Water Pipe Smoking

Introduction

Water (also known as hookah or shisha) pipes are well established for the smoking of flavoured tobacco.

The different temperatures and combustion regime mean that the inhaled smoke characteristics may be different to tobacco cigarettes, while the different smoking regime employed by users further changes the nature of the inhaled aerosol.

Background

This application note provides some preliminary particle size/concentration/mass data from a water pipe.

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 water pipe was assembled and prepared with a fresh charge of tobacco.

The SCS Smoking Machine was used to reproduce a high flow smoking profile, with a flow of 200ml/s and a puff duration of 6 seconds. The puff repeat period was set at 30 seconds.

These parameters represent a somewhat arbitrary choice, although the flexibility of the SCS system means that varying them is extremely straightforward.

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

The work was performed in an outdoor environment with an ambient temperature of ~20ºC. Neither ambient humidity nor temperature were controlled.

Results

The charcoal was ignited using a gas torch, and measurement of particle data commenced with the first puff.

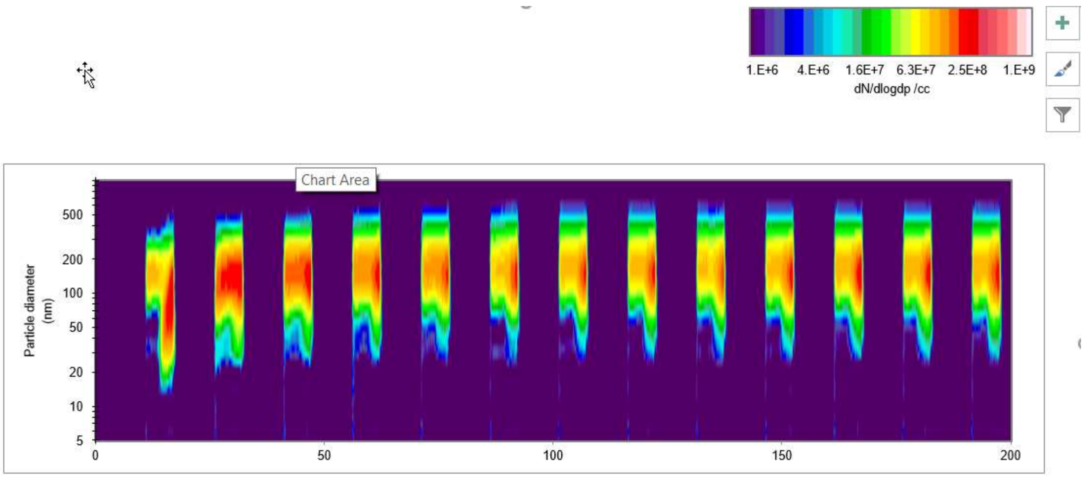

Figure 1: False colour contour plot of particle size / number data from water pipe smoking. Measurements commenced with lighting puff

The above false colour contour plot shows that the smoke size grows with subsequent puffs, starting around 70nm CMD and stabilising at 150 nm.

Aging of existing smoke left in the hose / mouthpiece in between puffs can be seen by comparing the first part of the puff (during which aged smoke is measured) with the latter part measuring fresh smoke.

