Analysis of Solid Waste Generation in a Wood Processing Machine

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Abstract The processing of the wood generates a significant amount of waste, presenting itself as a problem to the environment. The volume of waste generated from processing depends, in addition to other factors, on the type of processing machine. This work aimed to present a case study regarding the volume of waste generated in the processing of the logs of *Eucalyptus* sp.genus specie using processing machine Pica-Pau type. Pica-Pau type machine was located in Itapeva (state of São Paulo, Brazil). A total of 38 logs were used, with na average diameter of 34cm (excluding the bark and measured at base and top of the log), average length of 3 m and conicity of 1%. The average volume of 38 logs was equal to 10.35m³ and the volume of residues generated during log processing was 2.17m³, implying a transformation coefficient (C_t) of 79%. Processing machine Pica-Pau type was classifies a good machine to be used in the processing of logs, however, the processing time is higher than the time used by the most used band saws, making it less attractive in the processing of wood by large companies. From the qualitative point, the waste generated in the production of the plank is mostly the sawdust.

Keywords *Eucalyptus* sp., Log, Sawdust, Waste, Wood

1. Introduction

Wood can be used of several ways, for examples, in civil construction as structural members or materials to buildings and as raw material to panels and furniture industries [1-4]. In Brazil, woods of the genus *Pinus* and *Eucalyptus* from planted forests are used by this companies [5, 6].

One of the most important phases of the transformation of the wood into the most diversified products is its first processing, which must be carried out in a rational way taking full advantage of the log with the least possible residue production [7].

However, timber industries, particularly sawmills, generate a large amount of residue, with low yields of timber production, since the necessary uses of these wastes are not always given, which are dispersed and can lead to serious environmental and social problems [8].

It is estimated that the loss of wood in the first processing is around 50% of the original volume of the wood log used, that is, not only the problems of pollution, but also the economic problem with the waste of the raw material [9-13].

The company was chosen to carry out this research because it presents a different method of first processing than is usually used in the other sawmills of the region, using an alternative saw, wood processing machine, called Pica-Pau type. Company still uses this machine because, according to its directors, its main focus is the treatment of roundwood, that is, whole wood, and sometimes some customers order for sawed pieces of the genus *Eucalyptus* sp.

The aim of this paper was investigate the solid waste generation (qualitatively and quantitatively) during first processing of log in an alternative saw, wood processing machine, Pica-Pau type.

2. Material and Methods

The wood processing machine Pica-Pau type (Fig. 1.a) studied in this research was installed in a company located in the Itapeva city, state of São Paulo, Brazil. For study of waste volume were considered 38 logs of *Eucalyptus* sp. wood genus (Fig. 1.b) with average diameter (disregarding of bark and measured at the base and top of the log), length and conicity equal to 34 cm, 3 m and 1%, respectevely, with the

average extraction of 10 planks per log.

(a)

(b)

Figure 1. (a) Wood processing machine Pica-Pau type; (b) *Eucalyptus* sp. wood genus logs

After all necessary adjustments (Fig 2.a), the machine is driven causing the track to move horizontally toward the saw blade that moves perpendicularly to the movement of the log for removal of the planks (Fig. 2.b). Planks generated from wood processing had an average thickness of 2.50 cm, a length of 3 m and well varied widths (Fig. 2.b).

(a)

(b)

(c)

Figure 2. (a) Machine adjustments; (b) First processing of *Eucalyptus* sp. log; (c) Produced planks by machine Pica-Pau type

Eq. 1 present the count of the volumes of logs with cone trunk geometry (Fig. 3), where L denotes the length of the logs, n_t is the total number of logs processed and D_t and D_b are the diameters measured at the base and at the top of the roundwood, respectively. The total volume (V_{tor}) corresponding to the 38 logs calculated by Equation 1 was equal to 10.35 m³.

$$V_{tor} = \frac{\pi}{12} \cdot \sum_{i=1}^{n_t} L_i \cdot \left(Dt_i^2 + Db_i^2 + Dt_i \cdot Db_i \right) \quad (1)$$
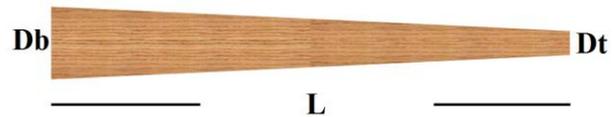

