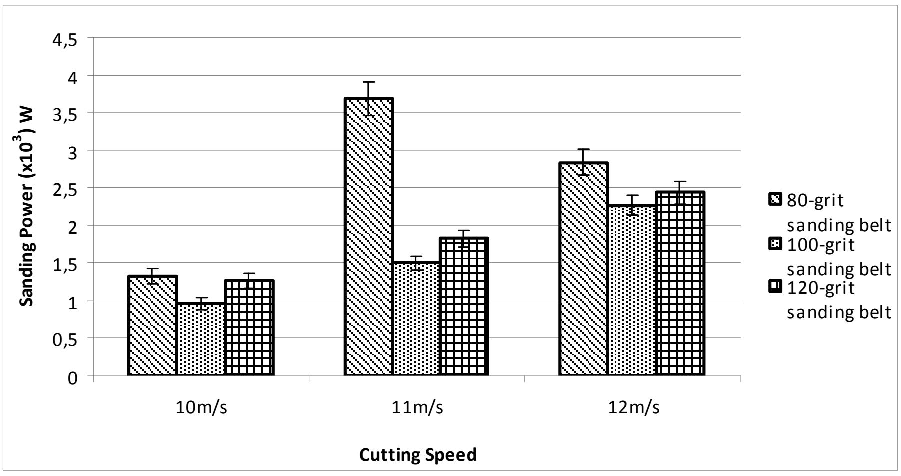

Figure 4 – Results of sanding power with 219.89 g/cm² pressure.

Note that the tests with load (Figs 5 and 6) follow the same configuration as the tests without loads, i.e., the lowest sanding force is still that of grade 80 and the cutting forces of the other 2 sanding belts are similar. An examination of the graphs indicates that the highest force variation with added load occurred at a speed of 10 m/s, when the incremental force reached almost 10 N.

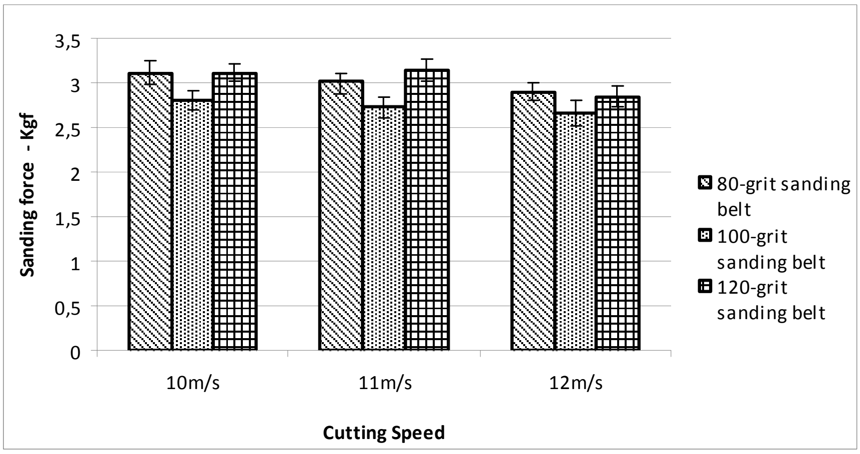

Figure 5 – Results of sanding force with 283.44 g/cm² pressure.

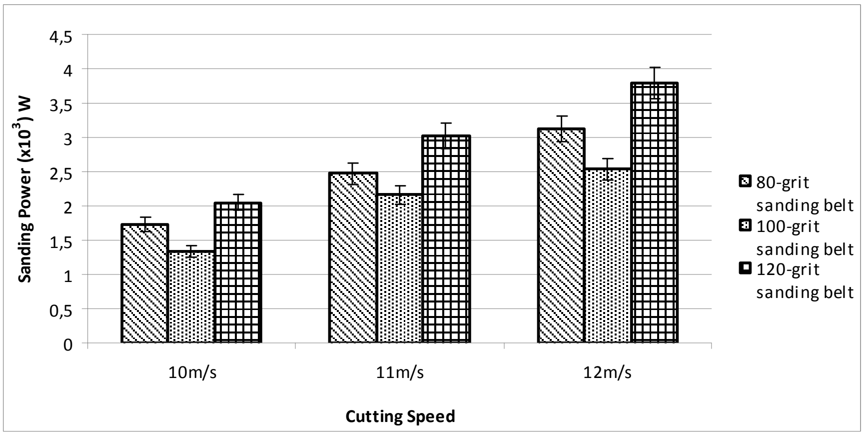

Figure 6 – Results of sanding power with 283.44 g/cm² pressure..