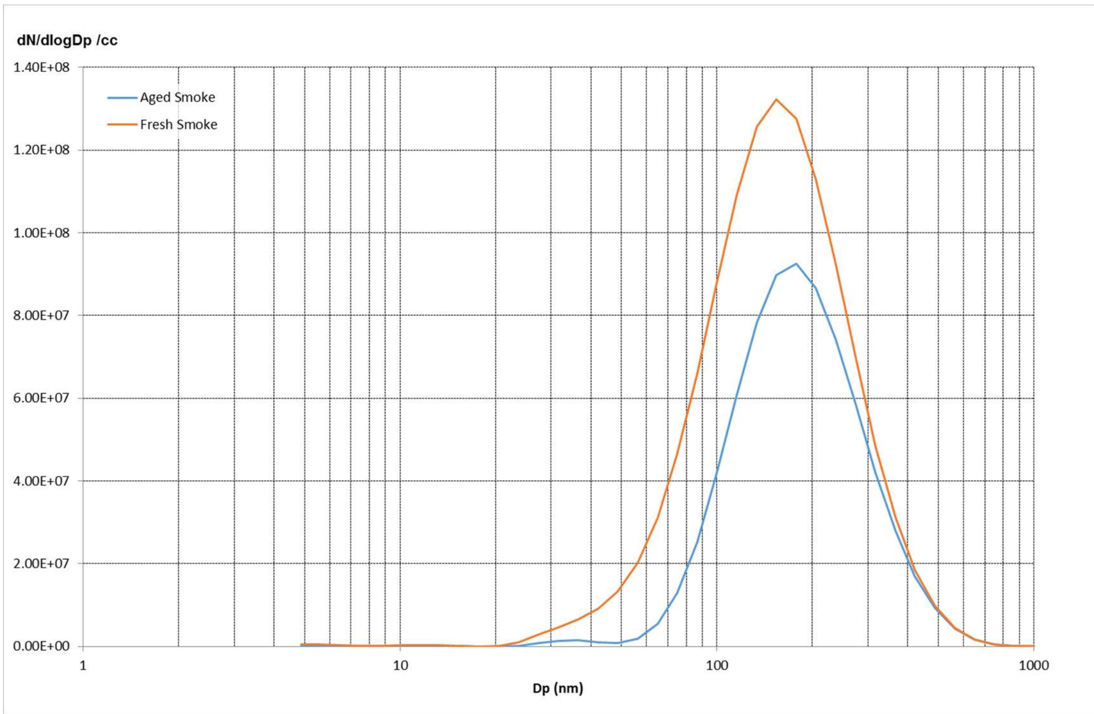

Figure 2: Comparison of average size distributions of fresh and aged water pipe smoke

Fresh smoke is observed to have a CMD around 150nm, while in 30 seconds the aged smoke has grown to ~175nm. Note that the concentration decreases as would be expected, the graph using separate y-axes to highlight the size shift.

After the 8th puff, the puff frequency was reduced to 1/minute from 2/minute. This visibly affects the size distribution (presumably due to a significant decrease in tobacco temperature).

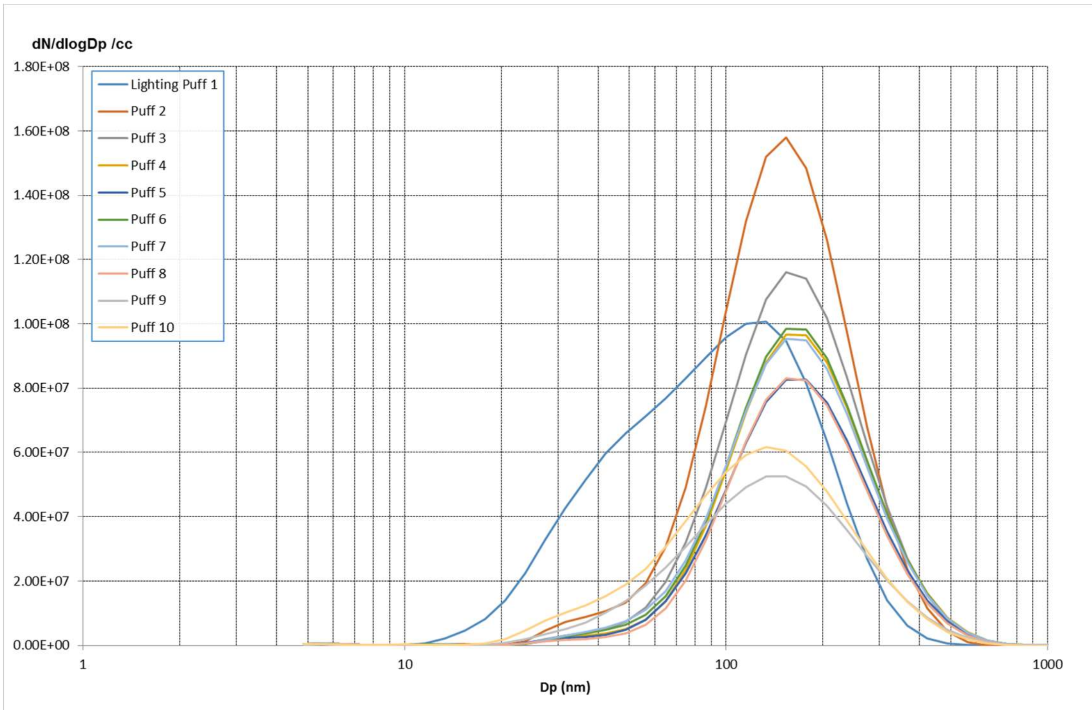

Figure 3: Comparison of average size distributions from successive water pipe puffs

Measurement of a full particle size spectrum allows the data to reweighted to volume concentration, and hence mass concentration. This can be integrated over time to allow calculation of total mass sampled.

