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The Effect of Machining Parameters on Surface Roughness of Alder Wood

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ABSTRACT- ***In order to build up a bridge between quality and productivity, the present research focus on optimization of CNC end milling process parameters to provide good surface finish as well as high material removal rate. Hence, after converting the lumbers and air drying at sheltered condition, specimens with dimension of 15×10×2.5 cm were randomly obtained from alder and prepared for CNC milling for evaluation of surface quality of the specimens after different milling condition, milling rate (8.37 and 15.07 m/s), feeding rate (6 and 12 m/min), depth of milling (1 and 5 mm), milling pattern (radial and tangential) and milling method (Up-milling and down-milling) were selected as variables. Edge roughness of the milled specimens was measured using Stylus profilometer following ISO 13565 standard. Evaluation surface quality was carried out employing Abot group (Rk, Rpk and Rvk). The influences of the parameters were analyzed as fractional factorial at completely randomized block design at 95 confidence level. The result showed that milling rate, milling pattern and feeding rate have significant influence on surface quality. In conclusion, for achieving an optimum surface quality when milling alder wood, milling speed of 150.07 m/s, feeding rate of 6 m/min, milling pattern of parallel, milling depth of 1 mm and milling on tangential section is recommended.***

Keywords---- Milling rate, Feeding rate, Profilometer, Surface quality

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1. INTRODUCTION

Quality and productivity are two important but conflicting criteria in any machining operations. In order to ensure high productivity, extent of quality is to be compromised. It is, therefore, essential to optimize quality and productivity simultaneously (Moshat et al., 2010). Technological progress along with consumer demands and expectations continues to increase demands on global resources, leading to major problem of material availability and environmental sustainability (Faruk et al. 2012). Productivity can be interpreted in terms of material removal rate in the machining operation and quality represents satisfactory yield in terms of product characteristics as desired by the customers (Moshat et al., 2010).The surface finish and material removal rate have been identified as quality attributes and are assumed to be directly related to productivity. On the other hand, solid waste management is a significant challenges and growing in many developed and developing countries. Solving old and new challenges requires human ingenuity and creativity and also need an approach to make better and greater use of renewable resources, increases the resilience and diversity of production systems (Aghakhani et al., 2013).

Alder (*alnus*) is the common name of around 34 different species of perennial dicotyledonous trees and shrubs belonging to the *Betulaceae* family that are widespread in temperate, cool and alpine ecosystems on open areas, in forests, in riparian habitats, in mine spoils, in gravel deposits and under wet and cold tundra conditions (Thomsen et al., 2013). In the evolution towards more modern systems, flexible manufacturing became prevalent between the 1970s and 1980s to enable low batch production of a wide range of parts that Computer Numerical Controlled (CNC) machines is a critical manufacturing resource due to their capability for being reprogrammed to produce different parts (Xu et la., 2007). Khazaeian et al. (2010) investigated the effect of milling condition on edge surface quality of MDF outer and core layers during CNC milling. The results showed that surface layer of MDF due to higher density has better response to milling but the core layer due to its lower density, the formed saw flour is as result of bending fracture that leads to rougher surface.

Khazaeian (2005), studied the influence of species and machining parameters on surface quality of poplar, beech and oak according to the results during transverse machining, the pattern of cutting (parallel cutting) has positive effect on surface quality and increase of feeding rate leads to decreasing surface quality and increasing cutting speed has more favorable effect in light of surface quality on specious with higher density. Davin et al (2007) evaluated the surface roughness of

MDF during milling process and reported that with increasing of cutting speed and decreasing feeding rate the surface roughness decreases. There is no available important on optimum milling (CNC) condition for alder, hence, the purpose of this study was to determine the effect of cutting rate, depth of cutting, feeding rate, milling pattern and milling direction on surface roughness of alder.