Comparing Fig. 3 with Fig. 5 and Fig. 4 with Fig. 6 shows that higher pressures required more force and power sanding. As can be seen, the sanding force and the sanding power increased in all the test configurations, due to the increased friction between the test specimen and the sanding belt.

Machining forces vary according to numerous factors, including sharpness of the abrasive grains, type of material to be machined, machining speed, the material moisture content content and granulometry of the abrasive, among many others. Therefore, high quality can be attained in the machining process provided there is a combination of these factors, without analyzing or altering only one of these variables.

Figs. 7 and 8 indicate the roughness values obtained in the tests. Note that the highest roughness values at all the speeds were obtained with the 80-grit sanding belt without additional load, while the lowest roughness values were obtained at a speed of 10 m/s with 80-grit sanding belt without additional load. At speeds of 11 and 12 m/s, the best results were obtained with the 100-grit sanding belt with additional load, and with the 120-grit sanding belt with additional load, respectively. Note, also, that the 80-grit sanding belt tests with loading yielded the lowest roughness values, and hence better surface quality. It can be stated that the best roughness values obtained with the 80-grit sanding belt were attained by increasing the specific pressure.

The best roughness values obtained with the 100-grit sanding belt were attained at a speed of 10 m/s without additional loading, and at 11 m/s with additional loading, with similar results attained at 12 m/s. The best roughness values obtained with the 120-grit sanding belt were attained with an increase in specific pressure.

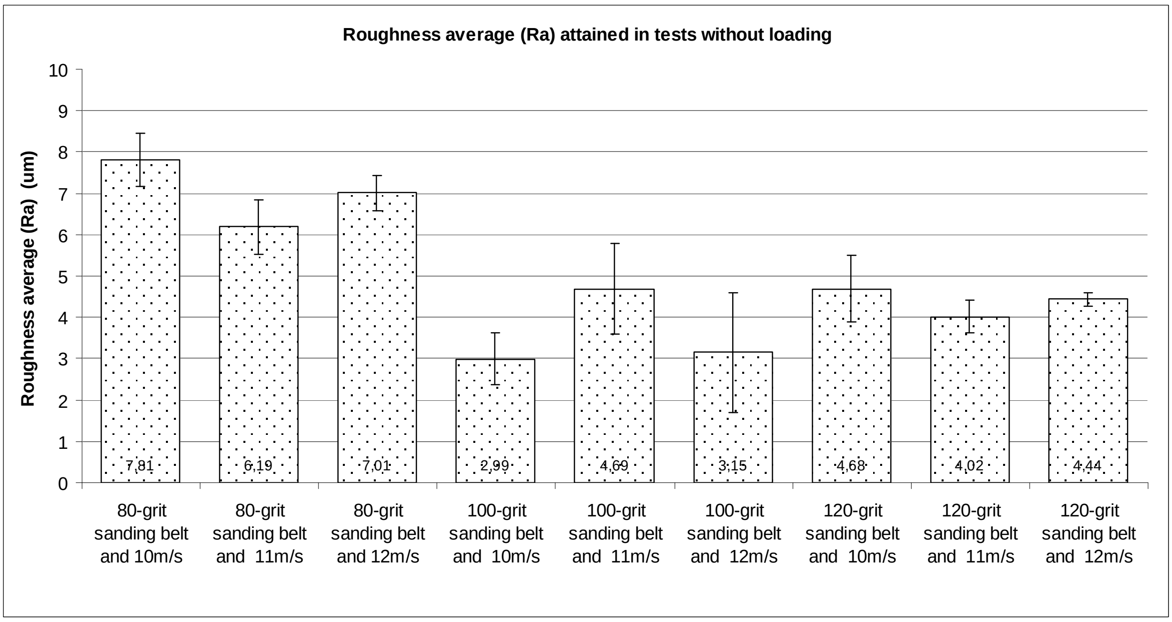

Figure 7 – Roughness average (Ra) attained in tests with 219.89 g/cm² pressure.

