



[CORESTA CONGRESS 2015]

The Flavor Delivery Characteristics of Twin Capsules Filter as Cigarette Designs

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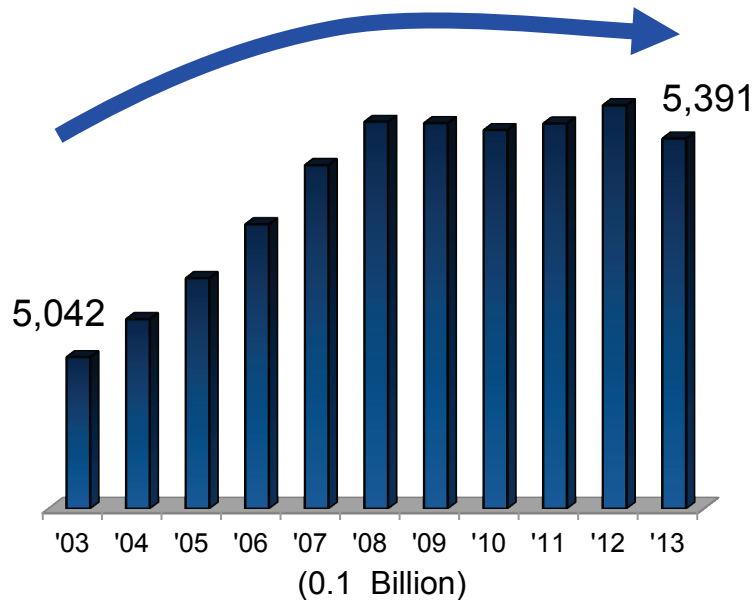
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I . Abstract

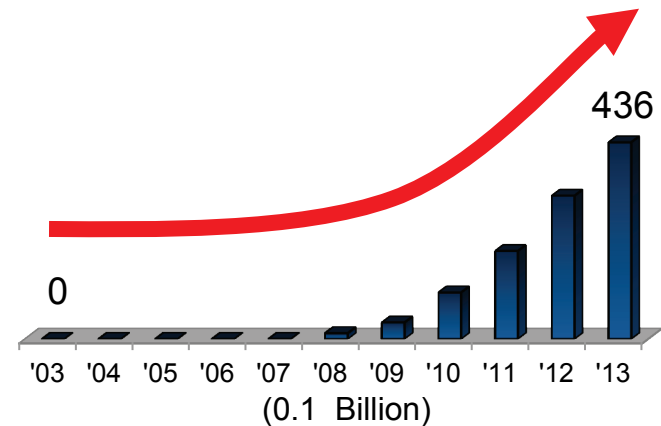
World Market Trend (2014, EURO Monitor)

- ◆ Sales of “Conventional cigarette” are getting smaller.
- ◆ However, sales of “Capsuled cigarette” are getting bigger.

[Conventional cigarette]



[Capsuled cigarette]





I . Abstract

What I will present

- ◆ The needs of “**Twin Capsules**” for more plentiful amount of flavor are getting increase.
- ◆ I focused on **effects of flavor delivery through main stream smoke**, when twin capsules were applied in one cigarette.
- ◆ As **ventilation levels and positions of capsule brake** changes, amount of flavor delivery was also changed.
- ◆ This research presents **the best means to deliver maximum amount of flavor** through main stream smoke.



II. Cigarette Designs

Filter & Tip Paper

- ◆ **NTM(Non Tobacco Material) was designed according to ventilation levels and positions of capsule brake.**

(Filter) Regular size, Dual + Twin capsules(Using same amount of flavor)

(Tip paper) 0 %(for High Tar) & 80%(for Low Tar) of Ventilation level

- ◆ **Combination**

| Case | Position of capsule brake | Ventilation level |
|------|---------------------------|-------------------|
| #1 | T E (Tobacco End) | 0 |
| #2 | T E (Tobacco End) | 80 |
| #3 | M E (Mouth End) | 0 |
| #4 | M E (Mouth End) | 80 |



III. Experimental Results

TNCO (Tar / Nicotine / Carbon Oxide)

- ◆ Every case showed that **tar was increased after capsule brake.**

| Classification | | TNCO (mg / cig.) | | |
|----------------|---------------------------|------------------|----------|--------------|
| Ventilation | Position of capsule brake | Tar | Nicotine | Carbon Oxide |
| 0 % | Nothing | <u>7.8</u> | 0.71 | 8.0 |
| | T E | <u>9.1</u> | 0.78 | 7.9 |
| | M E | <u>9.5</u> | 0.76 | 8.3 |
| | All | <u>10.7</u> | 0.84 | 8.5 |
| 80 % | Nothing | <u>3.5</u> | 0.37 | 2.6 |
| | T E | <u>4.4</u> | 0.39 | 2.9 |
| | M E | <u>4.3</u> | 0.39 | 2.7 |
| | All | <u>5.3</u> | 0.45 | 2.9 |