2. MATERIAL AND METHOD

The raw material of this study consisted alder (Alnus glutinosa) that kindly provided by from a particleboard plant in Gorgan, Iran. The experimental design is provided in table 1. Variables of this study included milling rate (8.37 and 15.07 m/s), feeding rate (6 and 12 m/min), depth of milling (1 and 5 mm), milling pattern (radial and tangential) and milling method (Up-milling and down-milling).

Table 1: The experimental design

Parameter			Repetition
Milling depth (mm)	Milling method	Milling pattern	
1	Up-milling	tangential	5
		radial	5
	Down-milling	tangential	5
		radial	5
5	Up-milling	tangential	5
		radial	5
	Down-milling	tangential	5
		radial	5

3. RESULT AND DISCUSSION

Tables 2, 3 and 4 show the effect of every variable on surface quality based on their importance. As in can be seen, the parameters based on their properties are (machining practices, cutting velocity (VC), interaction, cutting velocity and feeding velocity, interaction of feeding velocity and cutting pattern, interaction cutting velocity and cutting pattern and finally interaction feeding velocity and cutting depth.

Table 2: Effect of Milling depth

Milling depth (mm)	R_p	R_a	R_z	R_k	R_{pk}	R_{vk}	R_{max}	R_v
1	33.1	18.73	65.42	26.44	15.27	27.01	80.74	26.44
5	34.57	18.85	66.26	26.67	20.47	27.49	81.26	26.67

* Means with different letter groupings are different (P < 0.01).

Table 3: Effect of Milling method

Milling method	R_p	R_a	R_z	R_k	R_{pk}	R_{vk}	R_{max}	R_v
Up-milling	33.59	18.73	65.42	26.44	15.27	27.01	80.74	40.02
Down-milling	33.84	18.85	66.26	26.67	20.47	27.49	81.26	40.17

* Means with different letter groupings are different (P < 0.01).

Table 4: Effect of Milling pattern

Milling pattern	R_p	R_a	R_z	R_k	R_{pk}	R_{vk}	R_{max}	R_v
Tangential	32.19	18.28	64.80	26.10	17.24	25.69	80.09	39.31
Radial	35.24	19.29	66.88	27.07	18.50	28.81	81.91	40.89

* Means with different letter groupings are different (P < 0.01).

Regarding cutting velocity there is a reverse relation between cutting velocity and value of Ra. That this can be due to decreasing of teeth burden that finally leads to decreasing surface roughness. The other parameters do not independent effect on Ra but have interaction. According to interaction of two parameters of VC and VF, it's better to increase cutting velocity and decrease feeding velocity. Cutting pattern Ra and concerning interaction of cutting velocity and feeding velocity it seems that maximum cutting speed and minimum feeding velocity (figs 1-8).

At tangential direction should be applied. Cutting depth, however is considered as influence factor on surface roughness but at the given cutting and feeding velocities, did not have independent effect on any of roughness parameters but it has interaction with feeding velocity. Hence, for avoiding residues and saving the raw material it is better to use low cutting depth. At it is evident from Fig.2. Independent effect of milling method, milling velocity on Ra at 95% confidence level is significant, while, other parameters had no significant independent on effect on Ra.

As it can be seen from fig 3, interaction milling velocity and feeding velocity on Ra at 95% confidence level in comparison to other parameters have the highest influence. In other words, with increasing of feeding velocity and decreasing milling velocity, roughness parameters increased. (Paulo et al., 2005) evaluated the effect of milling and feeding velocities in CNC milling on MDF surface quality concluded that increasing milling velocity and decreasing feeding velocity feeds to better surface quality. Feeding interaction of feeding velocity and milling pattern on Ra parameters at 95% significance level is meaningful that with increasing feeding velocity and radial milling pattern lead to rougher surface. Sadoh and Nakato, 1987 by investigating the surface quality of ring porous and wood species during milling reported. That tangential surface has lower surface roughness.