Figure 3. Geometry considered to total volume of logs

After selecting the 38 logs and calculating their respective volumes, the estimated volume of residues (V_{res}) was obtained by the difference between the volume of the logs and the total volume of the planks (V_{ta}) (Eq. 3), where the total volume of the boards was obtained by means of Eq. 2, considering the geometry of each plank (Fig. 4).

$$V_{ta} = \frac{1}{2} \cdot \sum_{i=1}^{n_{ta}} L_i \cdot \left(e_{1i} \cdot t_{1i} + e_{2i} \cdot t_{2i} \right) \quad (2)$$

$$Vres = Vtor - Vta \quad (3)$$

From Eq. 2, e_1 and e_2 are thickness measureds at extremities of planks, t_1 and t_2 are width measureds at extremities of planks and n_{ta} is the total number of planks.
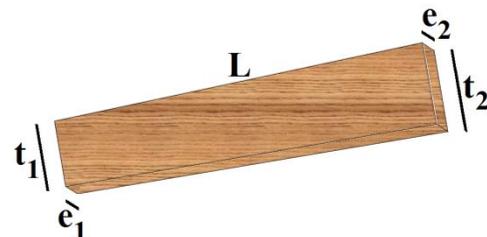
Figure 4. Geometry considered to volume of planks

The efficiency of the wood processing machine Pica-Pau type (C_t) was calculated by Eq. 4, expressed as a percentage.

$$C_t = \frac{V_{ta}}{V_{tor}} \cdot 100 \ (\%) \qquad (4)$$

3. Results and Discussions

Using Eq. 3, the volume of residues generated during processing of the 38 *Eucalyptus* wood genus logs was 2.17 m^3. This volume of waste is equivalent to 20.97% of the total volume of the logs, implying a transformation coefficient of 79%, which classifies the Pica-Pau type as a good machine to be used in the processing of logs.

However, a negative point for its use is the processing time, which is higher than the time used by other machines used by the industry [9-18], which makes it impossible to use it in the processing of roundwood by large companies, due to increased competitiveness and technological advances aimed at minimizing waste production with the shortest time of machine operations [16].

It can be observed that, even with this machine that has a high conversion value ($C_t = 79\%$), there is a considerable waste production, being the use of techniques that minimize the formation of residues a systemic practice during the processes of logs in sawmills, always aiming at improving production lines to reduce waste generations.

Qualitative analysis of resídue

From the qualitative analysis, the residues generated in the processing machine Pica-Pau type are mostly saw dust. The sawdust was deposited in a special compartment for collecting the residue (Fig. 5) or on the different points of machine elements (Fig. 6).

Figure 5. Sawdust generated by process with Pica-Pau type machine on the compartment for collecting

Figure 6. Sawdust generated on the different points of machine elements

4. Conclusions

Researches on waste production in the wood process industries is important for improvements in this sector. This study of, processing machine Pica-Pau type, proved to be eficient in agreement with the low production of waste versus the quantity of planks produced, however, the required processing time is higher than the time used by other machines with the same purpose, making it less attractive in large sawmills.

REFERENCES

[1]   Almeida, T. H.; Almeida, D. H.; Araujo, V. A.; Silva, S. A. M.; Christoforo, A. L.; Lahr, F. A. R. Density as estimator of dimensional stability quantities of Brazilian tropical woods. BioResources. v. 12. n.3, p. 6579-6590, 2017.

[2]   Almeida, T. H.; Almeida, D. H.; Ferro, F. S.; Varanda, L. D.; Campos, C. I.; Christoforo, A. L.; Lahr, F. A. R. Avaliação da qualidade na produção industrial de compensados por meio de teses de flexão e de cisalhamento. Madeira: Arquitetura e Engenharia. v.12, p. 45-50, 2011.

[3]   Almeida, D. H.; Ferro, F. S.; Varanda, L. D.; Souza, A. M.; Icimoto, F. H.; Christoforo, A. L.; Lahr, F. A. R. Quality control in plywood manufacturing: physical properties of commercial plywood of Pinus sp. International Journal of Composite Materials. v. 3, p. 163-167, 2013.