III. Experimental Results

The Amount of Flavor Delivery

- ◆ Position of capsule brake for good flavor delivery was
 - **Low ventilation** → **TE** section
 - **High ventilation** → **ME** section





| Classification | | Amount flavor (mg / cig.) |
|----------------|---------------------------|---------------------------|
| Ventilation | Position of capsule brake | |
| 0 % | Nothing | 0.02 |
| | T E | 0.78 |
| | M E | 0.61 |
| | All | 1.46 |
| 80 % | Nothing | 0.01 |
| | T E | 0.27 |
| | M E | 0.41 |
| | All | 0.76 |



III. Experimental Results

Actual Picture

- ◆ **Tar spreading area was broad**(flavor was absorbed to filter) **through filter**, it showed that **flavor delivery was getting lower in main stream smoke**.
- (Assume) A flow of tar is same as a flow of flavor.

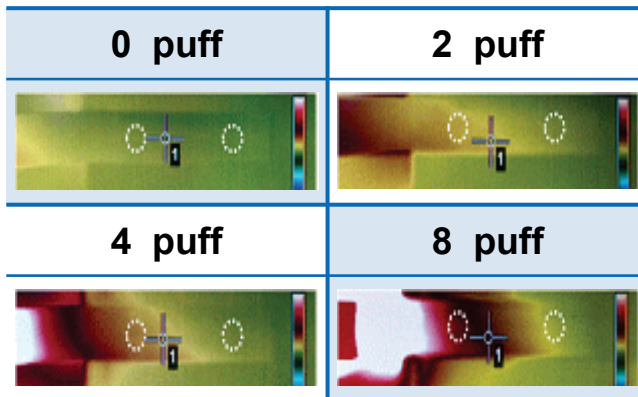
| Classification | | Tar spreading (TE + ME) |
|----------------|---------------------------|---|
| Ventilation | Position of capsule brake | |
| 0 % | T E |  |
| | M E |  |
| 80 % | T E |  |
| | M E |  |

III. Experimental Results

Thermal Image Analysis

- ◆ **(High ventilation) Effect of ventilation was relatively higher than thermal.**
 - Velocity of main stream smoke was decreased from TE section to ME section because of forward up & down direction of spreading.

- ◆ **(Low ventilation) Effect of thermal was relatively higher than ventilation.**
 - Velocity of main stream smoke was increased from TE section to ME section because of increasing diffusion coefficient forward to mouth direction.



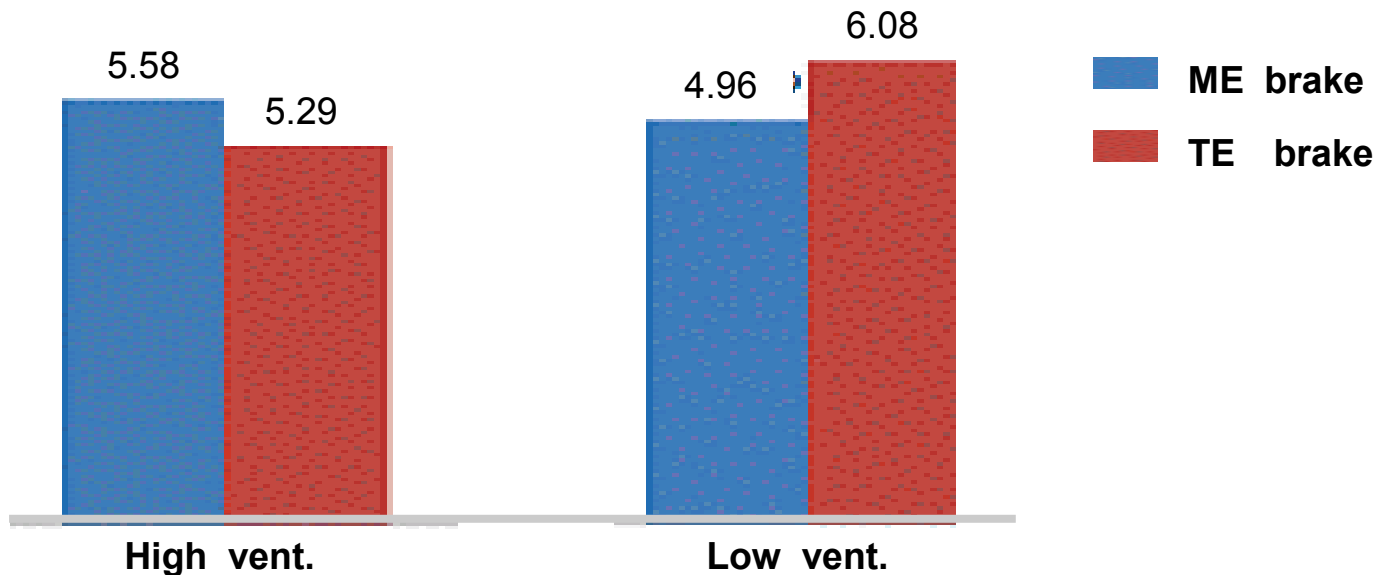
| Classification | | Thermal range |
|----------------|---------------------|---------------|
| Ventilation | Position of capsule | |
| 0 % | T E | 26.3 ~ 67.0 |
| | M E | 26.1 ~ 48.3 |
| 80 % | T E | 26.9 ~ 61.7 |
| | M E | 26.7 ~ 41.5 |