Interaction milling velocity and cutting pattern is significant at 95% significance level, so that with decreasing milling velocity and employing radial milling pattern surface quality decreases (figs 1-8). Interaction feeding velocity and cutting depth in significant ($p \leq 0.05$) and with decreasing cutting velocity and employing radial milling pattern, surface roughness increases.

Interaction feeding velocity and cutting depth is also significant ($p \leq 0.05$). With increasing of feeding velocity and cutting depth, surface roughness increases. Rmax among the studied variables, only milling method has significant in depend effect on R max ($p \leq 0.05$). Pareto charts (Fig 4) for Rmax verifies the result based on Fig 4 Rv parameters. At tangential direction should be applied. Cutting depth, however is considered as influence factor on surface roughness but at the given cutting and feeding velocities, did not have independent effect on any of roughness parameters but it has interaction with feeding velocity. Hence, for avoiding residues and saving the raw material it is better to use low cutting depth. At it is evident from Fig.2. Independent effect of milling method, milling velocity on Ra at 95% confidence level is significant, while, other parameters had no significant independent on effect on Ra.

Interaction of milling velocity and cutting pattern is significant at 95% significance level, so that with decreasing milling velocity and employing radial milling pattern surface quality decreases. Interaction of feeding velocity and cutting depth in significant ($p \leq 0.05$) and with decreasing cutting velocity and employing radial milling pattern, surface roughness increases. Interaction of feeding velocity and cutting depth is also significant ($p \leq 0.05$). With increasing of feeding velocity and cutting depth, surface roughness increases. Rmax among the studied variables, only milling method has significant in depend effect on R max ($p \leq 0.05$). Pareto charts (Fig 4) for Rmax verifies the result.

4. CONCLUSION

The result showed that milling rate, milling pattern and feeding rate have significant influence on surface quality. Increasing milling rate and decreasing feeding rate leads to increasing surface quality. The surface quality of the counter milled specimen resulted in increasing surface roughness. The other evaluated parameters did not have significant influence on surface roughness. Finally, for achieving an optimum surface quality when milling alder wood, milling speed of 150.07 m/s, feeding rate of 6 m/min, milling pattern of parallel, milling depth of 1 mm and milling on tangential section is recommended.

