Aerosol Temperature Measurements for Tobacco Heating Products and E-vapour cigarettes

Cerulean, Milton Keynes, UK

Introduction

THP products often include an element that is designed to cool the aerosol before it enters the mouth. The temperature of aerosol generation, with sufficient flavour and nicotine suspended in the aerosol, is higher than would be tolerated by the consumer. Consequently the temperature of aerosol exiting the mouthpiece is of considerable interest in product design.

Experimental

Measuring this aerosol temperature requires the overcoming of a number of design challenges. The measurement tool must have sufficient accuracy and granularity to give meaningful data. This can be achieved using a thermocouple with data logging system, with the important consideration of ensuring that the thermocouple is directly in the aerosol stream, as close the butt end as possible and also not of such a mass that the thermocouple cools the aerosol stream.

A design was produced that included a thermocouple inside a Cambridge filter pad holder (figure 1) that could be split so that the holder can still be used to collect the aerosol so both temperature and quantity of aerosol can be simultaneously determined and the potential interaction of the two can be explored.

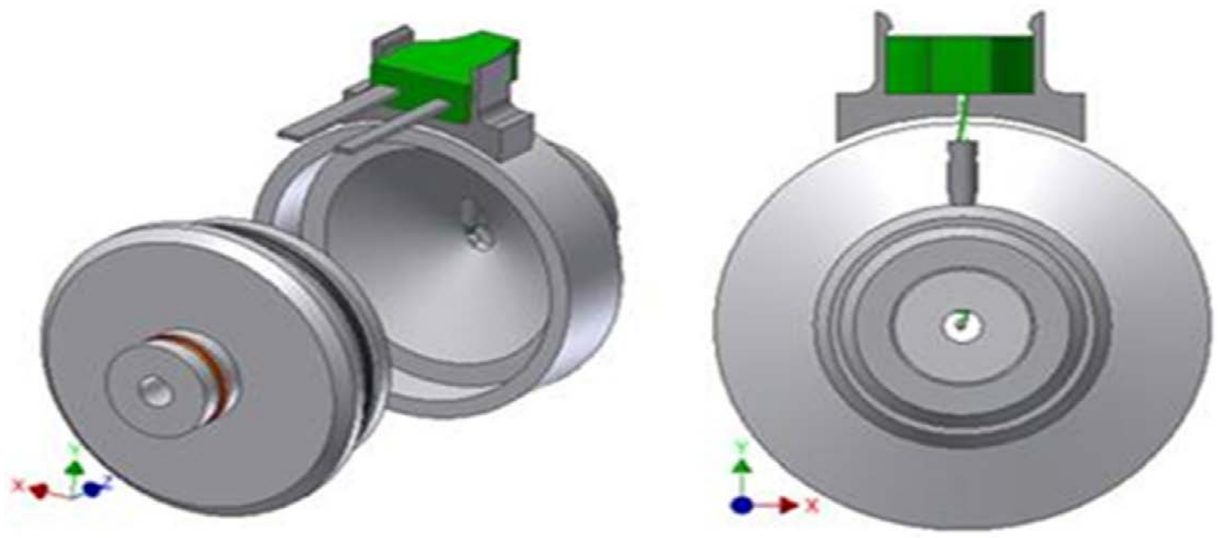

Fig. 1 System for measuring aerosol temperature directly from the real of a THP device using a thermocouple and data logging system on the Cerulean SM450e vaping machine

The technical specification of the system involved the use of five holders (figure 2) all logging simultaneously at a sample rate of 20Hz with a measurement range between 22° to 95° Celsius.

The logging system allows the temperature profile to be collected on a puff by puff basis and the maximum and minimum temperature of each puff can be determined together with a time stamp as well as how the temperature profile changes with a puff (see figure 2). The use of slightly different puff profiles creates different temperature profiles from the same THP system which is indicative that consumers will experience different mouth temperature depending on how the consumer puffs.

