Real-time particle size measurements of heat-not-burn tobacco device

Introduction

A novel technology referred to as "heat-not-burn" has emerged in recent years, in which tobacco products are electrically heated to produce an inhalable aerosol. The aerosol produced by these devices (which are commercially available) is notably different in particle size to that from either conventional tobacco cigarettes, or to e-cigarettes.

Heat-not-burn uses an electrical heating element to heat tobacco, which may either be loaded into the device in loose form by the user, or contained within a single use "pod" which is user replaceable.

Background

This application note provides some preliminary particle size/concentration/mass data from a heat-not-burn device, which was purchased at a retail outlet.

Smoking Cycle Simulator

The Cambustion Smoking Cycle Simulator allows the reproduction of smoking flow profiles such as ISO or Heath Canada, or recorded real world profiles. The use of the Constant Volume Sampling principle allows straightforward calculation of total particle mass / number emissions from the cigarette, based on downstream concentration measurements.

www.cambustion.com/products/scs

DMS500 Fast Particulate Spectrometer

The DMS500 Fast Particulate Spectrometer uses unipolar corona charging and parallel detection of particles of varying electrical mobility (using electrometers) to offer real-time measurement of the particle size spectrum between 5 and 1,000 nm (optionally between 5 and 2,500 nm). Various design features allow the instrument to offer 10Hz data with a $T_{10\text{-}90\%}$ of 200ms, which is well suited to the short duration of puffs on a standard smoking profile.

This is sufficiently fast to allow resolution not only of puff-puff variation, but also intra-puff variation in particle size and concentration. The DMS500 is the only instrument to provide this speed of size-spectrum measurement in the nanoparticle range.

www.cambustion.com/products/dms500/aerosol

Experimental Setup

A heat-not-burn device was purchased at a retail outlet, and fully charged using the supplied USB charger.

The Smoking Cycle Simulator was used to reproduce a standard ISO smoking profile, while providing a high level of dilution (minimum 10:1) close to the cigarette outlet to reduce coalescence effects due to the high concentrations. This level of dilution is similar to that encountered in real world human smoking.

The device was loaded, turned on and allowed to reach operating temperature before beginning the ISO smoking regime.

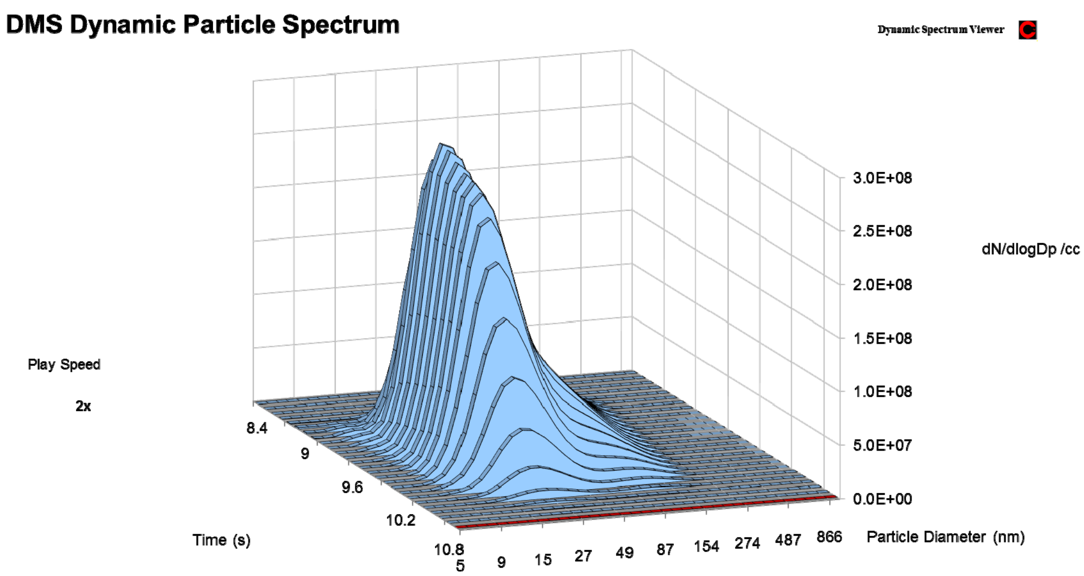
The resultant diluted smoke was fed into a DMS500 system, and particle size / mass data recorded at 10Hz.

