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Analysis Of Specific Cutting Energy In Planing Of Native Species Of Brazil For Solid Product Purpose

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Abstract

Wood industries tend to automate their processes, aiming to increase yield and quality, to add value to their products. Therefore, the frequency inverter is an indispensable accessory for this purpose, once it allows the monitoring and registration of the pre-set parameters during processing. The aim of this study was to understand the behavior of native wood species from Amazon region of Brazil,*Cedrelafissilis*, *Endopleura uchi*, *Erismauncinatum*, *Myroxylonbalsamum* and *Parapiptadeniarigida,* regarding the specific energy required to perform their planing. The results showed that *P. rigida*, *E. uncinatum* and *E. uchi* woods required higher specific cutting energy and were statistically the same. *C. fissilis* and *E. uchi* woods presented intermediate specific cutting energy consumption,*C. fissilis* and *M. balsamum* woods were the ones that required less specific cutting energy to be planed. The data found corroborate with those found in the literature. It was concluded that the specific cutting energy represents a good parameter to understand the behavior of wood during its mechanical processing.With the knowledge of the specific cutting energy values spent for the planing of the analyzed species, it is possible to indicate their use, since these species spent low cutting energy during processing and this is a factor of interest for the industries of the furniture sector. This study allowed to subsidize the decision making regarding the use of these species generating less waste, thus allowing the production of goods with greater added value, in agreement with the sustainable management of the Brazilian native forests.

Key words: Mechanical processing of wood, Furniture, Added value product.

INTRODUCTION

The scarcity of information about the technological characteristics of native Brazilian woods and their workability makes it difficult to use it on a large scale and to produce goods with higher added value. The study and generation of knowledge about these woods are of great importance to enable the production of massive pieces with high quality of machining.

Large processing units like sawmills and furniture factories try to automate their processes, aiming to increase yield and quality, to add value to their products. In order to improve production, it is necessary to control the process through specific equipments. The frequency inverter is an indispensable accessory for this purpose. It allows the monitoring and registration of the parameters established in the raw material processing.

Information on the behavior of wood during its machining process is a necessity related to processing within wood industries, mainly for economic and productive reasons. Machines and tools manufactured for wood processing, as well as operators, need reliable information on the main factors influencing the machining process (Eyma*et al*., 2004).

In this context, the evaluation of the specific cutting energy is very important to ensure that the machines are efficient in the mechanical processing, without energy waste. This is because the main problems faced by the wood industry are usually linked to high energy costs and constant production stoppages due to exceeding the nominal power limits of the electric engines.

The specific energy required when cutting is an important variable to be evaluated to ensure that the machines are being efficient in mechanical processing without energy waste. Also, it avoids overhead that generates interruptions in the production (technical stops) by exceeding the requested limits of electromotive motors. The specific cutting energy required can vary according to process parameters such as cutting speed and feed rate and also with the characteristics pertinent to the raw material, which is of great interest when working with wood (Guedes, 2016).

The knowledge about the energy spent during the machining process for different woods is fundamental for the engine sizing of the machine, thus avoiding that the power limit of the machinery is exceeded, besides indicating which are the better cutting parameters, such as cutting speedand feed rate, that will be more efficient for a particular type of cutting and wood.

The aim of this study was to understand the behavior regarding to the specific cutting energy required during the planingBraziliannative wood species.

Literature Review:

Wood machining is the processing of wood by means of a cutting tool, aiming the product quality and operator safety (Silva *et al*., 2005).

According to Bonduelle *et al*. (2002), wood machining can be expressed by the 5M function (raw material - wood; machine - constructive aspects; methodology - machining parameters; labor - operator training; environment - environmental degradation).

Wood, as a heterogeneous and anisotropic material, presents different physical / mechanical properties in the transverse, radial and tangential planes. Thus, wood can be machined in different ways depending on the attack direction between the cutting tool and its fibers. Leitz (2001) defines that wood can be machined longitudinally, transversally and at the top, each one having its peculiarities.