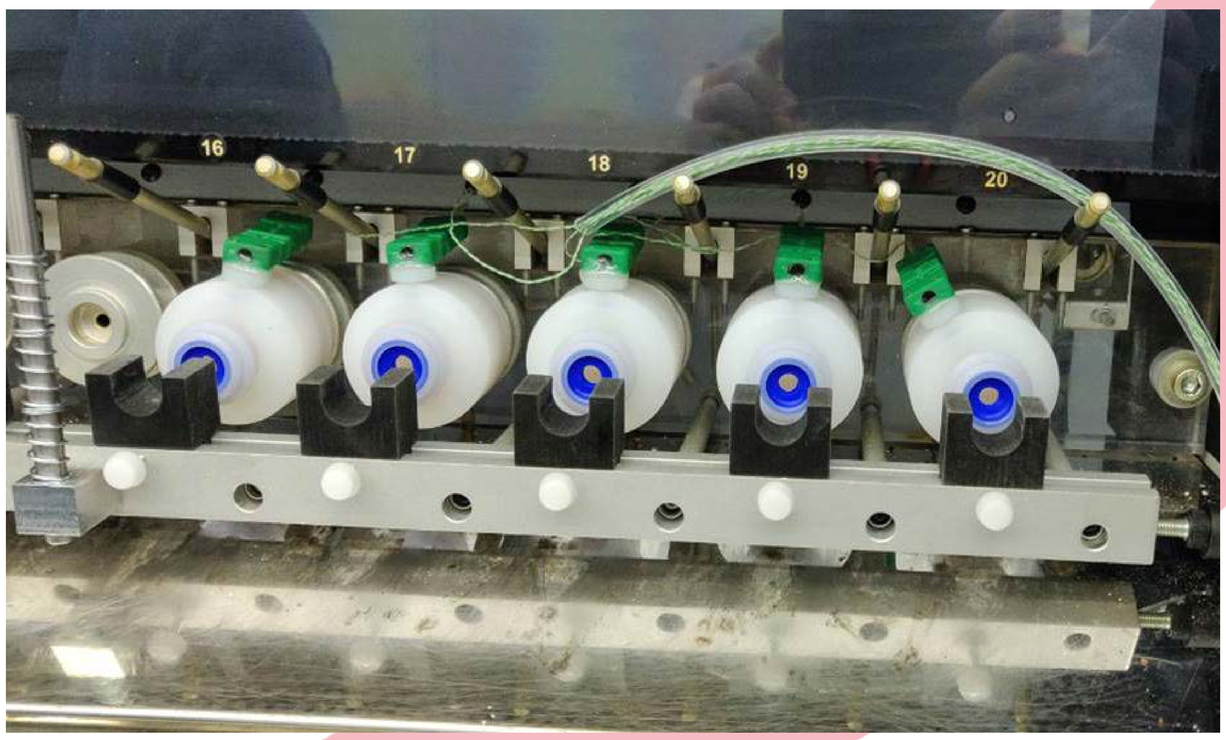

Fig. 2 Aerosol temperature measurement in situ on a Cerulean SM450 smoking machine

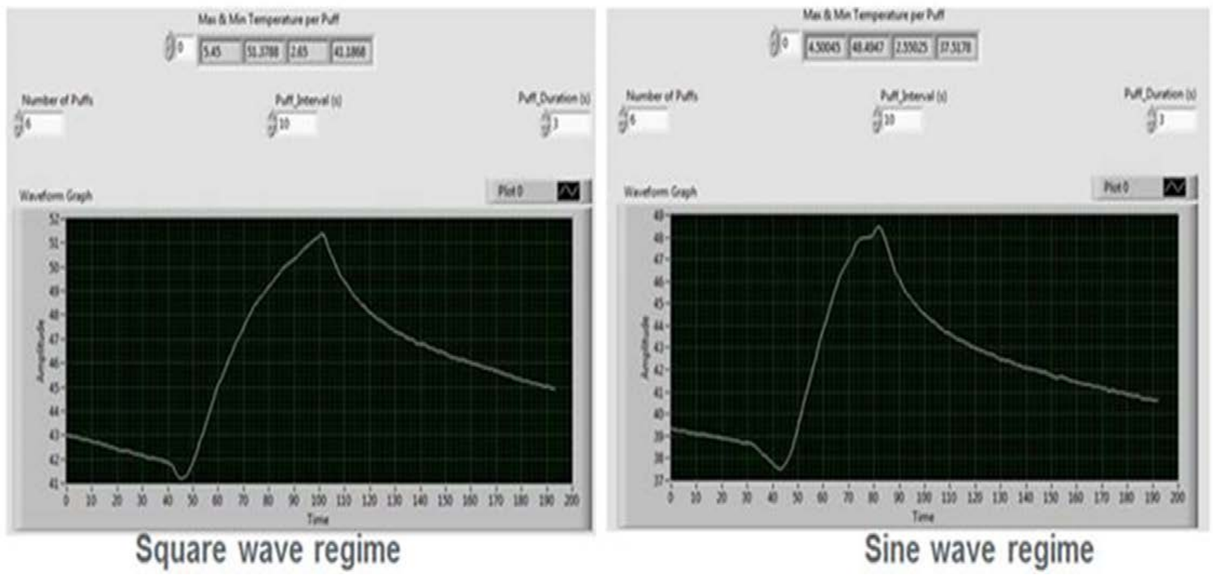

Fig. 3 Temperature profile for two different puff profiles for the same THP device. Rate of change of temperature is dependant on the flow rate which for the same puff volume is greater for the sine profile.