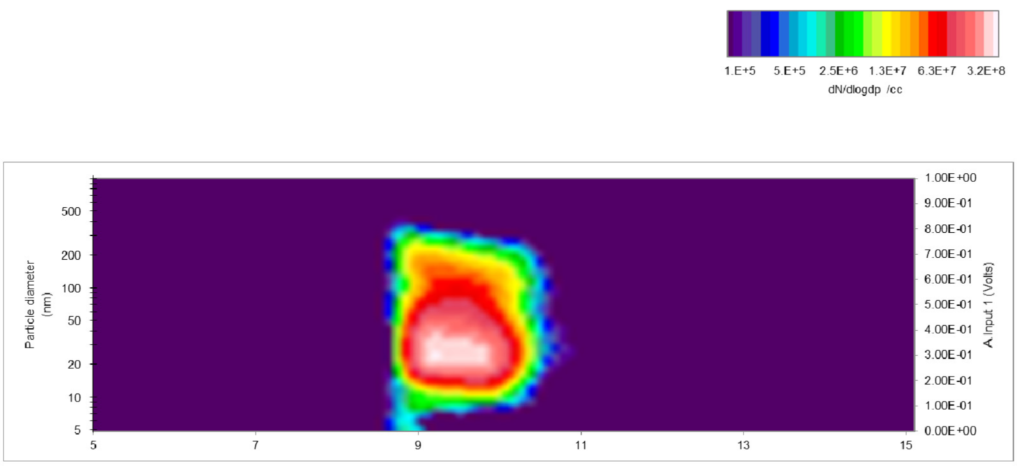
The work was performed in an indoor environment with an ambient temperature of ~23ºC.

Results

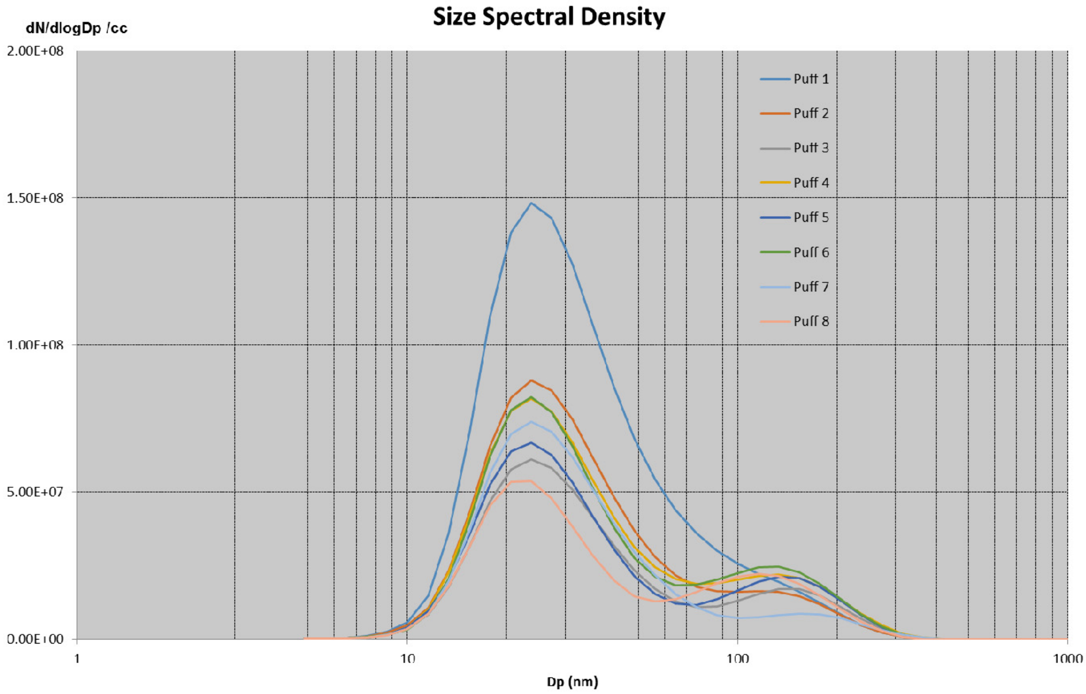
The 10Hz data available from the DMS500 allows measurement of the development of the aerosol during each puff.