According to Silva (2002), the optimization of the machining processes of wood results in great advantages, such as the reduction of the energetic cost demanded by the machine tools, greater use of the wood, increase in tool life and productivity, leading to cost reduction of the machining and the final product.

Specific energy is one of the important physical magnitudes of machining (Gorczyca, 1987). Variables such as strength, cutting time, cutting length, tool abrasion and cutting temperature, directly influence the machining process (Gorczyca, 1987; Rodrigues and Coelho, 2007).

The specific cutting energy is the effective energy consumed to remove a particular volume unit from the material (Salmon, 1992). It is calculated by the ratio between the cutting power and the material removal rate. The removal rate is the volume of material that has been removed in a certain time interval and is observed by means of the mechanical torque obtained by frequency inverter (Gontijo, 2012).

Souza *et al*. (2011) studied the influence of processing parameters such as feed rate, cutting speed and number of teeth in the specific cutting energy consumption to cut saturated and dried Eucalyptus wood. The cuts were made in a circular saw using an automated advance. The energy required was measured by the frequency inverter data. As a result, the authors confirmed that higher cutting speeds, lower feed rates, and circular sawing of 40 teeth consumed a greater amount of specific energy. The authors also determined the ideal cutting conditions for each genetic material, aiming to reduce specific cutting energy without compromising quality. As recommendations, the authors suggested that future work should confront energy as a function of humidity and density with radial distribution.

Gontijo (2012) analyzed the influence of cutting speed,feed rate and the number of teeth on the specific cutting energy consumption of natural hybrid of *Eucalyptus urophylla* and *E. camaldulensis* x *E. urophylla*logs. Circular saw with speed control was used to make the cuts. The specific energy was obtained by means of the frequency inverter. The results showed that higher cutting speeds and lower feed rates, in general, required high specific cutting energy.

Melo *et al*. (2015), in an experiment using different genetic materials, studied the influence of density on the specific energy consumption during wood cutting. Processing parameters such as feed speed, cutting speed, number of teeth, tool rotation and circular saw have been fixed. The genetic material influenced the maximum specific energy consumption. The cuts made lengthwise had superior consumption to those made transversally.

1. Methodology:

1.1 Materials:

It was used woods of five native species from the Amazon region of Brazil: *Cedrelafissilis*, *Endopleura uchi*, *Erismauncinatum*, *Myroxylonbalsamum* and *Parapiptadeniarigida*. These species came from the sustainable management of the Amazon forest of the state of Pará.

1.2 Planing:

The mechanical processing was performed in a planer (Figure 1), with a 105 mm diameter head, with three sharp knives and a rotating tool fixed at 4000 min^{-1}. The planer in question had an exhaust system which favors the exit of the chip, making it possible to measure the cutting energy for the effective cutting of the wood. The specimens were planed with feed rate set at 6 $m*min^{-1}$through the automated advance coupled to the planer.

