THP puff-by-puff delivery using the Cerulean SM450e vaping machine

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Introduction

Tobacco heating products (THPs), a relative newcomer to the test laboratory, are predicted to increase in sales by over 230% in the next 4 years; displacing a significant proportion of conventional cigarette sales.

These THPs normally consist of a heating device (containing electronics and a battery) into which a special tobacco stick is placed. This stick uses reconstituted tobacco with high moisture content, and when the tobacco is heated up to 350°C using a battery-powered heating-system, during the puff an aerosol is produced that contains nicotine, flavours and other chemicals. The remainder of the stick construction cools and filters the aerosol.

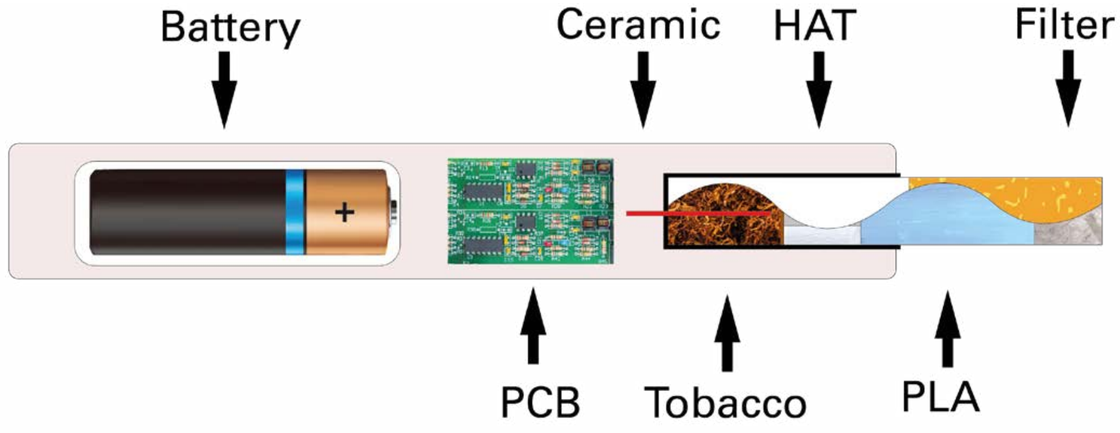


Figure 1: Tobacco Heating Product schematic

These tobacco heating products exhibit particular challenges when performing "traditional" TNC (tar/nicotine/CO) analysis. The test equipment of choice for measuring yields of total particulate matter (TPM) is a linear smoking, or perhaps vaping machine, such as the Cerulean SM450e.

To be considered is the set of parameters used for puffing, the regime, used for generating the aerosol and then the consistency of aerosol delivery throughout the puffing experience. This can be a key consumer metric, i.e. will my puff experience be the same as last time or varies throughout when the stick is puffed?

A way to examine the aerosol delivery consistency of THP's is to measure the delivery from the sticks on a puff by puff basis. This experiment was conducted using the Cerulean SM450e vaping machine with a little ingenuity and discipline.

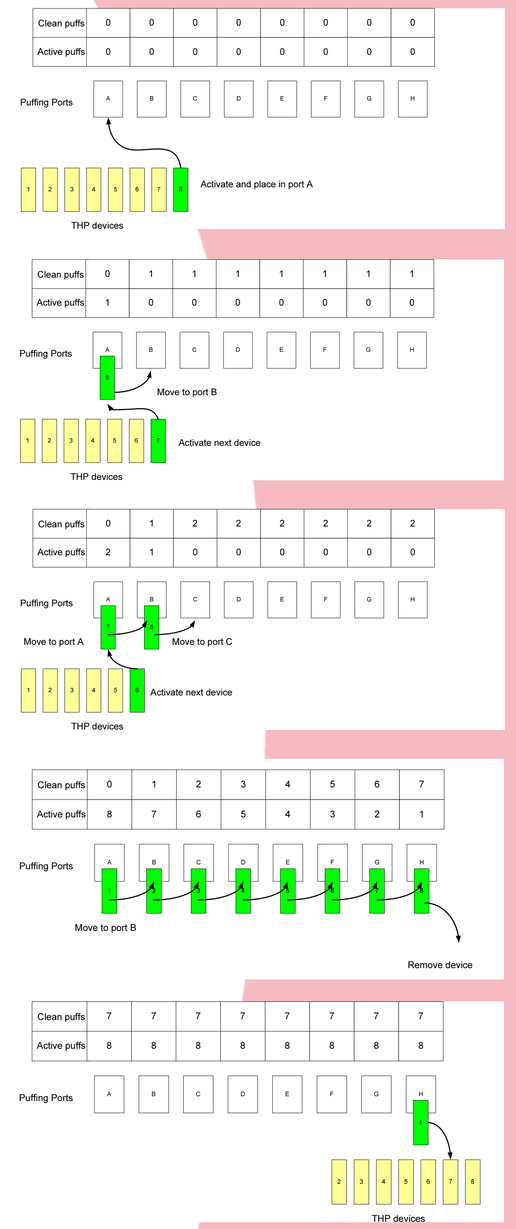
Figure 2: Cerulean SM450e vaping machine

