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Effect of cutting parameters on dust emission and surface roughness during helical planing sucupira wood

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Introduction

Average chip thickness is one of the most significant parameter affecting the amount of dust generated during wood machining. Thus, the optimisation of particle size in order to minimize and/or decrease the dust emissions during wood machining is of great interest. Moreover, chip thickness can be manipulated by setting different cutting parameters.

The aim of this study was hence to determine the effect of two cutting parameters on dust emission during helical planing sucupira wood.

Material and Methods

- All samples were initially placed in a conditioning room set at 20°C and 40% RH (8%) and then at 20°C and 65%RH (12%)
- Experiments were carried out with 30 flat-sawn boards of sucupira (*Diplotropis* sp.) wood from Northern Brazil
- Boards dimensions were 900 (L) x 60 (T) x 20 (R) mm
- Helical planing treatments were performed with a Casadei R63H3 planer ($\alpha = 30°$; $\phi = 14°$)
- Cutting parametes is showed in table 1
- A surface of 12.5 x 15 mm was analyzed per sample by Surface Map 2.4.13 software

Table 1: Cutting parameters used in the present study.

Parameter	Values
Moisture content (%)	8 and 12
Feed speed (m.min⁻¹)	8.5, 12, 16, and 20
Wavelength (mm)	1.5, 2.1, 2.8, and 3.5
Average chip thickness (mm)	0.10, 0.14, 0.18, and 0.22
Cutting depth (mm)	0.5

$$\text{Concentration} = A * \left(\frac{12}{f}\right)$$

A= measured mass fraction concentration (mg/m³)
f= current feed speed (m/min)

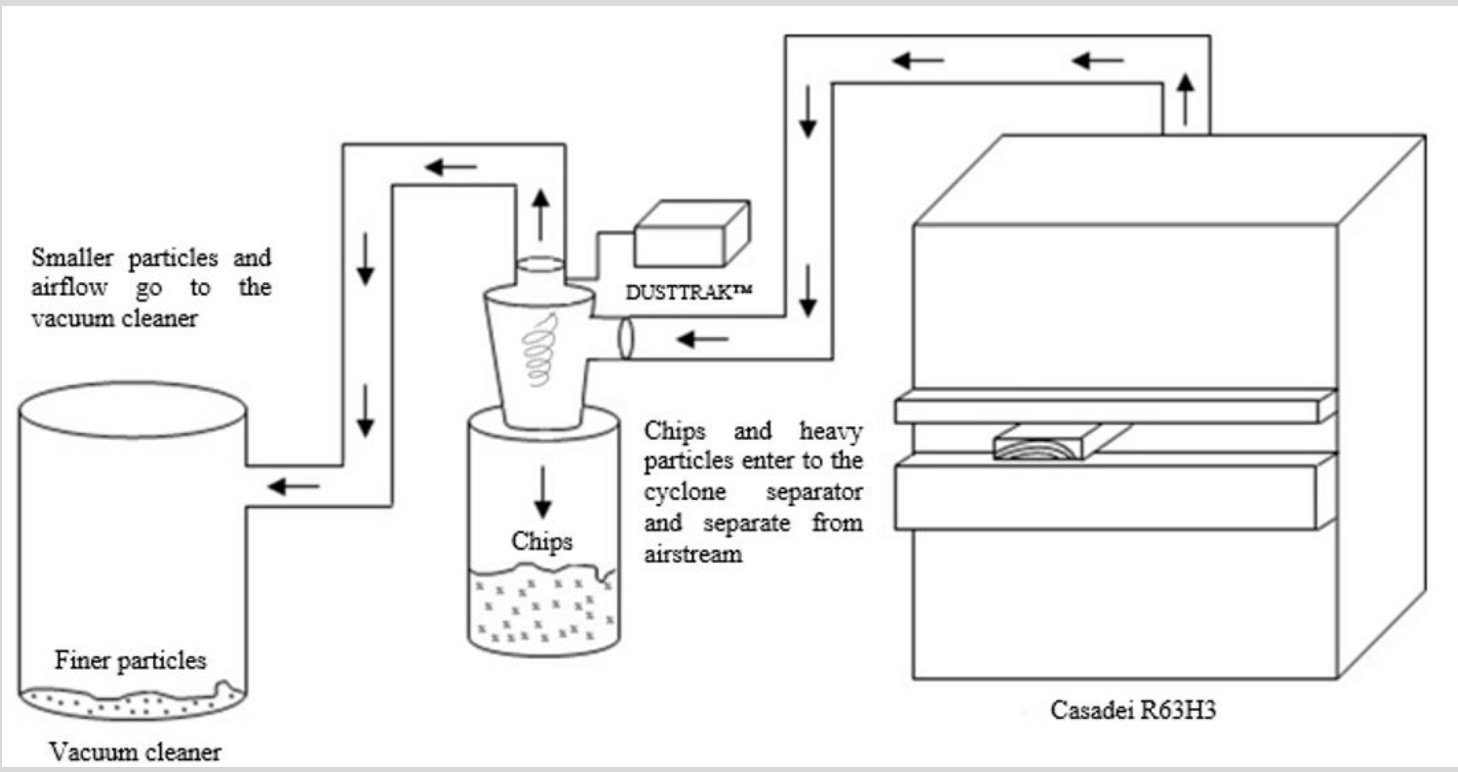

Figure 1: Dust measurement system used during machining treatments.

