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# Design and Performance Assessment for a Novel Friction Smoke Generator

A thesis presented in partial fulfilment of the  
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## Abstract

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Friction is one of the methods used to generate smoke for food smoking applications. The method involves pressing a plank of wood against a spinning wheel, roughened to provide frictional heating. The heating raises the interface temperature above 240 °C, where smouldering occurs. The primary objective of this project was to understand the dynamics of a novel friction smoke generator, designed in a prior project, but optimised here. Sub-objectives included understanding the frictional system and its thermodynamic behaviour, and preliminary attempts to define the composition of the smoke.

The novel aspect of the design is supplementary heating additional to the heat generated by friction. This means the interface temperature is less dependent on frictional heating. A system control strategy was developed to control temperature and force.

Twenty seven experiments were carried out. Nine of them investigated the smouldering limits without supplementary heating for various pressing forces and sliding speeds. The other twelve runs were conducted with supplementary heating for 100, 150 and 200 °C and various forces at constant sliding speed. The last six experiments were selected runs from the previous experiments where smoke was collected for composition analysis.

With no supplementary heating, pyrolysis takes place when the pressing force is  $\geq 49.1$  N and the wheel speed is at  $\geq 2500$  rpm. These conditions generate interfacial temperatures within the pyrolysis range. When the system was heated, the limit where smouldering starts when 9.81 N and 200 °C were applied. Two significant results were obtained. First, the progression of smouldering, resulted in a low and high wear rate of wood. The shift between these is proposed to be an endothermic to exothermic transition. Second, the time to reach this shift is a function of the pressing force and system temperature, becoming instantaneous at 200°C for forces  $> 29.4$  N. These allowed insight to be gained into the dynamics of heat and mass transfer during friction smoking. The smoke composition analysis indicates that controlling the volatiles formation is highly achievable by varying the smoking conditions (i.e. auxiliary heat, pressing force).

The current design has some limitations, which include uncertainties in the conversion of electrical to mechanical power, vibration of the wood plank, conduction along the motor shaft and ingress of air. Recommendations are to address these by placing a thermal break on the shaft, preventing ambient air ingress into the chamber and adding a torque transducer. Further study is also recommended on the roughness and design of the friction wheel, and on scale up.



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## List of Publications

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### **Conference papers:**

Seraj, M. A., Jones, J. R., Ripberger, G. D., and Chen, Q. (2018) *Smouldering Limits in Frictional Heating of Wood – Pilot Study*. In Chemeca 2018: Queenstown, New Zealand. Available in September, 2018

### **Posters:**

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Seraj, M. A., Jones, J. R., Chen, Q., Eyres, G. (2018, June). *The Smouldering Limits of Mānuka Wood in Friction Smoke Generator*. Poster presented at FIET symposium [Presented by Muhammad Seraj].

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Seraj, M. A., Jones, J. R., Ripberger, G. D. (2017, June). *Design of a Friction Smoke Generator with Precise Control*. Oral presentation presented at FIET symposium [Presented by Muhammad Seraj].

Seraj, M. A., Jones, J. R., Chen, Q., Eyres, G. (2018, June). *The Smouldering Limits of Mānuka Wood in Friction Smoke Generator*. Oral presentation presented at FIET symposium [Presented by Muhammad Seraj].

