Objectives

I. Introduce a mathematical model of the electric cigarette thermal behavior
II. Advise the user
III. Introduce parameters for the normalization of electronic cigarette market

Materials

✓ E-liquid: 45% Propylene-glycol, 45% Glycerin, 10% ethanol
✓ Wick: Japanese cotton
✓ Electrical generation: Controlled alimentation (no discharge)
✓ Temperature measurement: Thermocouple with K probe placed on the central loop
✓ Resistances: Kanthal and Nichrome metals (0.32mm diameter)

Methods

Mathematical model

The thermal balance between the resistance and the outside could be expressed as:

$$m_C \frac{dT(t)}{dt} = P - hS(T(t) - T_{out})$$

After resolution and linearization in short times, the temperature rise follows:

$$\frac{dT(t)}{dt} = \frac{P}{m_C}$$

- $T$: Temperature of the resistance
- $C$: Resistance heat capacity
- $m$: Resistance’s mass
- $P$: Power delivered
- $h$: External heat coefficient
- $S$: External surface of the resistance
- $T_{out}$: Temperature of external environment

Resistance geometry

Results

Power influence

- Power increase the temperature rise.
- This influence seems linear.

Geometry influence

- Temperature rise decrease with the resistance mass.
- This diminution seems to be shape of a hyperbola.
- The number of loops and the diameter of rolling-up have the same influence.

Material influence

- The temperature rise of Nichrome resistance seems to have the same behavior than Kanthal resistance.
- For a done mass resistance, Nichrome have a higher temperature rise. (Cpr Kanthal: 460 Jkg⁻¹K⁻¹, Cpr Nichrome: 450 Jkg⁻¹K⁻¹)

Conclusions

- Mathematical model: The power linearity and the mass variation hyperbola confirm that the temperature rise in a resistance of electronic cigarette behaves like in the boxed equation.
- Utilization advice: A heavy resistance has a slower temperature rise. This behavior might be healthier for e-liquid degradation[9].
- Normalization recommendation: The power supply is not a parameter being enough for controlling the energy contribution of a resistance in the e-liquid. It has to appear a report of power by unit area or unit mass of resistance used.

Outlook

- Thanks to U-SAV®, these results are in the course of coupling with analyses of emissions in order to verify if the temperature rise is the phenomenon which controls the degradation of a liquid during its heating.

References


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