Results

Table 2: F-values obtained from the ANOVA for sucupira dust concentrations produced during helical planing.

Source of variation	Dust concentrations				
	$PM_{1.0}$	$PM_{2.5}$	$PM_{4.0}$	PM_{10}	Total PM
Moisture content (MC)	43.3**	49.7**	57.4**	98.0**	102.2**
Feed speed (FS)	21.2**	20.9**	28.8**	94.4**	122.7**
MC*FS	3.3*	2.6	2.2	1.7	2.27

*,** statistically significant at the 5 and 1% probability levels, respectively.

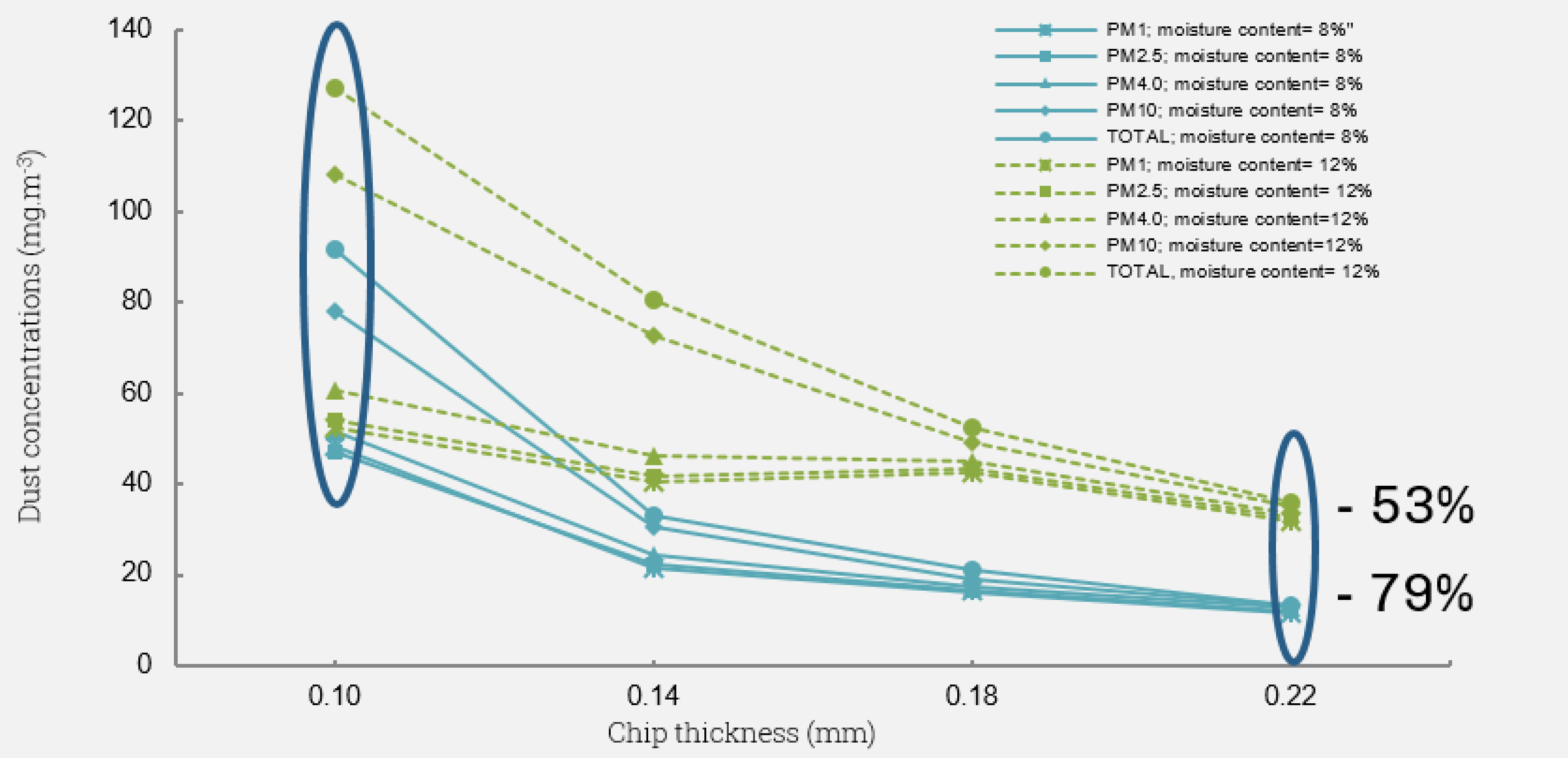

Figure 2: Dust concentrations as a function of average chip thickness for particle size fractions.

Table 3: Predictive models for adjusted dust concentrations for each dust size fraction as a function of moisture content and average chip thickness.