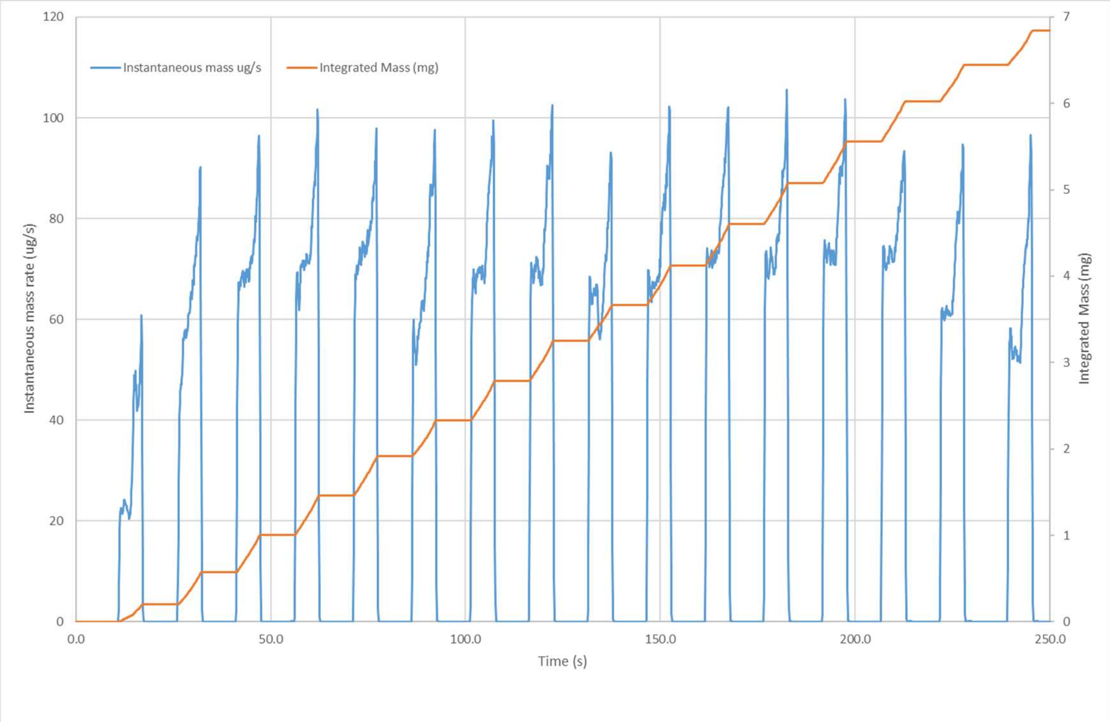

Figure 4: Instantaneous and integrated mass emissions from successive puffs of water pipe

Note the difference in mass emission rate between aged smoke (initial) and fresh smoke (towards the end of each puff) is clearly visible.

Although average size distributions may be used for ease of data handling, the DMS500 measures at 10Hz and is able to resolve rapid changes in particle size distributions. This is evident during (for example) the lighting puff shown in Figure 5. Note that it would be a matter for further study to identify whether the large particles seen (at relatively low concentration) at the start of the lighting puff are a result of lighting process, or the sampling of heavily aged smoke retained inside the water pipe from the previous smoking session.

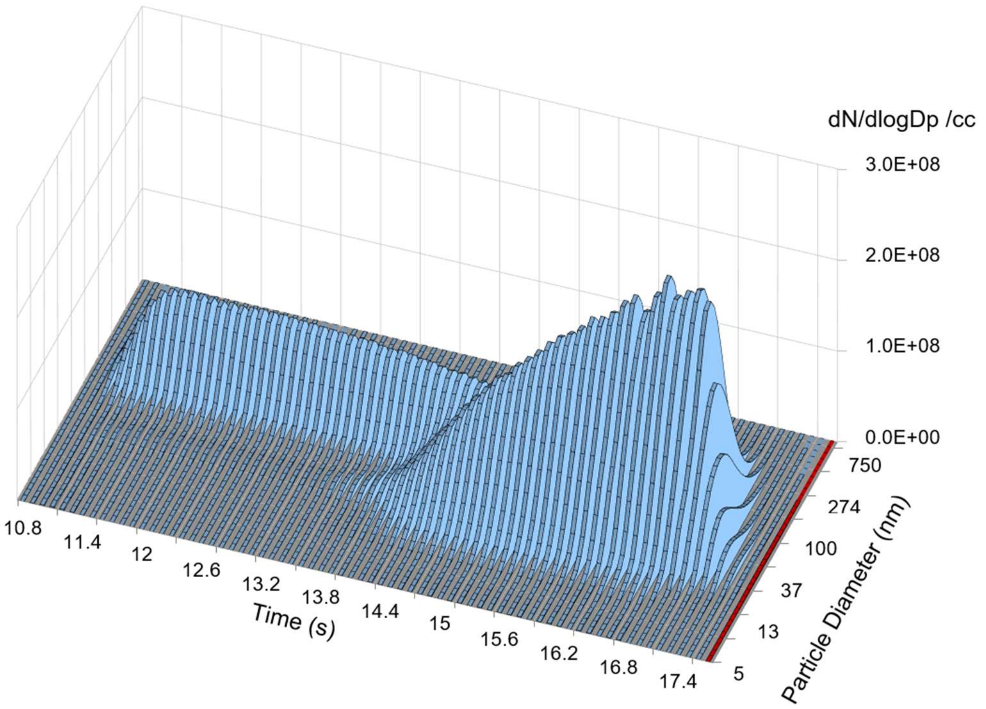

Figure 5: 10 Hz size distributions from water pipe during initial puff

Conclusions

The DMS500 and SCS are capable of water pipe smoking at representative flows and puff repeat intervals, while offering customisation of these parameters. Measurement of a full size spectrum shows changes in CMD during the smoking session, and mass weighting shows changes through the session. The different size nature of aged and fresh smoke is identified within a single puff.

Further Reading

SCS:	www.cambustion.com/products/scs
DMS500	www.cambustion.com/products/dms500/aerosol
Publications	www.cambustion.com/publications/Tobacco%20Aerosol