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STUDY ON INFLUENCING FACTORS OF SANDING EFFICIENCY OF ABRASIVE BELTS IN WOOD MATERIALS SANDING

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ABSTRACT

The aim of this paper was to explore the correlation between the sanding efficiency and the surface quality, provided a standard for judging the end of belt life in the actual production, so that improved the overall economic efficiency under the premise of ensuring product quality. This study selected material type, Manchurian ash, Birch and medium density fiberboard (MDF), sanding direction (longitudinal and transverse) and granularity (60 and 100 grit) as influencing factors, analyzed their influence on the sanding efficiency and the surface quality, and observed the surface of specimens by SEM. Results indicated that the highest sanding efficiency was obtained by MDF when sanded with 60 grit abrasive belt, Manchurian ash acquired the lowest sanding efficiency when sanded with 100 grit abrasive belt in longitudinal direction. Moreover, the lowest Ra was yielded by Manchurian ash when sanded with 100 grit abrasive belt in transverse direction, MDF gained the highest Ra when sanded with 60 grit abrasive belt. It also could be noted that there was not a visible correlation between sanding efficiency and surface quality in all cases in this study, but the belt should be replaced when the material removal rate reduced to a certain level, so that acquire better product quality and economic efficiency.

KEYWORDS: Sanding efficiency, surface roughness, material type, sanding direction, granularity.

INTRODUCTION

As a precise machining process, the sanding process will influence the quality of wood products. The sanding efficiency of abrasive belts can be evaluated by material removal rate, while the surface quality can be evaluated by surface roughness Ra. However, both of them will be influenced by many factors, such as properties of wood, granularity of abrasive belt, sanding direction, pressure and so on.

Taylor et al. (1999) studied the relationships between the input variables and material removal rate, surface roughness. For evaluating the impact of factor-level combinations of input variables (wood species, interface pressure, type of abrasive mineral and sanding direction), a randomized full-factorial design with local control was utilized in their experiments. All treatments considered were replicated through a sequence of three different granularities. The results signified that the individual effect of pressure was significant throughout all granularity levels. Furthermore, with regard to the coarsest grit size and all species, silicon carbide yielded a better surface than aluminum oxide. Two-way and three-way factor interactions were not visible for both material removal rate and surface roughness.

According to Magoss and Sitkei (2001), the surface quality would be influenced by several factors both from wood properties and machining processes. The wood properties included grain, density, moisture content and any others, such as the number and distribution of fibers and conduits, the content of cellulose, lignin and extractivest.

According to Saloni et al. (2005), the material removal rate could be changed with the variation of pressure, abrasive type, granularity and sanding speed. When the pressure increased, the power consumption increased linearly. In most cases, a higher snading speed could produce a better surface. Sanding process was characterized by material removal rate, final surface texture and power consumption for wood.

On the basis of Saloni (2007), several variables should be controlled in the sanding process, such as sanding direction, sanding speed and pressure as well as the moisture content and later cleaning. Moreover, Ratnasingam et al. (1999) stated that precautions to these variables were for the purpose of improving the sanding quality and extending the belt's service life.

Porankiewicz et al. (2010) stated that because there were many various sanding parameters, especially wood species, the problem of sanding intensity and power consumption had not been solved yet. For the purpose of obtaining an ideal sanding efficiency, different sanding parameters should be taken into consideration for different wood species.

MATERIAL AND METHODS

Three species of materials were selected in this study, Manchurian ash (*Fraxinus mandshurica* Rupr.), Birch (*Betula*) and MDF as specimens, dimensions of them were 50×50×30 mm, and the average density of them were 0.62, 0.47 and 0.78 g.cm^{-3} successively, both the equilibrium moisture content of Manchurian ash and Birch were 8 % approximately. The granularities of abrasive belts used in this study were 60 and 100 grit, and all the abrasive belts were composed of aluminum oxide grains.

Experiments were done on an abrasive belt sanding efficiency test system. The system was composed of a loading unit that supplied a certain pressure, a moving unit that taken the specimen reciprocating motion, and an electronic counter that recorded the sanding frequency. Also, a surface roughness tester Surtronic 3^{+} manufactured by Taylor Hobson was used to evaluate the surface quality, and a precise balance BSA423S manufactured by Sartorius was applied to record the removal rate of the specimen. In addition, a SEM was utilized to observe the morphology of the sanded surface.

