

УДК 674.02

DOI: 10.18698/2542-1468-2017-4-70-72

## OPTIMIZATION OF THE CUTTING SCHEDULE DURING SANDING

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The present paper work is part of a research project developed in Romania during last few years and applied to several under-utilized wood species, such as alder, poplar and birch, with a view to capitalize these wood resources for their further use in furniture industry. The paper aims to identify the best cutting schedule during the wood sanding process when considering the power consumption as an optimization criterion. The sanding was applied to black alder wood (*Alnus glutinosa* L.) by using a wide belt sander machine with variable cutting parameters, three grit sizes, and three sanding directions. The experiments were performed under industrial conditions and all data were processed through the regression method. The results of the present study showed the increase of power consumption along the increase of feed speed and cutting depth, respectively.

**Keywords:** black alder, sanding process, feed speed, cutting depth, power consumption

**Suggested citation:** Salca Emilia-Adela. Optimization of the cutting schedule during sanding. Lesnoy vestnik / Forestry Bulletin, 2017, vol. 21, no. 4, pp. 70–72. DOI: 10.18698/2542-1468-2017-4-70-72

### INTRODUCTION

The sanding process is the last machining operation applied to wooden surfaces mostly in wood-working and furniture industry, with a view to increase the surface quality of the product by enhancing its appearance and thus increasing its aesthetic value [1]. The sanding process of wood was extensively studied during the last decade. There are several variables to be considered for the sanding process, such as: wood moisture content, wood species, wood density, processing direction, grit size, cutting pressure, belt speed, feed speed, cutting depth, and grit size [2–4]. The grit size influences the wood surface quality while the speed, pressure and oscillations do not have a certain and critical effect upon it [5]. Kilic et al. showed the interaction wood-machine-tool with its direct effect on wood surface quality [6]. The material removal rate can change with the variation of pressure and the power consumption were found to increase with the increase of sanding pressure [7]. In his study Saloni found that the power consumption during sanding increased with the belt speed and feed speed [8]. Varanda et al. also confirmed that a higher belt speed consumed more power to different types of sandpapers [9]. Javorek et al. found that the wood species presented a very low influence on power consumption, but the pressure, sanding direction and speed had an overwhelming influence upon the cutting power [10].

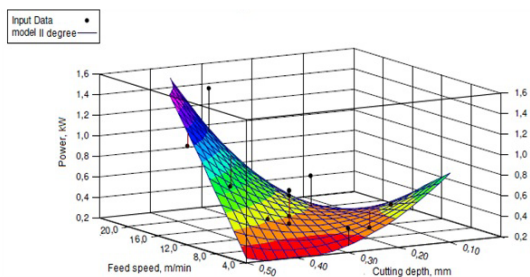
The present paper aims to identify the best cutting schedule during the wood sanding process when considering the power consumption as the optimization criterion. The sanding was applied to black alder wood (*Alnus glutinosa* L.) by using a wide belt sander machine with variable cutting parameters, three grit sizes, and three sanding directions.

### MATERIAL AND METHOD

Defect free black alder (*Alnus glutinosa*) timber pieces were purchased from a local company in Buzau, Romania. The samples were cut at dimensions of 300 by 95 by 16 mm and they were sanded on a wide belt sander machine having the following technical characteristics: abrasive belt dimensions of about 1900 × 1130 mm, sanding speed (against the feed direction) of about 16 m/s, contact pressure of about 4,5 bar and feed speed between 4 and 20 m/min. The samples presented 8 % moisture content. The feed speed and cutting depth varied as follows: 4, 8, 12, 16 and 20 m/min and 0,1; 0,2; 0,3; 0,4 and 0,5 mm, respectively. The factorial experiment with two variables was applied. The sanding was performed for a total of 39 wooden samples along three cutting directions (13 pieces allocated for each direction) such as parallel, perpendicular and at 45° angle to the grain. Three grit sizes of corundum abrasive, namely 80, 100 and 120 were used for the experiment. They were combined into three different sanding programs having the following sequences: 80 and 120 grit sizes; 100 and 120 grit sizes and 120 grit size. Initially the 60 grit size sandpaper was used for the calibration step. The power consumption of sanding and feeding was recorded at milisecond but the effective power during sanding was calculated as a difference between the recorded power and the power during idle running. The regression method with a second degree non-linear model was used.

### RESULTS AND DISCUSSIONS

The effect of sanding by using various cutting schedules on the power consumption was shown through the 3D surfaces obtained by mathematical simulation for each one of the sanding sequence



**Fig. 1.** Variation of power consumption during the parallel sanding of black alder wood using the sanding sequence of 100 and 120 grit sizes as a function of feed speed and cutting depth

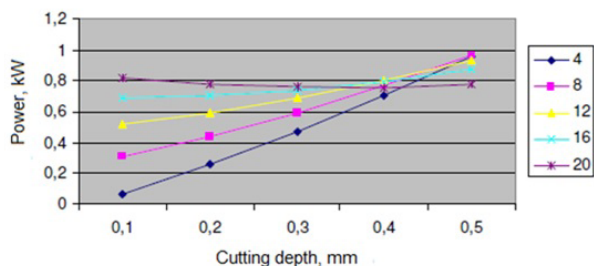
**Рис. 1.** Изменение потребления энергии при параллельном шлифовании древесины черной ольхи с использованием последовательности шлифования размером 100 и 120 зерен в зависимости от скорости подачи и глубины резания

and sanding direction. Fig. 1 presents an example of such variation of power consumption using the parallel sanding sequence of 100 and 120 grit sizes as a function of the feed speed and cutting depth.