III. Experimental Results

Sensory Evaluation

◆ Good intensity of flavor was

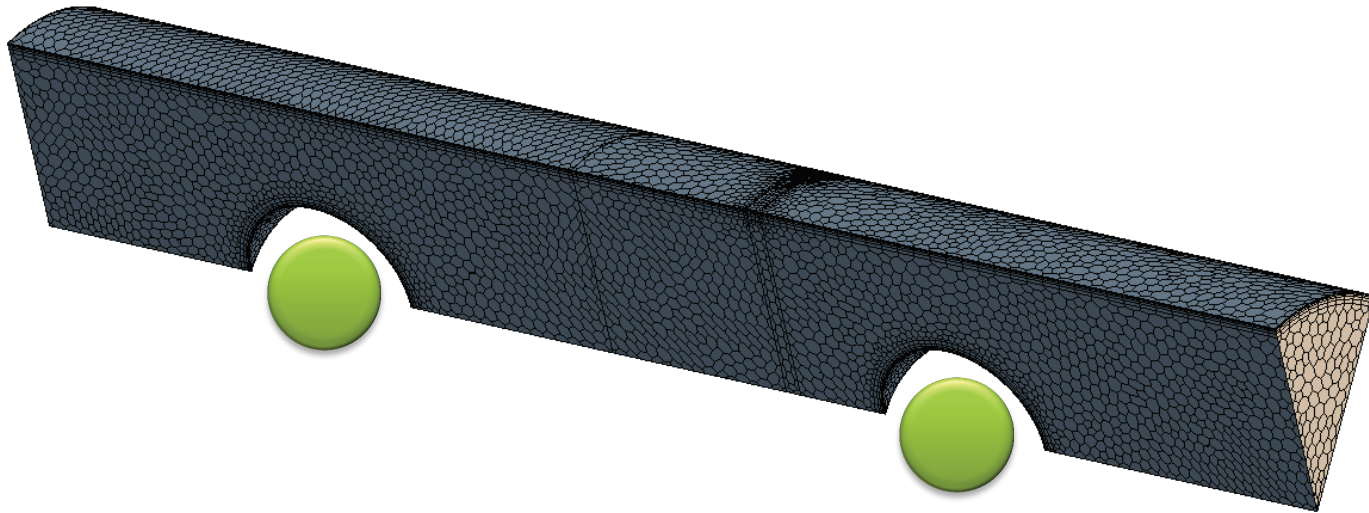
- High ventilation → ME section
- Low ventilation → TE section



IV. Estimates Using CFD(Computational Fluid Dynamics) Program

Geometry

- ◆ CFD is a branch of fluid dynamics,
- ◆ It is the best program for moving flavor through main stream smoke.



IV. Estimates Using CFD(Computational Fluid Dynamics) Program

Settings

- ◆ (Assume) **Flavor** → **Menthol** (volatile),

Liquid did not flow, only gas flowed.

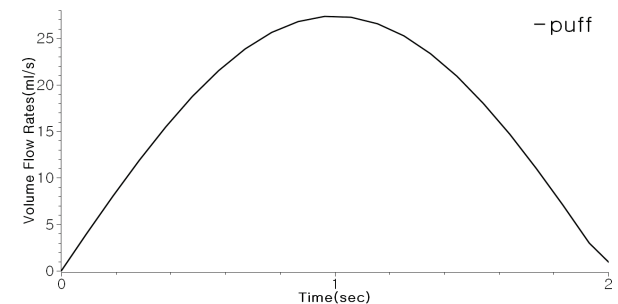
Capsule shell maintained the state of sphere.