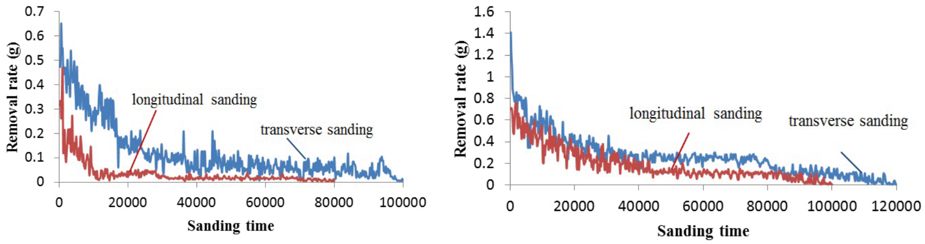
Prior to the experiments, all the specimens were machined by a circular saw and a planning machine to ensure the dimensions, and then sanded to a satisfactory surface by the sanding machine. After fixing the abrasive belt and the specimen, the test system was turned on. After sanding at circles of 200 times, removed the specimen and measured the material removal rate by the precise balance. Similarly, after sanding at circles of 1000 times, removed the specimen and measured the surface roughness Ra by the surface roughness tester.

Repeated above-mentioned experiments until the material removal rate declined to zero approximately, then varied the variables in this study. But with regard to MDF, there was not a specific sanding direction. In all test conditions, three repetitions were made to minimize the influence of wood anatomies when measured the surface roughness. The final value of the surface roughness was an average value. Finally, observed the sanded surface morphology of specimens by SEM, analyzed the results acquired in all experiments.

RESULTS AND DISCUSSION

Variations of sanding efficiency

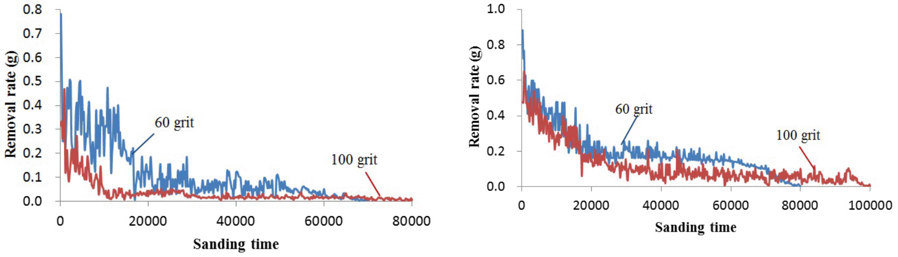
Fig. 1 shows comparisons of sanding efficiency between longitudinal sanding (sanding motion parallel to the wood grains) and transverse sanding (sanding motion perpendicular to the wood grains) of Manchurian ash and Birch sanded with 100 grit abrasive belts. It presents similar results when sanded with 60 grit abrasive belt. As it can be seen, the removal rate of longitudinal sanding is lower than that of transverse sanding. According to Stewart and Crist (1982), during sanding process, each abrasive particle acted as a small knife with a low or even negative rake angle, inducing high normal forces on the wood surface. The fibers are cut off directly when sanded in the perpendicular direction to the wood grains, while they are mostly stripped when sanded in the parallel direction to the wood grains. In addition, some abrasive particles may fall into the notches of wood vessels, leading to these particles move along the notches in the whole longitudinal sanding process. While there are more effective particles participate in sanding in transverse sanding virtually.



a) b)

Fig. 1: Comparisons of sanding efficiency between longitudinal sanding and transverse sanding of Manchurian ash and Birch sanded with 100 grit abrasive belt
Note: a) Manchurian ash b) Birch.

Fig. 2 shows comparisons of sanding efficiency between 60 and 100 grit abrasive belts of Manchurian ash sanded both in longitudinal and transverse direction. It indicates that the sanding efficiency of 60 grit abrasive belt is higher than that of 100 grit, whatever the sanding direction is. Also, the sanding of Birch and MDF reveal similar results. It is because that the abrasive belt of 60 grit has a deeper particle penetration relatively in the case of a certain speed and pressure. Moreover, the gap among particles of 60 grit abrasive belt is larger than that of 100 grit, it is beneficial to remove chips and reduce the heat immediately, leading to a delay of particle loss.



a) b)

Fig. 2: Comparisons of sanding efficiency between 60 and 100 grit of Manchurian ash sanded both in longitudinal and transverse direction.
Note: a) Longitudinal direction, b) Transverse direction.