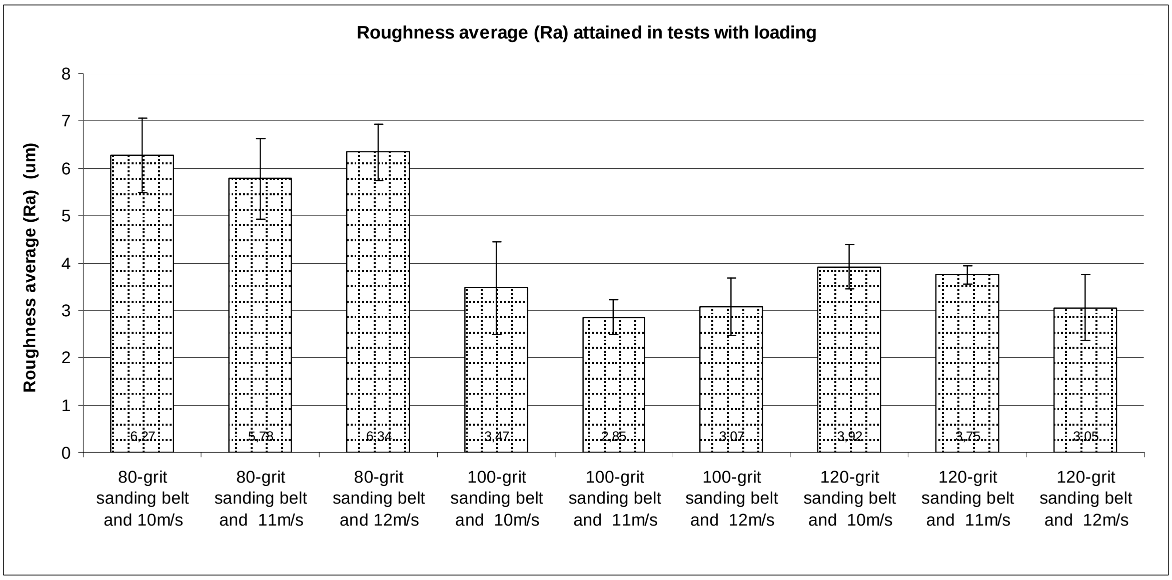

Figure 8 – Roughness average (Ra) attained in tests with 283.44 g/cm² pressure.

According to Magoss and Sitkei (2001), the surface quality depends on several factors that can be found in the properties of the wood and in the machining process. The properties of wood include the species, density, moisture content and the physicochemical properties. The physicochemical properties include the specific number and distribution of fibers and conduits, from the physical standpoint, and the content of cellulose, lignin and extractives, from the chemical standpoint.

4. CONCLUSIONS

The data acquisition system was efficient in capturing in sanding pressure and sanding force data, proving completely reliable to capture physical process variables. The methodology employed here can be used in industrial environments, for the process and quality control of manufactured parts.

- Higher pressures produced lower roughness (comparing Fig. 7 and 8).
- There was a visible difference in the quality of the surface finish provided by the 80-grit sanding belt and the other grits. However, the 100 and 120-grit sanding belts yielded similar surface finishes.
- The variation in sanding speed did not affect the roughness of the test specimens to any noticeable degree. This was probably due to the low variation in speed applied in the tests (10, 11 and 12 m/s). The sanding force increased slightly at lower speeds.

• With regard to the sanding force, it can be stated only that the 100 grit yielded the lowest sanding force and that the other grits produced forces similar to each other.

• With regard to the sanding force, an increase in specific pressure led to an increase in forces. However, the granulometry that showed the highest increase in sanding force was the 120-grit sanding belt.

5. ACKNOWLEDGEMENTS

Special acknowledgements are due to FAPESP – Fundação de Amparo à Pesquisa do Estado de São Paulo-Brazil, for its financial support of this research.

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