As a result of the performed analysis, the following conclusions were pointed out:

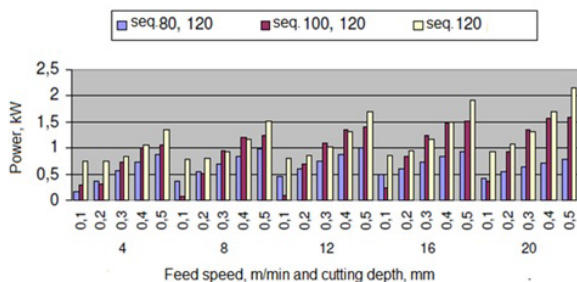
- The most reduced value of the power consumption of about 0,06 kW was recorded for the sanding of black alder wood at an angle of 45 degree to the grain orientation, during the sanding sequence of 120 grit size after calibration, for a feed speed of 4 m/min and a cutting depth of 0,1 mm (fig. 2).

- In case of parallel sanding at a feed speed of 16 m/min and a cutting depth of 0,1 mm when applying the sanding sequence of 100 and 120 grit sizes, a minimum power consumption of about 0,13 kW was determined, while in the case of perpendicular sanding, for the same sanding sequence, the minimum value of about 0,07 kW was determined at a feed speed of 8 m/min and a cutting depth of 0,1 mm (fig. 1 and fig. 3).



**Fig. 2.** Variation of power consumption during the sanding of black alder wood at an angle of 45 degree to the grain orientation when using the sequence of 120 grit size as a function of feed speed and cutting depth

**Рис. 2.** Изменение энергопотребления при шлифовании древесины черной ольхи под углом 45 градусов к ориентации зерна при использовании последовательности размером 120 зерен в зависимости от скорости подачи и глубины резания



**Fig. 3.** Variation of power consumption during the perpendicular sanding of black alder wood when using three sanding sequences as a function of feed speed and cutting depth

**Рис. 3.** Изменение энергопотребления при перпендикулярном шлифовании древесины черной ольхи при использовании трех шлифовальных последовательностей в зависимости от скорости подачи и глубины резания

- The power increased with the increase of feed speed and cutting depth for all the sanding programs.

- The highest power consumption was determined, as expected, in case of perpendicular sanding for all three sanding sequences (fig. 3). Such sanding is not recommended for production because the specific productivity represents 30...100 % of the sanding when processed parallel to the grain.

- The cutting schedule are to be chosen based on the criterion of a minimum power consumption and therefore the parallel sanding is recommended.

- It appeared that the sanding sequence of 100 and 120 grit sizes generated the best results for a minimum power consumption.

### CONCLUSIONS

The results of the present work showed that the parallel sanding with a sequence of 100 and 120 grit sizes may be selected to fulfill the criterion of a minimum power consumption. Based on the findings of this work and apart of the presented approach, by applying a joint criterion of power consumption and surface quality, a better cutting schedule may be obtained.

Such results are to be compiled in future works with a view to achieve a more efficient use of the raw material for furniture manufacturing.

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Received 10.05.2017

## ОПТИМИЗАЦИЯ РЕЖИМОВ РЕЗАНИЯ ПРИ ШЛИФОВАНИИ

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Настоящая работа является частью исследовательского проекта, выполняемого в Румынии в течение последних нескольких лет и направленного на применение некоторых малоиспользуемых древесных пород, таких как ольха, тополь и береза, с целью капитализации этих древесных ресурсов для их дальнейшего использования в мебельной промышленности. Целью статьи является определение наилучшего режима резания во время процесса шлифования древесины при рассмотрении потребления энергии в качестве критерия оптимизации. Шлифование древесины ольхи черной (*Alnus glutinosa* L.) проводилось с использованием широколенточно-шлифовальной машины с переменными режимами резания, для трех размеров абразивного зерна, в трех направлениях шлифования. Исследования проводились в промышленных условиях, все данные обрабатывались методом регрессионного анализа. Результаты данного исследования показали увеличение потребления энергии по мере увеличения скорости подачи и глубины среза, соответственно.

**Ключевые слова:** ольха черная, процесс шлифования, скорость подачи, глубина среза, потребление энергии

**Ссылка для цитирования:** Salca Emilia-Adela. Optimization of the cutting schedule during sanding. *Lesnoy vestnik / Forestry Bulletin*, 2017, vol. 21, no. 4, pp. 70–72. DOI: 10.18698/2542-1468-2017-4-70-72

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Статья поступила в редакцию 10.05.2017 г.