Fig. 3 shows comparisons of sanding efficiency among the three different species of specimens sanded with 100 grit abrasive belt, Manchurian ash and Birch were sanded both in longitudinal and transverse direction. The similar results also can be found when sanded with 60 grit abrasive belt. As we can see, the removal rate of MDF is the highest, while the lowest sanding efficiency is gained by Manchurian ash, no matter any direction it is sanded in. It is mainly due to the influence from the properties of material itself. The hardness of Manchurian ash is the highest relatively. Besides, Manchurian ash has the best capability of resisting wear and tear than Birch and MDF. Moreover, MDF is made from fibers, it are combined through the function of adhesive, leading to a lower internal bonding strength. And the adhesive can accelerate the loss of the particles.

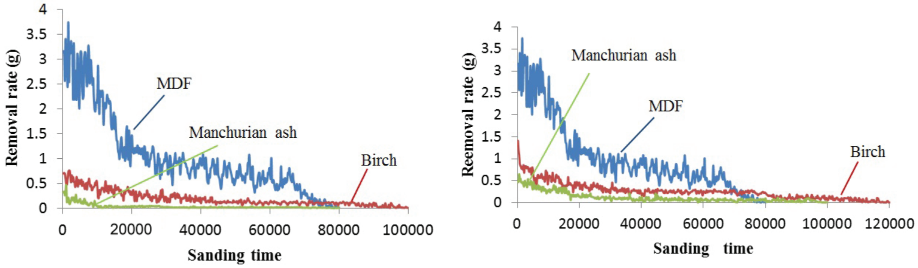


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Fig. 3: Comparisons of sanding efficiency among the three different species of specimens sanded with 100 grit abrasive belt in longitudinal and transverse direction.
Note: a) Longitudinal direction, b) Transverse direction.

Variations of surface roughness

Fig. 4 indicates variations of surface roughness of Manchurian ash sanded with 60 and 100 grit abrasive belts, both in longitudinal and transverse directions. The sanding of Birch and MDF signify similar results. It can be noted that the surface roughness of longitudinal sanding is higher than that of transverse sanding, and the surface roughness presents a negative correlative trend with the increase of abrasive granularity. The similar observation has been reported by de Moura et al. (2005), they confirmed that surface roughness was obviously higher in perpendicular to the moving direction of abrasive belt than along it. According to de Almeida Varasquim et al. (2012), more abrasive particles would act on the surface when the bigger grit abrasive belt was used. Thus, efforts would be distributed in a larger number of grains and the machining groove, so each grain would present a smaller depth, favoring a better finish.

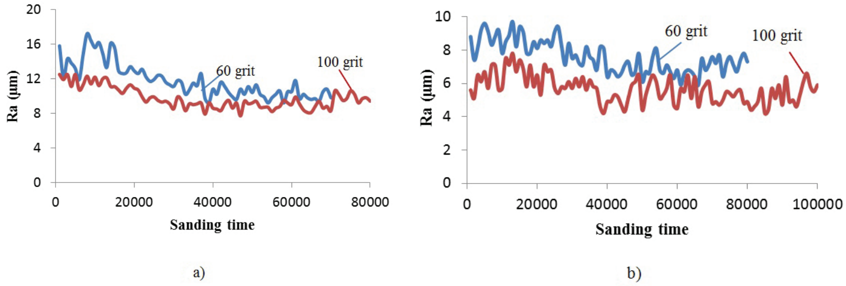

Fig. 4: Variations of surface roughness of Manchurian ash sanded with 60 and 100 grit abrasive belts. Note: a) Longitudinal direction, b) Transverse direction.

Fig. 5 shows comparisons of surface roughness Ra of three kinds of specimens sanded with 100 grit abrasive belt, Manchurian ash and Birch were sanded in longitudinal direction. A similar result can be found when sanded in transverse direction, even sanded with 60 grit abrasive belt. It signifies that the highest surface roughness is obtained by MDF, and the sanding of Manchurian ash acquires the lowest surface roughness. It is mainly resulted from the different properties of specimens itself. Fibers of MDF seem to be more irregular and smaller than solid wood, and they are combined through the function of adhesive. However, fibers of solid wood are combined to each other directly through intermolecular forces. In the sanding process, fibers of MDF could not be cut off completely, leading to wood wools on the surface. While Manchurian ash has a relatively higher hardness so that sanding traces on the surface are not visible. Moreover, on the basis of Aguilera (2011), the resulting surface roughness at different machining conditions followed a linear relationship with the density distribution of MDF, leading to a higher roughness level of the core layer and a lower surface roughness level of the outer layers with higher density.