Experimental

A test was performed on a Cerulean SM450e in fixed puff mode, each port being fitted with a Cambridge filter pad holder (CFH) that traps the aerosol generated from 8 THP devices during the experiment. Before the first puff was taken, the first device was activated and placed into the first port of the vaping machine.

A puff was then taken (as depicted in fig. 3). It was then moved to the second port and a second device activated and placed into the first port. After the second puff was taken, the two devices were shifted to the next port and a third device activated and placed into the first port and so on until all devices were loaded and all ports had taken puffs on 8 THP devices. The schematic (see fig. 3) shows how the THP devices progress along the machine.

The capture pads were weighed pre and post test, and so represented the first, second, third and so on puffs from a total of 8 THP devices. This gives us an average yield for each puff taken from the device.



Step 1:
Activate and load

Step 2:
Puff.
Advance device.
Activate second device. Load second device

Step 3:
Puff.
Advance device x 2
Activate third device.
Load third device

Step 9:
Puff
Advance device x 7
Discard device in last port

Step 16:
Puff
Discard last device

Figure 3: Experiment technique

Once we completed this experiment, we compared the puff-by-puff data from a tobacco heating product as the puffing conditions were varied. For instance, we changed the puff duration or the puff interval (see fig. 4).

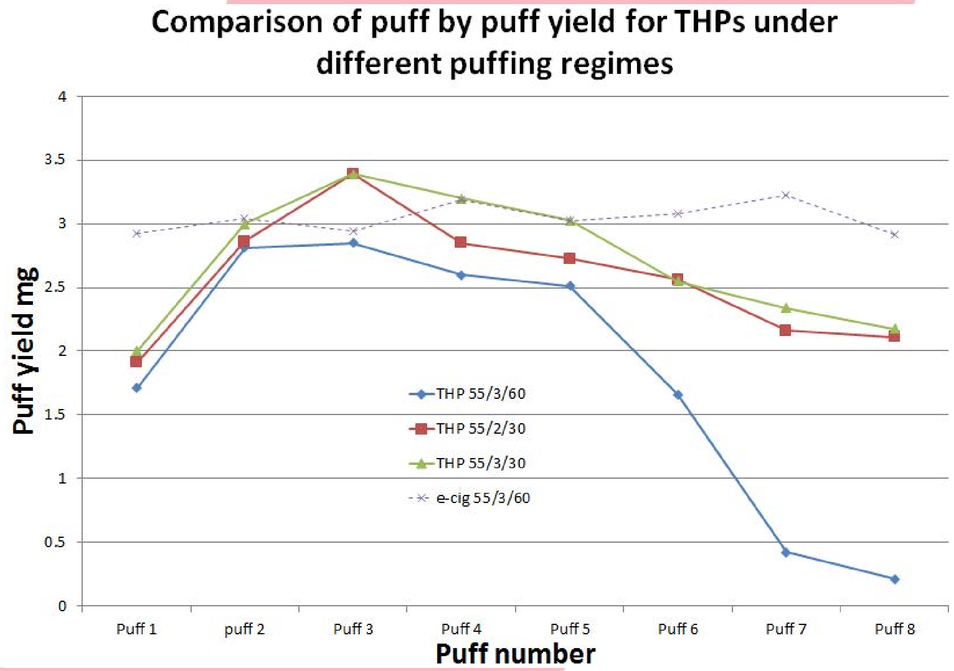


Figure 4: Experiment results under different puffing regimes

It can be clearly seen that the puff duration has only a small effect on the puff-by-puff delivery but the puff interval has a marked effect on delivery.

With this product, the puffing experience "times out" after 6 or 7 minutes so that for the last two puffs, when there is 60 seconds programmed between puffs, we only got mild heating effects. For the shorter 30 seconds inter-puff intervals, the heating device is still fully functional and the THP continues to deliver nicotine and flavours.

It is worthy of note that the first puff will be less satisfying than subsequent puffs as the heater first "kicks in" and that there is a "die away" as a function of the programming of the electronics of the THP heater.

Conclusions

For product developers, understanding the consistency of aerosol delivery is very important. For those comparing the performance between different tobacco heating products, this experiment highlights the risk of choosing the wrong puffing regime unless the operation and performance of the whole system is understood.

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