- ◆ **CORESTA puffing conditions**

(The amount of smoking) **37.5 ml / 2 sec**

(The total smoking puff) **8 puffs**

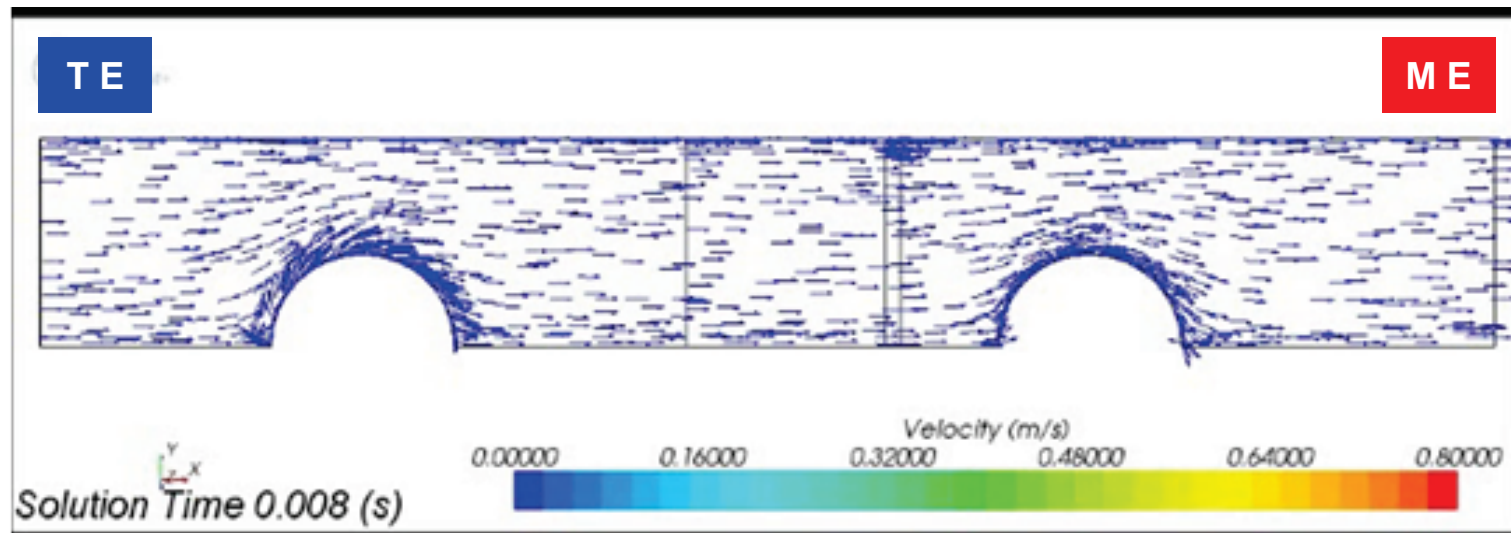
(Puff equation : Sine func.) $\dot{Q} = \int_0^2 27.49 \sin\left(\frac{\pi}{2}t\right) dt$



IV. Estimates Using CFD(Computational Fluid Dynamics) Program

Analytical Results

- ◆ **0 % of ventilation level** (High Tar, Case #1 & #3)
 - As below chart, flow of **TE section** was a little bit faster than ME.
 - Also, focused on amount of flavor, **TE section** was lightly larger than ME.