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# Thesis Contents

Abstract.....	I
Acknowledgement.....	III
List of Publications.....	III
List of Figures.....	VI
List of Tables.....	VII
Chapter 1 Introduction.....	1
1.1 Background.....	1
1.2 Project objectives.....	2
Chapter 2 Literature Review.....	3
2.1 Introduction.....	3
2.2 Review of wood degradation chemistry.....	3
2.3 Influences of smoking conditions on the flavouring and PAH compounds.....	6
2.4 Synopsis of friction smoke generator.....	10
2.5 Frictional properties of wood.....	13
2.6 Influential factors on friction mechanisms.....	14
2.7 Temperature rise at the friction zone.....	17
2.8 Evaluation of the contact temperature.....	20
2.9 Reaction kinetics during friction.....	28
2.10 Estimating the influential parameters on heat and mass transfer.....	30
2.11 Review of friction smoke patents.....	38
2.12 Torque estimation in an induction motor.....	40
2.13 Smoke analysis methodology.....	43
2.14 Closure.....	43
Chapter 3 Design and Control Strategy.....	45
3.1 Introduction.....	45
3.2 Friction smoke generator design novelty.....	45
3.3 P&ID and CAD design.....	46
3.4 Control strategy.....	47
3.5 Friction wheel characteristic.....	48
3.6 Closure.....	48
Chapter 4 Experimental Approach.....	49
4.1 Introduction.....	49
4.2 Coefficient of friction experiment.....	49
4.3 Smouldering limits without supplementary heating experiments.....	51
4.4 Smouldering limits with supplementary heating.....	52
4.5 Smoke collection – preliminary experimental design.....	53
4.6 Closure.....	55
Chapter 5 Results and Discussion.....	57
5.1 Introduction.....	57
5.2 System limitations.....	57
5.3 Smouldering limits without supplementary heating.....	62
5.4 Smouldering limits with supplementary heating.....	64
5.5 Discussion of friction results.....	70
5.6 Smoke analysis.....	80
5.7 Proximate analysis.....	82
5.8 Closure.....	84
Conclusion and Recommendations.....	87
References.....	89
Appendix - A: Raw and supplementary data.....	93
Appendix - B: Auxiliary information.....	96



## List of Figures

Figure 2.1: The primary chemical constituents in woods .....	4
Figure 2.2: Formation of primary, secondary and tertiary volatiles.....	8
Figure 2.3: Influence of smouldering temperature on the amount of phenolic constituents.....	8
Figure 2.4: The PAH yield from lignin at various temperatures.....	8
Figure 2.5: Content of PAHs and some phenolic compounds using different smoking techniques....	12
Figure 2.6: The influence of MC on CoF for different wood species.....	14
Figure 2.7: Effect of MC on CoF from wood on steel .....	14
Figure 2.8: The influence of MC on fibre recovery from the surface softness .....	15
Figure 2.9: The influence of saturated steam on the CoF for various wood species.....	15
Figure 2.10: The variation of CoF for various wood species and steel roughness .....	16
Figure 2.11: Simulated temperature distribution in wood with respect to grit size and distance. ....	16
Figure 2.12: Interface temperature between stationary wood log and rotating steel disc .....	17
Figure 2.13: Schematic of various configurations of friction welding of wood.....	18
Figure 2.14: Temperature and CoF profile at the interface during friction welding.....	19
Figure 2.15: Schematic diagram for embedded and dynamic thermocouples set-up.....	20
Figure 2.16: Geometrical contact areas .....	22
Figure 2.17: Schematic diagram of Pin-on-Disc contact.....	22
Figure 2.18: Contact temperature rise comparison between measurement and models.....	25
Figure 2.19: The effect of forced and natural convection on contact temperature rise.....	25
Figure 2.20: The influence of the sliding speed on the flash temperature rise over time.....	26
Figure 2.21: Frictional temperature profiles for low and high Peclet numbers.....	26
Figure 2.22: Kinetic mechanisms of wood and lignin decomposition.....	29
Figure 2.23: Experimental setup from Lede, Jacques <i>et al.</i> (1985) and Peacocke, G. V. (1994) .....	31
Figure 2.24: The effect of disc velocity on ablation rate at $P=0.5$ MPa and different $T_{disc}$ .....	32
Figure 2.25: The effect of disc velocity on ablation rate at $T_{disc} = 1073$ K and different pressures ....	32
Figure 2.26: Lede's and Peacocke's work on the variation of $V/P$ with heating .....	32
Figure 2.27: The effect of pressure on ablation rate for different rod diameters.....	32
Figure 2.28: Force diagram for wood particle ablation experiment.....	33
Figure 2.29: Estimation of liquids devolatilization times with reactor temperature .....	34
Figure 2.30: Variation of heat transfer coefficient with contact pressure .....	36
Figure 2.31: The change in $(\lambda)$ as a function $(\rho)$ for various American hard wood species.....	37
Figure 2.32: The change in $(\lambda)$ as a function $(\rho)$ for various African hard wood species.....	37
Figure 2.33: Thermal conductivity for American and African wood species.....	38
Figure 2.34: Top and side views of flat friction wheel with grits .....	39
Figure 2.35: Control scheme produced based on Anderson <i>et al.</i> (1971) design. ....	39
Figure 2.36: Schematic of the voltage envelop for an AC induction motor at free load .....	40
Figure 2.37: Schematic of the AC motor and VSD working principle under load conditions. ....	41
Figure 2.38: Simplified circuit model for an induction motor .....	41
Figure 2.39: The effect of load on current consumption and rotor slip .....	42
Figure 2.40: Schematic of GC-MS devise. Retrieved from google image. ....	43
Figure 3.1: Conceptual schematic smouldering vs grinding of wood plank during friction .....	45
Figure 3.2: Friction smoke generator P&ID schematic .....	46
Figure 3.3: Friction smoke generator CAD design. ....	47
Figure 3.4: Friction wheel design patterns.....	48
Figure 4.1: The change in VSD voltage and current as a function of motor speed at free load.....	50