Dust fraction	Intercept	Coefficients		Adj. R^2
		Moisture content (%)	Chip thickness (mm)	
$DC_{PM_{1.0}}$ =	24.44	+ 4.37 (MC)	- 219.25 (a_{av})	0.65
$DC_{PM_{2.5}}$ =	22.18	+ 4.60 (MC)	- 216.23 (a_{av})	0.68
$DC_{PM_{4.0}}$ =	28.07	+ 4.97 (MC)	- 258.53 (a_{av})	0.74
$DC_{PM_{10}}$ =	61.83	+ 7.74 (MC)	- 560.19 (a_{av})	0.84
DC_{Total} =	81.23	+ 8.56 (MC)	- 686.92 (a_{av})	0.84

*all coefficients are significant at the 5% probability level.

Equation to convert adjusted dust concentration to mass fraction concentration:

$$[\ ]\ mg/m^3 = DC_{PM_n} / \left(\frac{12}{s}\right)$$

DC_{PM_n} = concentration value for a given particle size fraction (mg/m³)
s= feed speed (m/min)

Table 4: Roughness values for sucupira surfaces prepared by helical planing.

Moisture content (%)	Feed speed (m.min⁻¹)	Average chip thickness (mm)		Factor 1 S_a	S_q	S_v	S_z	S_{vk}	Factor 2 S_p	S_k	S_{pk}
8	8.5	0.10		$24^{Aa}_{(5)}$	$50^{Aa}_{(10)}$	$412^{Aa}_{(59)}$	$494^{Aa}_{(63)}$	$118^{Aa}_{(19)}$	$82^{Aa}_{(13)}$	$9^{Aa}_{(3)}$	$6^{Aa}_{(2)}$
	12	0.14	40%	$28^{Aa}_{(5)}$	$57^{Aa}_{(10)}$	$473^{Aa}_{(62)}$	$554^{Aa}_{(66)}$	$131^{Aa}_{(21)}$	$81^{Aa}_{(14)}$	$11^{Aa}_{(3)}$	$7^{Aa}_{(2)}$
	16	0.18		$40^{Ba}_{(5)}$	$85^{Ba}_{(10)}$	$591^{Ba}_{(62)}$	$686^{Ba}_{(66)}$	$174^{Aa}_{(21)}$	$94^{Aa}_{(14)}$	$13^{ABa}_{(3)}$	$10^{Aa}_{(2)}$
	20	0.22		$40^{Ba}_{(5)}$	$79^{Ba}_{(10)}$	$562^{Ba}_{(62)}$	$660^{Ba}_{(66)}$	$172^{Aa}_{(21)}$	$98^{Aa}_{(14)}$	$15^{Ba}_{(3)}$	$8^{Aa}_{(2)}$
12	8.5	0.10		$23^{Aa}_{(5)}$	$44^{Aa}_{(10)}$	$292^{Aa}_{(62)}$	$364^{Aa}_{(66)}$	$111^{Aa}_{(21)}$	$72^{Aa}_{(14)}$	$9^{Aa}_{(3)}$	$7^{Aa}_{(2)}$
	12	0.14		$30^{ABa}_{(5)}$	$53^{ABa}_{(10)}$	$351^{Aa}_{(66)}$	$468^{Aa}_{(70)}$	$129^{Aa}_{(22)}$	$88^{Aa}_{(14)}$	$12^{Aa}_{(3)}$	$6^{Aa}_{(2)}$
	16	0.18	41%	$36^{Ba}_{(5)}$	$79^{BCa}_{(10)}$	$625^{Ba}_{(66)}$	$721^{Ba}_{(70)}$	$168^{Ba}_{(22)}$	$96^{Ba}_{(14)}$	$14^{ABa}_{(3)}$	$9^{Ba}_{(2)}$
	20	0.22		$39^{Ba}_{(5)}$	$86^{Ca}_{(12)}$	$682^{Ba}_{(70)}$	$765^{Ba}_{(75)}$	$184^{Ba}_{(25)}$	$119^{Ba}_{(14)}$	$16^{Ba}_{(3)}$	$10^{Ba}_{(2)}$

Values represent the average of 10 repetitions. Standard errors are presented in parentheses. Values followed by the same letters are not significantly different at the 5% probability level. Uppercase letters: mean comparisons between feed speeds for each moisture content separately. Lowercase letters: mean comparisons between moisture contents for each feed speed separately. Factor 1: Sa = mean surface roughness, Sq = root-mean square roughness, Sv = maximum depth of valleys, Sz = ten points height of the surface, Svk = reduced valley depth and factor 2: Sp = maximum height of peaks, Sk = core roughness depth, Spk = reduced peak height.

Conclusions

- Dust emission decreased and core roughness depth (S_k) increased as average chip thickness increased
- Dust emission decreased as moisture content decreased but for certain dust particle size fractions
- The best helical planing condition was obtained when using 8% MC and 0.18 mm average chip thickness. This condition was the fastest feed speed allowable to obtain the best surface quality while minimizing dust production

Acknowledgements

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For more information please contact one of the authors