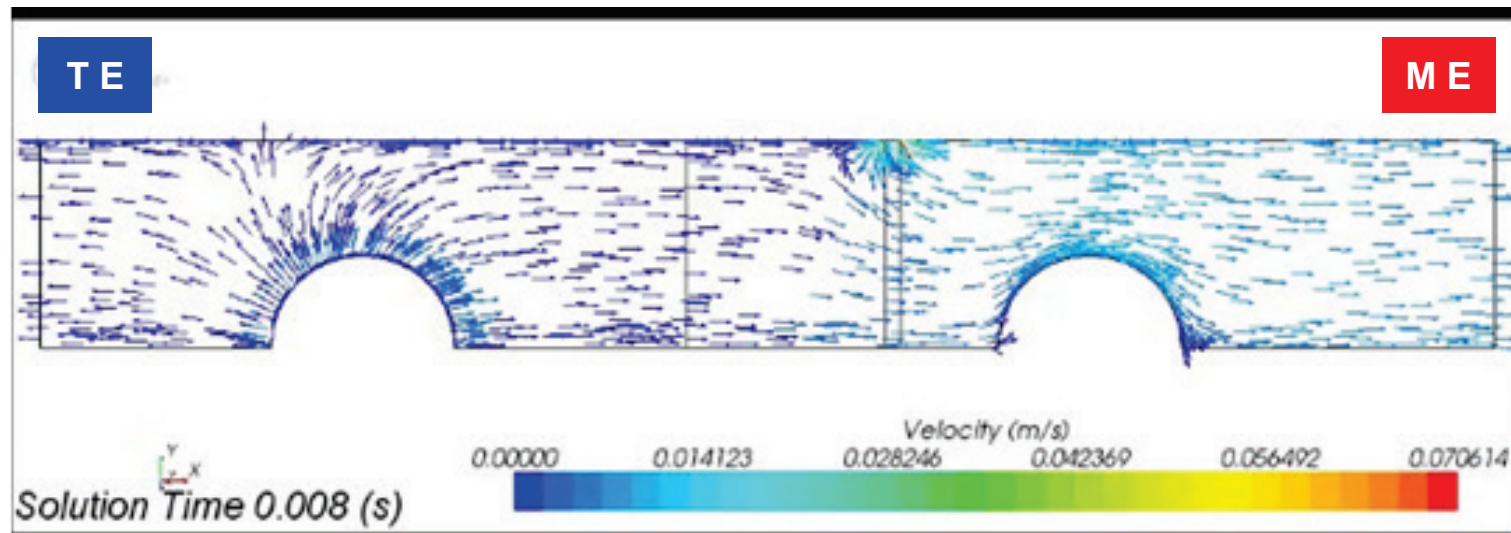


IV. Estimates Using CFD(Computational Fluid Dynamics) Program

Analytical Results (Con't)

◆ **80 % of ventilation level** (Low Tar, Case #2 & #4)

- As below chart, flow of **ME section was much faster** than TE.
- Also, focused on amount of flavor, **ME section was much larger** than TE.

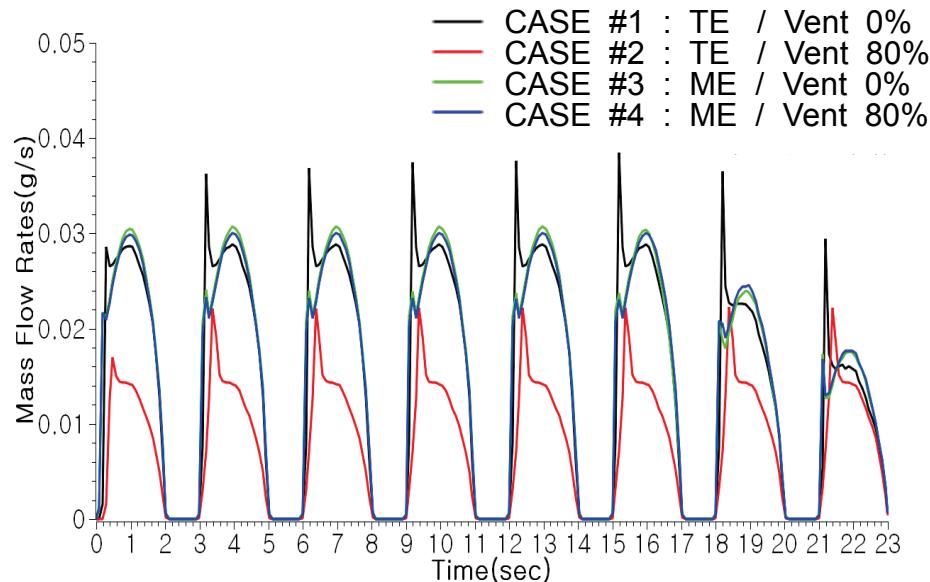


IV. Estimates Using CFD(Computational Fluid Dynamics) Program

Analytical Results (Con't) : Summary

◆ Which position of capsule brake was good for higher amount of flavor delivery in case of different ventilation levels :

- **Low ventilation** (High Tar) : **TE** section
- **High ventilation** (Low Tar) : **ME** section



| Case | Amount flavor (Ratio) |
|------|-----------------------|
| #1 | 1.94 |
| #2 | 1.00 |
| #3 | 1.74 |
| #4 | 1.93 |



V. Conclusions

The best cigarette design of twin capsules (different amount of flavor) filter

Which position of capsule with huge amount of flavor is better for delivering maximum amount of flavor through main stream smoke?

HIGH Ventilation



LOW Ventilation





**Thank you for
your attention !!!**