

Visualization on Reaction of Diesel Particulates in Regeneration of DPF

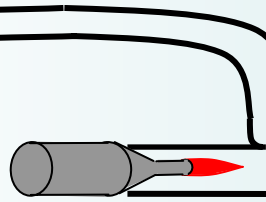
Katsunori HANAMURA

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Tokyo Institute of Technology
Japan**

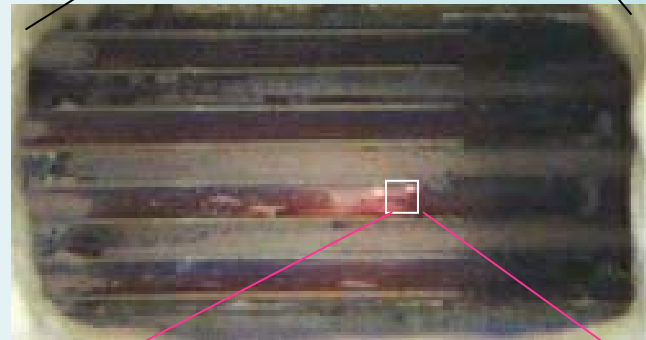
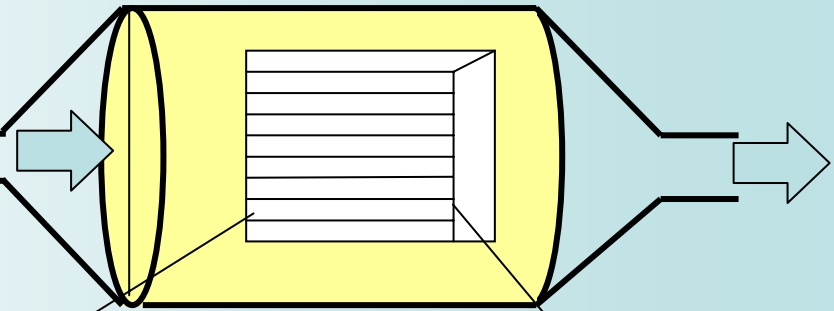
Diesel Engine