The following waterfall and false colour contour plots show the first puff only:

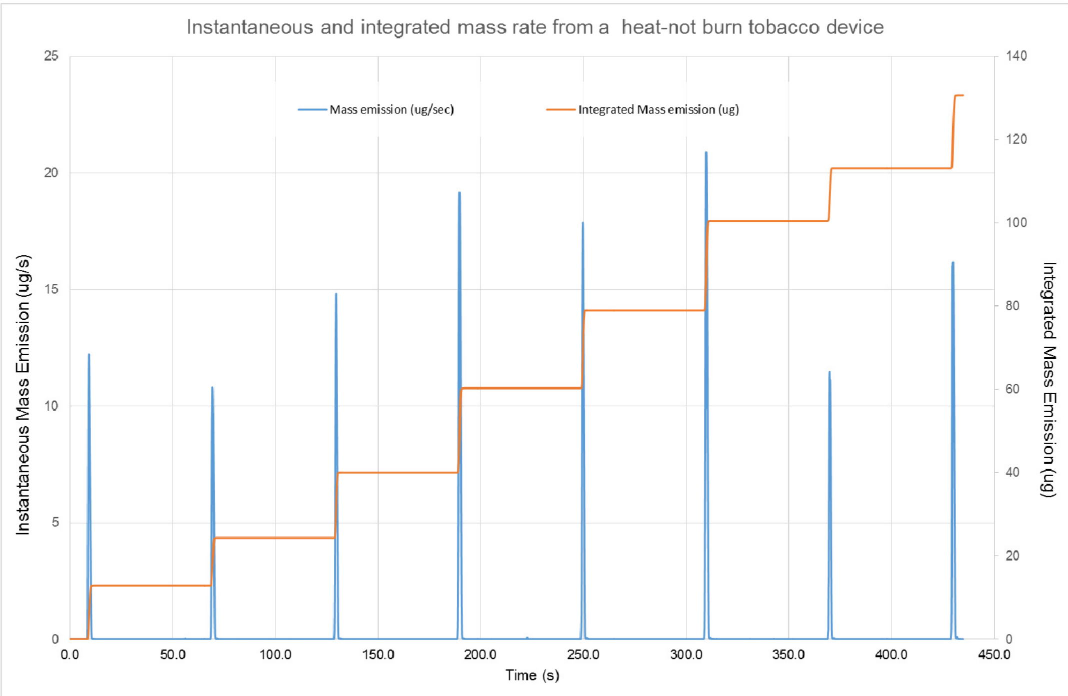




The size spectra were automatically volume weighted and assumed unit density to provide instantaneous and integrated mass.



The DMS500 is able to output calculated mass concentration (in this case unit density was assumed, but this is configurable) and to integrate to calculate total mass emission from the device.



Conclusions

The combination of DMS500 and SCS allow reproduction of standard smoking profiles, and measurement of instantaneous and integrated particle mass and number, combined with puff-by-puff size/number spectra.

Several features are notable:

The aerosol spectrum is bimodal, with the relative significance of the modes changing during the ISO smoking regime.

No dilution was applied within the DMS500 during the measurements, so it is surmised that the bimodal nature of aerosols (apart from the first puff) results from recirculation and nucleation / coalescence within the device. Aged aerosol would have a larger particle size, and this could result in the second mode.

This could be further studied with longer puffs to purge the device, or shorter intervals between puffs to reduce the time available for smoke coalescence.

Also of note is that the mass emission varies significantly puff-to-puff. The device tested incorporated a movement sensor, which shuts off the heating if the device is left stationary for a period. It was therefore necessary to remove the device from the SCS between puffs, in order to reactivate the heater.

It is possible that poor control of this process (time before the puff when the heater was reactivated) resulted in the variable mass emissions observed. A more systematic approach to this aspect would identify if this is likely to be the case.

Further Reading

SCS:	www.cambustion.com/products/scs
DMS500	www.cambustion.com/products/dms500/aerosol
Publications	www.cambustion.com/publications/Tobacco%20Aerosol
Application note 12:	http://www.cambustion.com/sites/default/files/dms12v01.pdf
Application note 14:	http://www.cambustion.com/sites/default/files/instruments/DMS/dms14v01.pdf