[4]   Almeida, T. H. Criação e implantação de procedimentos logísticos em uma indústria de móveis: estudo de caso.51 p., 2013. Monografia (Graduação em Engenharia Industrial Madeireira). Campus Experimental de Itapeva, Universidade Estadual Paulista, Itapeva, 2013.

[5]   Almeida, D. H. Análise das resistências ao embutimento e de compressão para madeiras de Pinus e Eucalipto. 100 p., 2011. Monografia (Graduação em Engenharia Industrial Madeireira). Campus Experimental de Itapeva, Universidade Estadual Paulista, Itapeva, 2011.

[6]   Almeida, D. H.; Almeida, T. H.; Molina, J. C.; Ferro, F. S.; Christoforo, A. L.; Lahr, F. A. R. Embedment strength of Pinus sp. wood to metal pins. Advanced Materials Research. v.884, p. 653-656, 2014.

[7]   Gonçalves, M. T. T. Processamento da madeira. Bauru: Center Xerox, 2000. 242p.

[8]   Brand, M. A.; Muñiz, G. I. B.; Silva, D. A.; Klock, U. Caracterização do rendimento e quantificação dos resíduos gerados em serraria através do balanço de materiais. Revista Floresta. v. 32, n.2, p 247-259, 2002.

[9]   Murara Junior, M. I.; Rocha, M. P.; Timofeiczyk Junior, R. Rendimento em madeira serrada de Pinus taeda para duas metodologias de desdobro. Revista Floresta. v. 35, n.3, p 473-483, 2005.

[10] Vieira, R. S.; Lima, J. T.; Silva, J. R. M.; Hein, P. R. G.; Baillères, H.; Baraúna, E. E. P. Small wooden objects using Eucalypts sawmill wood waste. BioResources. v. 5, n.3, p 1463-1472, 2010.

[11] Ofoegbu, C.; Ogbonnaya, S.; Babalola, F. D. Sawmill conversion efficiency and wood recovery of timber species in Cross River State Nigeria. Agriculture and Forestry. v.60, n.1, p. 105-113, 2014.

[12] Silva, C. P.; Vieira, R. S.; Silva, I. C.; Pereira, A. S.; Baraúna, E. E. P. Quantification of waste produced in the Gurupi, TO lumber industry. Floresta e Ambiente. v.24, e00065613, 2017.

[13] Monteiro, T. C.; Lima, J. T.; Silva, J. R. M.; Trugilho, P. F.; Baraúna, E. E. P. Energy balance in sawing *Eucalyptus grandis* logs. BioResources. v.12, n.3, p. 5790-5800, 2017.

[14] Almeida, D. H.; Poleto, S. F. S.; Almeida, T. H.; Lahr, F. A. R. Análise da geração de resíduos sólidos no processamento da madeira em máquina tipo Pica-Pau. In: *III Simpósio sobre Resíduos Sólidos (SIRS), 2013, São Carlos*.

[15] Fagundes, H. A. V. Produção de madeira serrada e geração de resíduos do processamento de madeira de florestas plantadas no Rio Grande do Sul.173 p., 2003. Dissertação (Mestrado em Administração). Universidade Federal do Rio Grande do Sul, Porto Alegre, 2010.

[16] Heinrich, D. Simulação da produção de madeira serrada.158 p., 2010. Dissertação (Mestrado em Inovação na Edificação). Universidade Federal do Rio Grande do Sul, Porto Alegre, 2003.

[17] Dutra, R. I. J. P.; Nascimento, S. M.; Numazawa, S. Resíduos de indústria madeireira: caracterização, consequências sobre o meio ambiente e opções de uso. Revista Científica Eletrônica de Engenharia Florestal.n.5, p 1-19, 2005.

[18] Alves, L. S.; Silva, S. A. M.; Azambuja, M. A.; Varanda, L. D.; Christoforo, A. L.; Lahr, F. A. R. Particleboard produced with sawmill waste of different wood species. Advanced Materials Research. v. 884, p. 689-693, 2014.