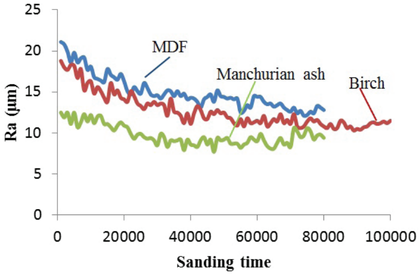

Fig. 5: Comparisons of surface roughness of three kinds of specimens sanded with 100 grit abrasive belt in longitudinal direction.

As it can be seen in the comparison of Figs. 3 and 5, the removal rate declines significantly in the beginning period, then the variation tends to be stable within a long period, followed by a slowly downward trend in the later period. The surface roughness seems to present a similar trend, but increases slightly when the removal rate decreases to a certain level. The comparisons of other conditions concerned in this study reveal the same trends. It is because the existence of resin, extractive, and adhesive will corrode the particle surface to a certain extent. In the later processing period, particles of abrasive belt becomes dull severely, they cannot act as sharp knives to cut off fibers opportunely, and leave many significant nicks on the specimen surface.

SEM analysis of sanded surface

Fig. 6 show the SEM images of surface of Birch and Manchurian ash, both sanded with 100 grit abrasive belt in longitudinal and transverse directions. As we can see, sanding traces of Birch are more visible than that of Manchurian ash, whatever the sanding direction is. In addition, the traces of longitudinal sanding seem to be more obvious than that of transverse sanding. The fibers of Birch are cut off directly when sanded in transverse direction, while they seem to be stripped when sanded in longitudinal direction. The surface of Manchurian ash sanded in longitudinal direction seems to be the smoothest, while surface of Birch sanded in transverse direction appears more wood wools. The similar phenomena have been discovered by de Moura and Hernandez (2006).

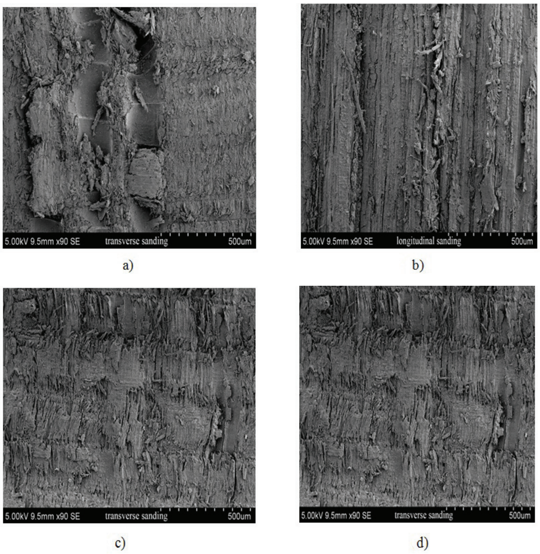

Fig. 6: SEM images of surface of Birch and Manchurian ash sanded with 100 grit abrasive belt. Note: a) Birch sanded in transverse direction, b) Birch sanded in longitudinal direction, c) Manchurian ash sanded in transverse direction, d) Manchurian ash sanded in longitudinal direction.

CONCLUSIONS

The most important conclusion was that there was no linear relationship between the sanding efficiency and the surface quality. But when the sanding efficiency decreased to a certain level, the surface quality of specimens seemed to be worse and worse, the belt should be replaced timely so that ensure the product quality and the overall economic efficiency in actual production.

The highest sanding efficiency was obtained by MDF when sanded with 60 grit abrasive belt, while Manchurian ash acquired the lowest sanding efficiency when sanded with 100 grit abrasive belt in longitudinal direction. Moreover, the lowest Ra was yielded by Manchurian ash when sanded with 100 grit abrasive belt in transverse direction, while the MDF gained the highest Ra sanded with 60 grit belt.

The smaller granularity belt seemed to be more suitable for precise sanding of wood products, while the bigger granularity abrasive belt was more appropriate to improve the productivity in the wood processing industry.

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