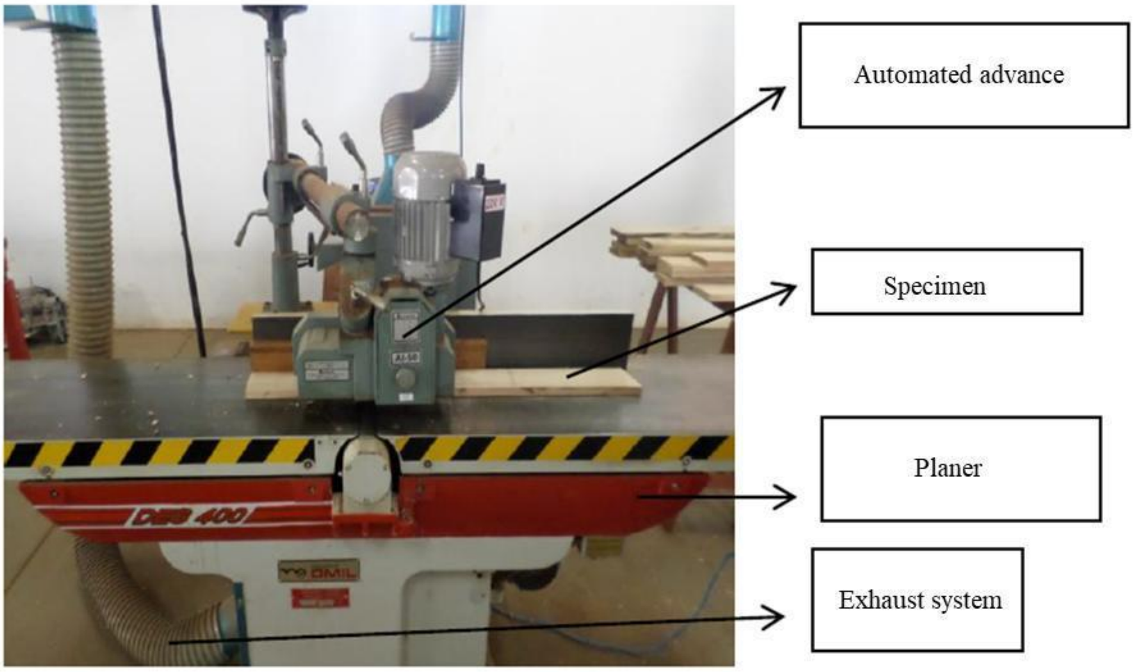

Fig. 1: Setup of the planing process.

1.3 Frequency inverter:

The cuts were monitored by the frequency inverter (CFW-W08) coupled to the activation engine of the planer cutting tool of the wood machining laboratory DCF / UFLA.

The data acquired by the frequency inverter were exported to Excel, which enabled the adjustment and confection of the graphs response. The data capture,realized by the parameterization software, was performed without interruption over time and four readings were taken every second. This method resulted in an extensive database, most of which presented energy only from the rotation of the engine, without the effective cutting of the wood and which had to be filtered from the general database (Figure 2), as described by Braga (2011).

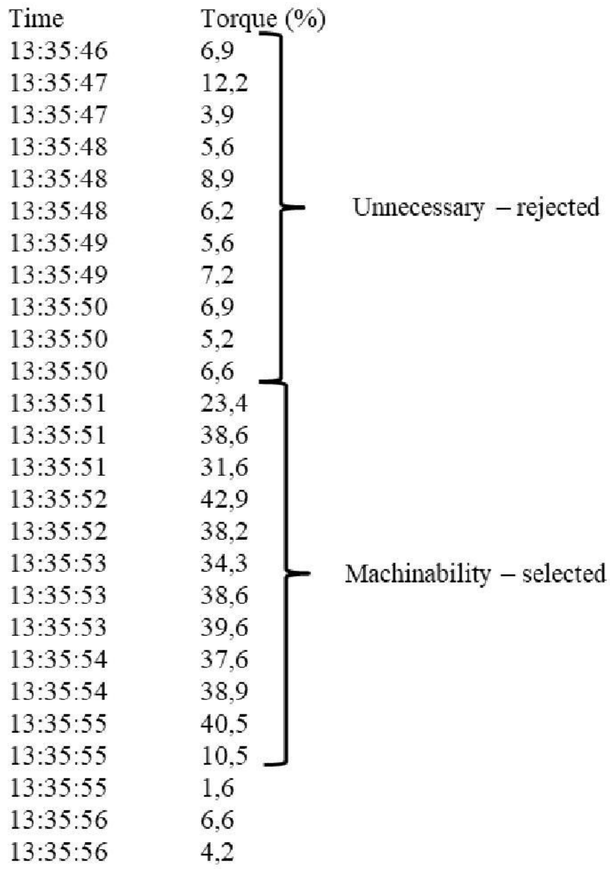

Fig. 2: Data adjustment and filtering presentation of values without effective cutting energy

The torque values provided by the frequency inverter are not in the standard unit, which is Newton meter (N.m.). The values obtained correspond to a percentage of the nominal torque value of the engine, so it was necessary the conversion for a better interpretation of the data. In this way, the same procedure adopted by Souza (2009) was used, which establishes the use of a sequence of mathematical formulas that take into consideration the engine torque and the volume of material processed, to provide the specific cutting energy.