Figure 4.2: Power factor as a function load for induction motor .....	50
Figure 4.3: Frictional heating experiment set up.....	52
Figure 4.4: Frictional heating with external heating aid experiment set up .....	53
Figure 4.5: Smoke collecting strategy .....	54
Figure 4.6: Experimental setup and instrumentation for smoke sampling .....	55
Figure 5.1: Schematic of the heat flow ( $\rightarrow$ ) that causes overheating to the front bearing.....	59
Figure 5.2: The influence of temperature on motor current and COF.....	59
Figure 5.3: The effect of pressing force on current consumption at ambient conditions.....	60
Figure 5.4: The ball bearing temperature profile for various temperatures. ....	61
Figure 5.5: The variations in CoF, $T_f$ and wear profiles as a function of force and wheel speed. ....	62
Figure 5.6: Onset volatilisation time boundaries as a function of force and wheel speed .....	64
Figure 5.7: The influence of supplementary heat on CoF and wear of wood at 3000 rpm.....	67
Figure 5.8: Onset volatilisation time boundaries as a function of force and onset temperature .....	69
Figure 5.9: The effect of ( $T_E$ ) and ( $F_N$ ) on the transition time and the magnitude of wear rate.....	69
Figure 5.10: The mechanical power supplied for smouldering as a function of amount of wear.....	70
Figure 5.11: Equation coefficients for equation 5.2 as a function of the set-point temperature.....	72
Figure 5.12: Ratio of mechanical power input to wear rate for open door experiment .....	77
Figure 5.13: Ratio of mechanical power input to wear rate for closed door experiment .....	77
Figure 5.14: Cross-section of mānuka feedstock .....	78
Figure 5.15: The change in real contact area due to tar formation .....	78
Figure 5.16: Aromatic profile at 3000 rpm with various applied forces and onset temperatures .....	81
Figure 5.17: PAH profile at 3000 rpm with various applied forces and onset temperatures.....	82
Figure 5.18: Proximate analysis of the char yield from various smoking conditions .....	82
Figure 5.19: Char calibration curve. The yielded char recalculated for temperature.....	83
Figure A.1: Tar deposit on the friction wheel at various operating conditions. ....	93
Figure A.2: The effect of pressing force on various motor speeds.....	94
Figure A.3: GC - plot for mānuka smoke evolved during friction .....	95
Figure A.4: Wear profile during smoke sampling.....	96
Figure B.5: Air pressure verses air flow calibration curve.....	97
Figure B.6: Calibration curves actuator travel distance load cell.....	98
Figure B.7: Induction motor components .....	98

## List of Tables

Table 2.1: Sensorial judgment of few phenols .....	5
Table 2.2: The effect temperature on aromatic volatiles in wood smoke. ....	7
Table 2.3: Influence of the temperature on the phenol, carbonyl and acid yields in smoke.....	7
Table 2.4: Influence of OC used in smouldering on volatile component composition .....	9
Table 2.5: The peak temperature as a function of the thermocouple distance from the interface. ....	19
Table 2.6: The estimated thickness of liquid layer with variation of friction force .....	34
Table 3.1: List of items in friction smoke generator P&ID.....	46
Table 5.1: Assumptions used in the transient thermal analysis. ....	61
Table 5.2: Ranges of wear per kilojoule of mechanical energy input, at 3000 rpm wheel speed.....	76
Table A.1: Smoke sampling experimental data.....	94
Table B.2: Determining the moisture content (MC) of air-dried mānuka wood.....	97
Table B.3: Selection of mānuka wood planks measurements.....	97