The electronic systems used to heat the THP are known to vary in terms of aerosol mass delivery, the use of the temperature measurement tool can highlight distinct delivery differences beyond aerosol mass.

Five "identical" THP devices were selected and then tested using the same heated tobacco sticks. The temperature sensing system was utilised on five adjacent channels on a Cerulean SM450e vaping machine and a series of puffs taken for comparison purposes.

The puffs were 55ml in volume, of three seconds duration and at 30 second intervals. Figure 4 represents a plot of the maximum temperature achieved by each puff from each puffing channel.

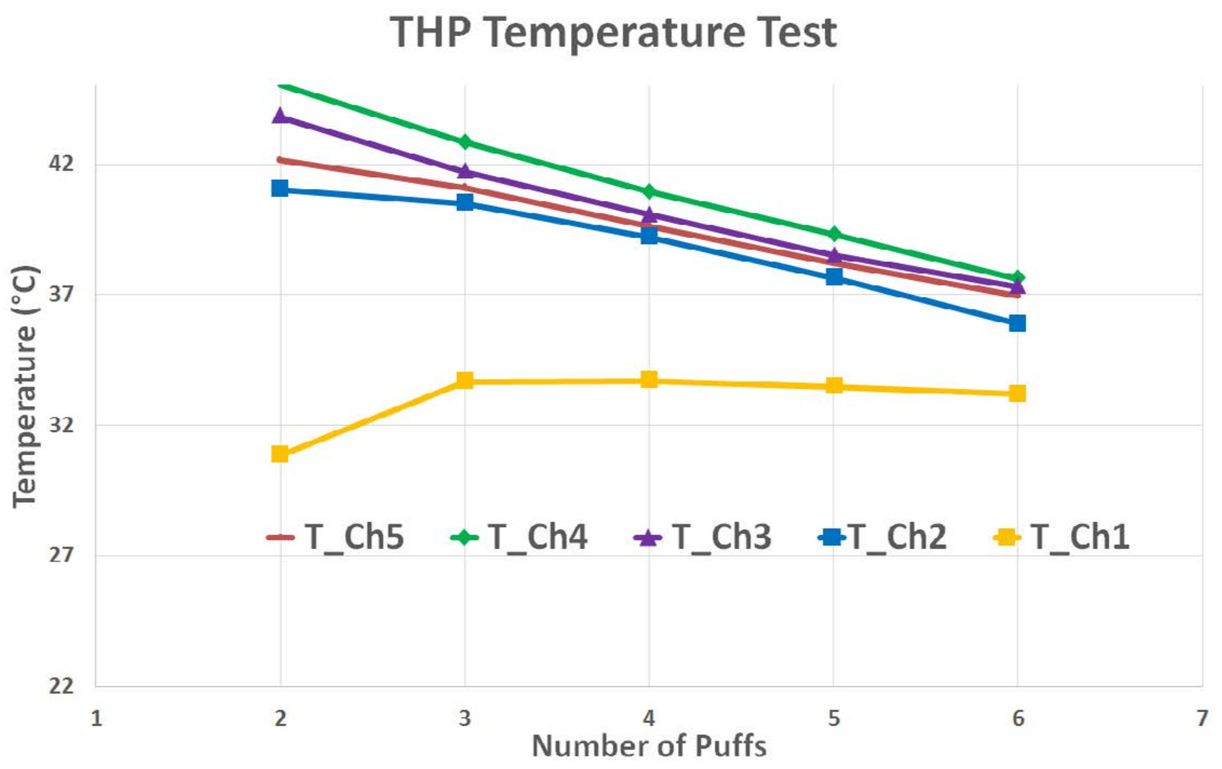

Fig. 4 Plot of maximum puff temperature for five nominally identical THP devices. Four devices have similar aerosol temperature profiles, one "outlier" reached temperature after more puffs and did not achieve the same temperature as the other devices.

As can be seen from Figure 4, the majority of the THP devices had a higher first puff temperature than subsequent puffs which gradually drops by 5° Celsius over six puffs.

There is a distinct outlier, the THP device in channel 1. This took three puffs to obtain a maximum temperature for the aerosol and even then this was 7-9° Celsius lower than the typical THP devices used in the remaining channels.

Conclusions

It is clear that aerosol temperature measurement is another tool in the scientist's armoury when developing new THP products or variants on existing THP sticks. It also can highlight "rogue" heating devices for elimination from statistical analysis in product performance tests.

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