1.4 Statistical analysis:

The statistical analysis was performed using the analysis of variance (ANOVA) at 5% of significance and, if significant, Tukey test at 5% of significance was applied.

RESULTS AND DISCUSSION

The specific cutting energy values obtained during the planing of the five species ranged from 0.073697 KJ*cm^{-3} for *E. uncinatum*to 0.320742 KJ*cm^{-3} for *P. rigida*, with coefficient of variation equal to 0.35%. It was observed that the specific energy spent for the planing was low and this can be explained by the ease workability of the evaluated species.

The analysis of variance of the specific cutting energy obtained during the planing of the five species can be found in Table 1. It is observed that there was statistical difference between the species, at 5% of significance. Practically, this indicates that to spend less energy during the planing process, it should be observed the choice of genetic material.

Table 1: Summary of analysis of variance of the specific cutting energy spent during planing

Source of variation	Degree of Freedon	Middle Square
Species	4	0.024859*
Residue	52	0.001907
Total	53	-

* significant by the F test at 5% of significance

Through the multiple comparison of means by the Tukey test, at 5% of significance (Table 2), it was observed that the specific cutting energy was grouped into three distinct classes. The speciethat, on average, consumed the most energy to be planed was *P. rigida*and the specific energy spent was 45% higher than in*M. balsamum*, that was the specie that consumed on average less specific energy during the planing.

Table 2: Multiple comparison of the means of the specific cutting energies in the planer for five different native species of Brazil

Species	Specific Energy (KJ*cm^{-3})
P. rigida	0.256751 a
E. uncinatum	0.243399 a
E. uchi	0.232495 ab
C. fissilis	0.190093 bc
M. balsamum	0.141026 c

Means followed by at least one of the same letter do not differ from each other at 5% significance, by the Tukey test.

Néri *et al*. (2000), evaluating cutting forces (90°-0°) in *Eucalyptus* sp. observed that the cutting force tends to increase with increasing in wood density and cutting thickness. Rezende *et al*. (2012), working with species of *Khayaivorensis* and *Khayasenegalensis*, found average basic densities of 0.487 g*cm^{-3} and 0.510

g*cm^{-3} respectively, while Andrade (2013), working with these same species, found higher values of cutting energy for *K. senegalensis*. The work done by these authors corroborates with the results found in this study since the species with higher densities presented higher consumption of specific cutting energy.

Guedes (2016) studied the effect of moisture and density of three species with high, medium and low densities and in eight different humidities on the specific cutting energy during milling and observed that the moisture had a negative relation with the specific cutting energy and the density presented positive relationship, since higher densities indicate higher thicknesses of the cell wall and consequently greater resistance to cutting. The data about density found by this author corroborate with the observed in this study.

Conclusion:

It was concluded that the specific cutting energy represents a good parameter to understand the behavior of wood during its mechanical processing. With the knowledge of the specific cutting energy values spent for the planing of the analyzed species, it is possible to indicate their use, since these species spent low cutting energy during processing and this is a factor of interest for the industries of the furniture sector.

This study allowed to subsidize the decision making regarding the use of these species, generating less waste, thus allowing the production of goods with greater added value, in agreement with the sustainable management of the Brazilian native forests.

This work provides information on native Brazilian species about their machinability during planing, but little is known about the behavior of these species during machining in other types of cutting or even during finishing steps, such as their quality when sanding or varnishing , encouraging the study of these species to promote their use as an alternative raw material to the species commonly used in the furniture industries.

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