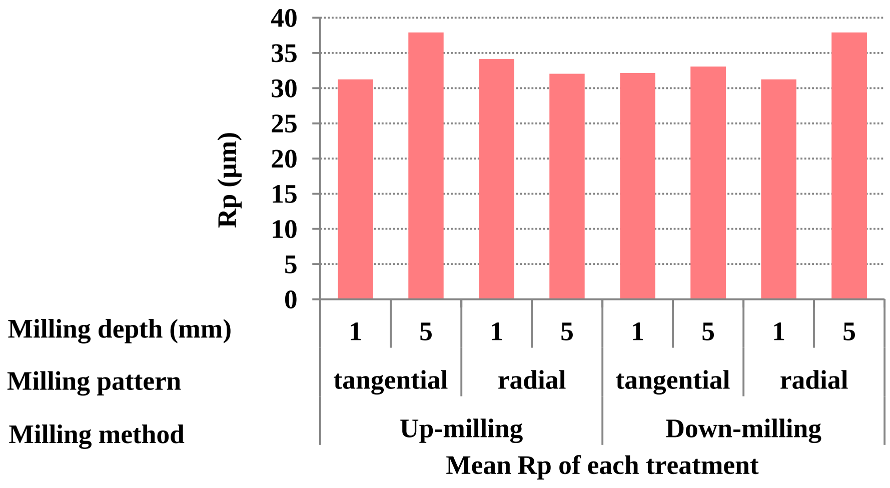

Figure 1: Effect of different parameters on mean Rp of each treatment

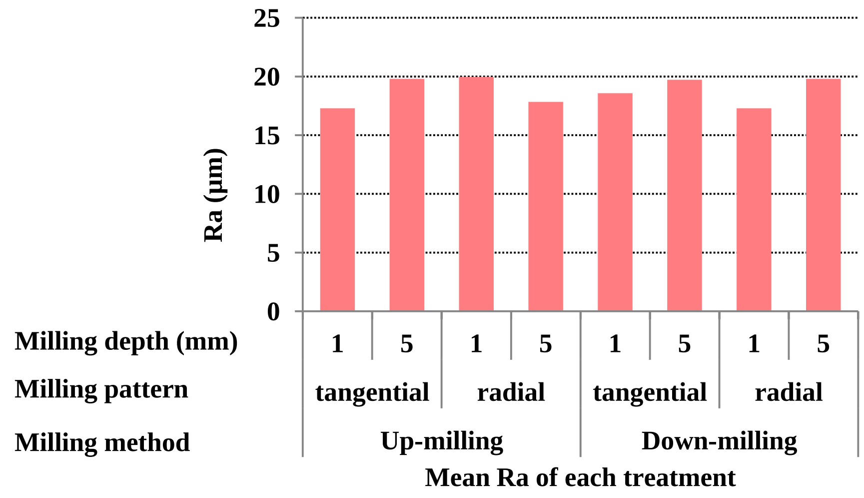

Figure 2: Effect of different parameters on mean Ra of each treatment

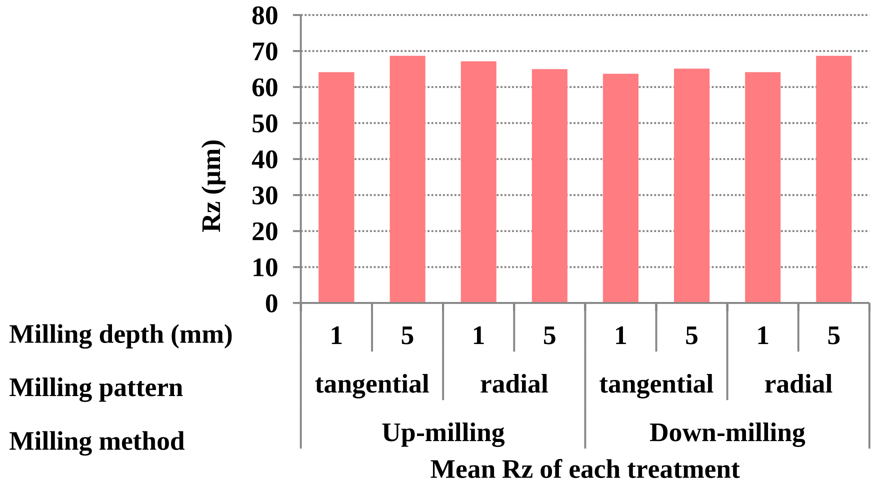

Figure 3: Effect of different parameters on mean Rz of each treatment

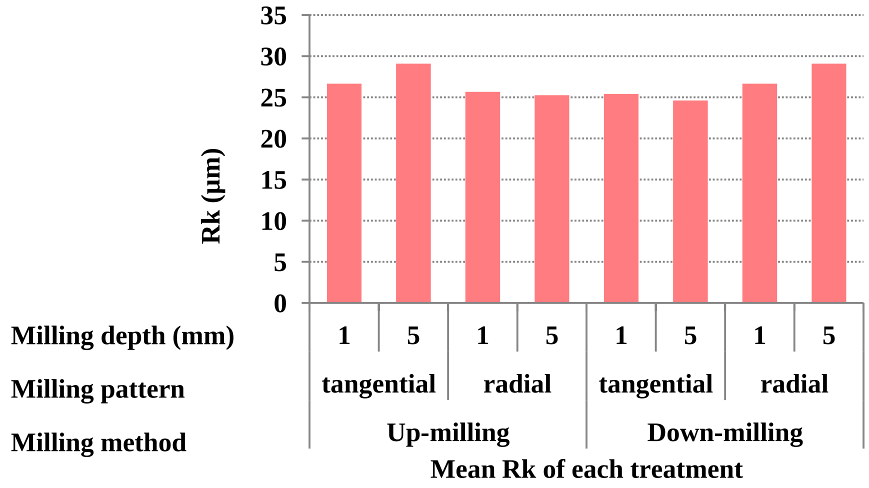

Figure 4: Effect of different parameters on mean Rk of each treatment

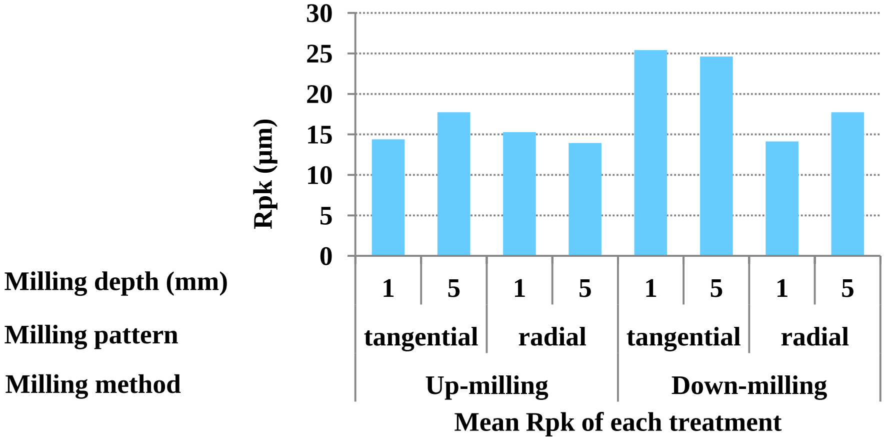

Figure 5: Effect of different parameters on mean Rpk of each treatment

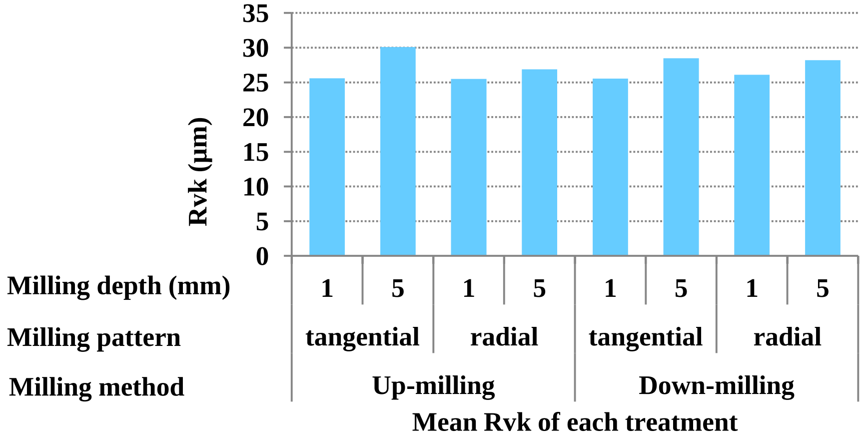

Figure 6: Effect of different parameters on mean Rvk of each treatment

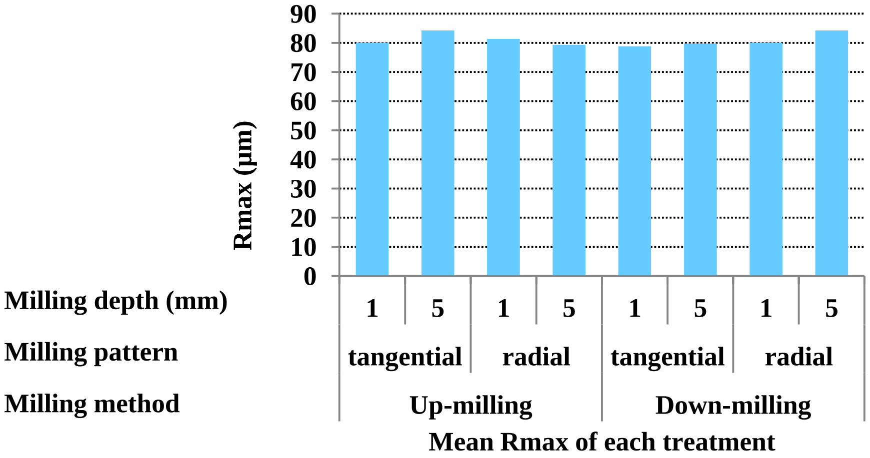

Figure 7: Effect of different parameters on mean Rmax of each treatment

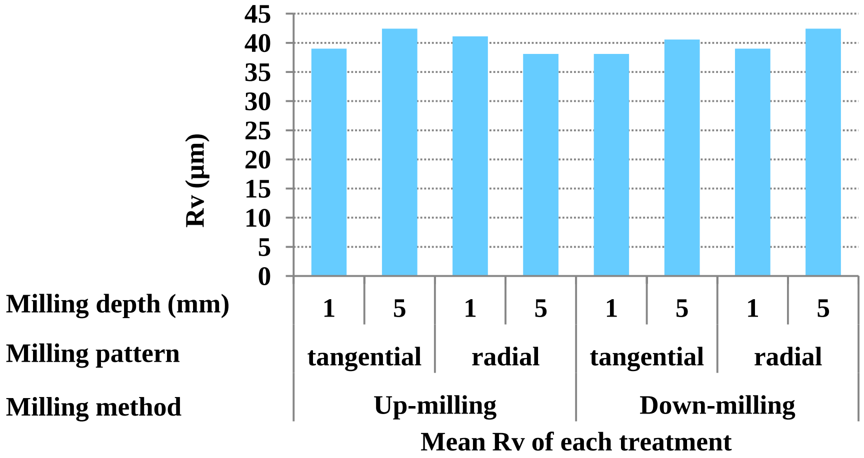

Figure 8: Effect of different parameters on mean Rv of each treatment

