Design and Performance Assessment for a Novel Friction Smoke Generator

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Abstract

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 ≥49.1 N and the wheel speed is at ≥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

Conference papers:

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Posters:

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

Conference and Seminar presentations:

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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].

Seraj, M. A., Jones, J. R., Chen, Q., Eyres, G., Zhang, Y. (2018, June). *Frictional Smoking of Food*. Oral presentation presented at NZIFST conference [Presented by Muhammad Seraj].

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