Detection of E-Cigarette Aerosol Generation Over Life

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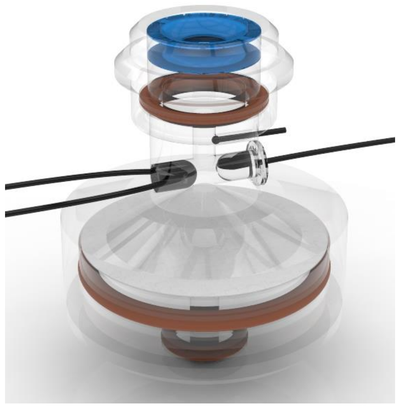
OBJECTIVE

E-Cigarettes generate an aerosol by vaporising 'e-juice' that is carried by a wick to a heater. Yield and end-of-life are conventionally determined by measuring the mass lost from the product or gained in a trap, but either is labour-intensive and has limited resolution, for example, to detect the final active puff of a product.

The objective of this work was to investigate temperature rise and opacity of the aerosol as real-time methods to compliment the absolute yield information provided by mass balance. Both disposable and rechargeable product types were studied.

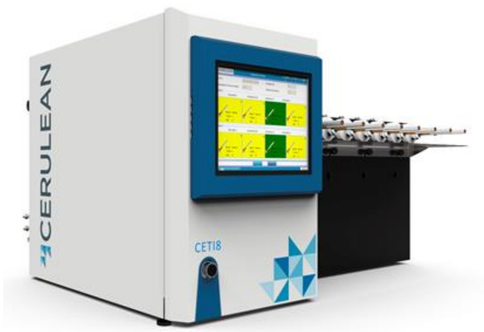
METHOD

Two detectors were fitted into an otherwise standard 44 mm Cambridge filter holder (CFH), illustrated right:



- A thermocouple to detect the increase in puff temperature due to the heater
- A light emitting diode / light–dependent resistor (LDR) pair to detect the opacity of the aerosol

A CETI8 instrument was used to generate the puffs and the data were logged externally at this development stage.



- The puffing profile was a square puff of 3 s / 55 ml x 30 s, which is under consideration as the recommended standard
- The outputs of the sensors were logged at 65 readings per second

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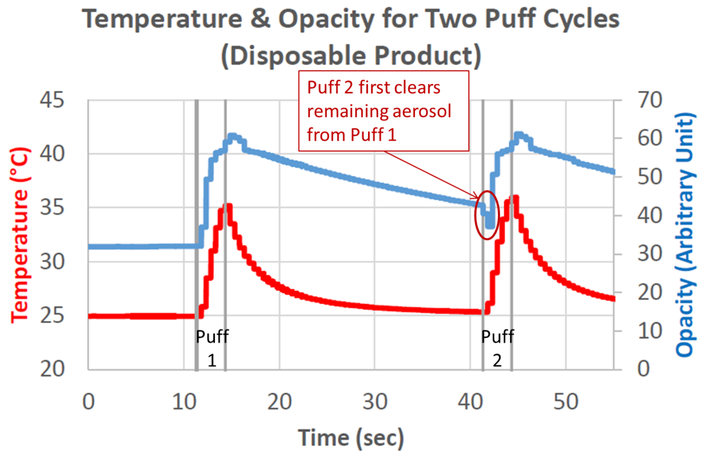
RESULTS

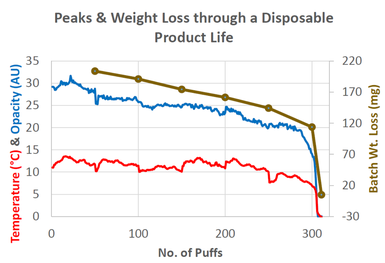
A plot of opacity (effectively the amount of scattered light) and puff temperature for just the first two puffs of a vaping run is shown below.

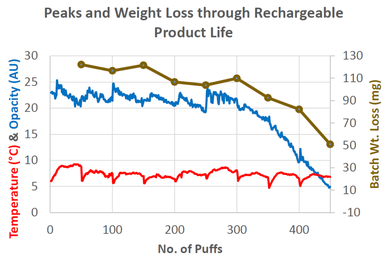


Several measures can be obtained from the profiles:

- Peak temperature and opacity for each puff
- Area under the curve for each puff for temperature and opacity
- Cumulative area under the curve for temperature and opacity

The plots below show typical through-life behaviour for a disposable and rechargeable product as peak height of the temperature and opacity logs and as weight loss of the product at 50 puff intervals. The battery for the rechargeable product was replaced every 50 cycles .



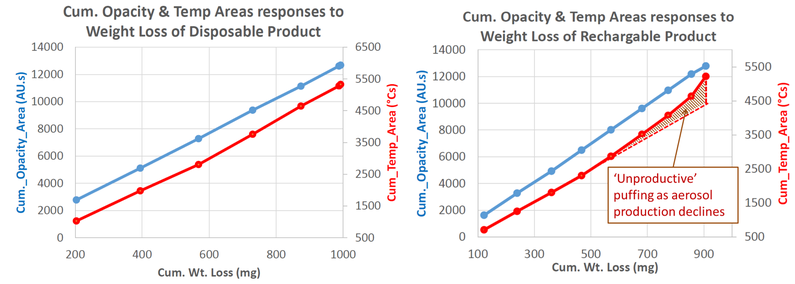


For the disposable, it can be seen that the production of aerosol is abruptly terminated as the battery expires after 311 puffs, whereas for the rechargeable, the puff temperature is maintained (since the battery was replaced) but that after about 300 puffs the production of aerosol gradually declines as the e-juice runs out.

Stopping the puffing run to weigh either the product or the filter-holder every 50 cycles is labour-intensive so use of the puffing data to track product condition and lifetime was investigated.

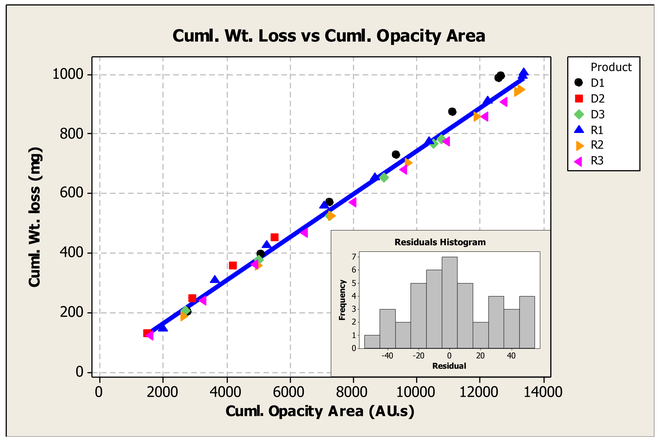
ANALYSIS

The figures below present the *cumulative* area under the curve for opacity and temperature for the disposable and rechargeable products plotted against the cumulative weight loss of each product.



The aerosol plots appear to be linear while the temperature plots are both somewhat curved, particularly for the rechargeable product. This equates to the less productive puffs towards end-of life as the e-juice runs out.

Cumulative aerosol opacity can be used to provide a good indication of actual weight loss, typically to within 10%, e.g. for three disposable and three rechargeable products, as here:



CONCLUSIONS

- Real-time measurements of aerosol opacity and puff temperature can be obtained reliably during machine vaping of e-cigarettes.
- Cumulative aerosol opacity appears to offer a means to simplify routine testing by reducing the need to weigh the product over life.