5. REFERENCES

- Aghakhani M., Enayati H., Naddalizadeh H., Pirayesh H., 2014. The potential for using the sycamore (Platus orientalis) leaves in manufacturing particleboard. Int J Environ Sci Technol 11(2):417–422
- Davin P.J., Clemente V.C., Silva S., 2007. Surface roughness aspects in milling MDF. Int J Ad Manuf Technol, DOI 10.1007/soo 170-007-1318-z.
- Faruk O., Bledzki A.K., Fink HP, Sain M., 2012. Biocomposites reinforced with natural fibers: 2000–2010. Prog Polym Sci 37:1552–1596
- Khazaeian A., 2005. 3D caracterization of wood surface quality measuring strategy, influence of species and machining parameters, Ph.D. Thesis, university of ENGR, 241 pages.
- Khazaeian A., Mazomei Z., Tabarsa T., 2010. Evaluation of MDF edge surface quality during milling, Journal of wood and forest sciences, 1(17): 49-63 (in Persian).
- Moshat S., Datta S., Bandyopadhyay A., Pal P.K., 2010. Optimization of CNC end milling process parameters using PCA-based Taguchi method, International Journal of Engineering, Science and Technology, 2(1): 92-102.
- Paulo P., Gordon S., 2005. Characterization of the wear behavior of polycrystalline diamond (PCD) tools when machining wood-based composites, Journal of Materials Processing Technology, 162-163: 665-672.
- Sadoh T., Nakato K., 1987. Surface properties of wood in physical and sensory aspects, Wood science and Technology, 21: 11-20.
- Thomsen P.T., Ahrenfeldt J., Thomsen S.T. 2013. Assessment of a novel alder biorefinery concept to meet demands of economic feasibility, energy production and long term environmental sustainability, biomass and bioenergy, 53: 81-94.
- Xu X., Newman S.T., 2006. Making CNC machine tools more open, interoperable and intelligent review of the technologies computers in industry, 57: 141–152.