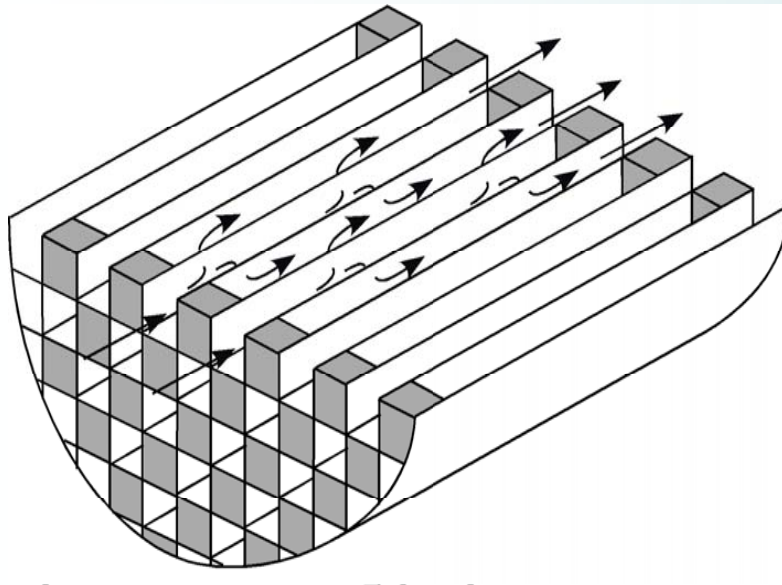
Burner



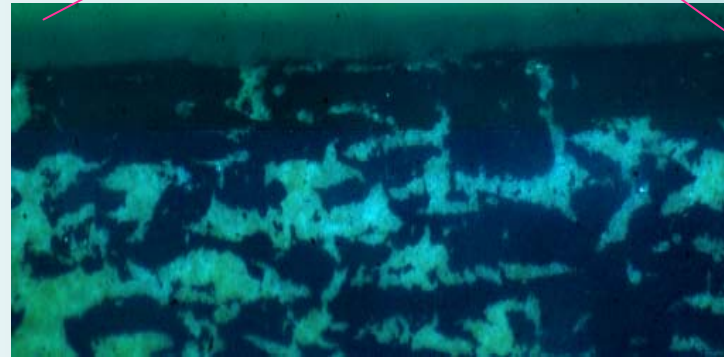
DPF



PM Combustion in Regeneration



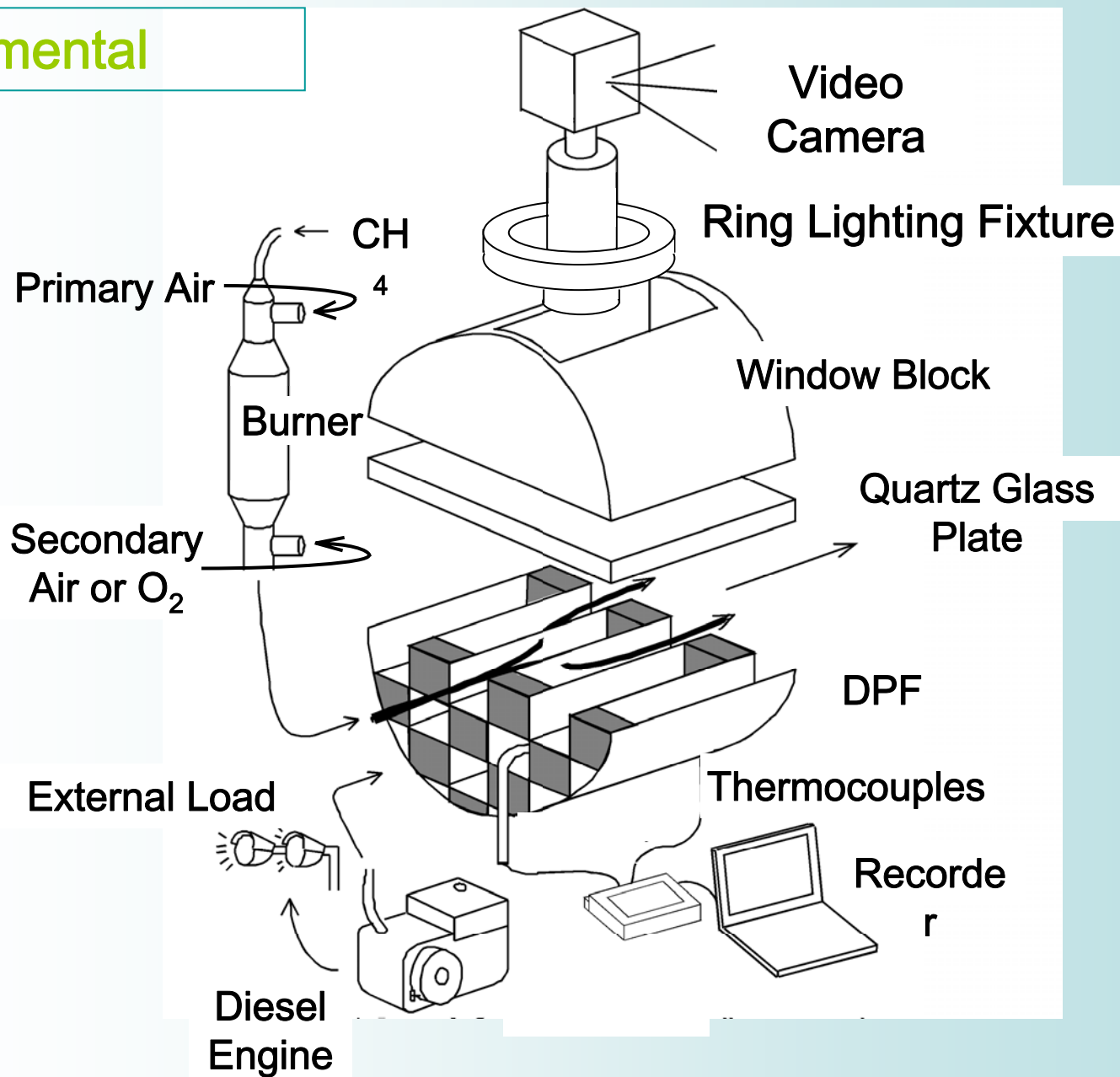
DPF for Visualization

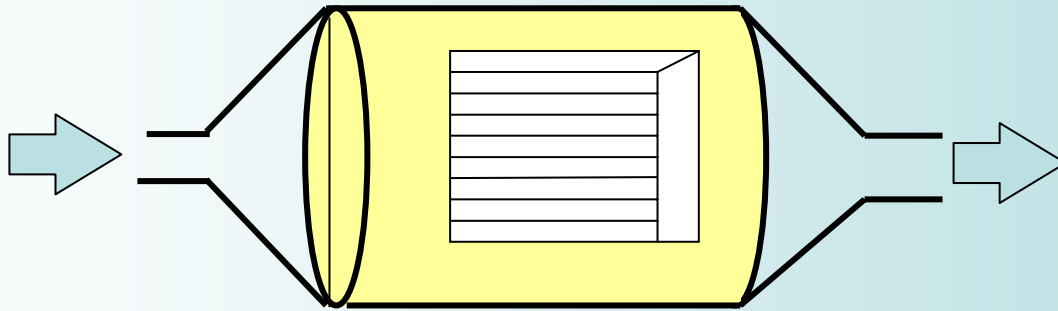


Microscopic Observation in Regeneration

I. Macroscopic Observation

Experimental Setup

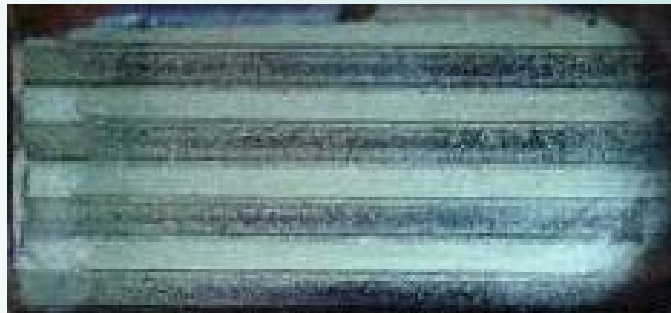




Before Trapping



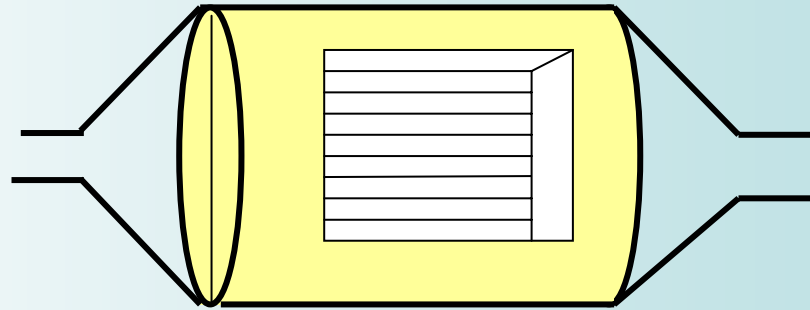
40 seconds past



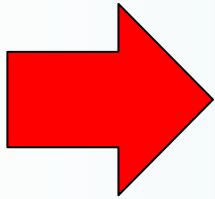
1.5 hours past



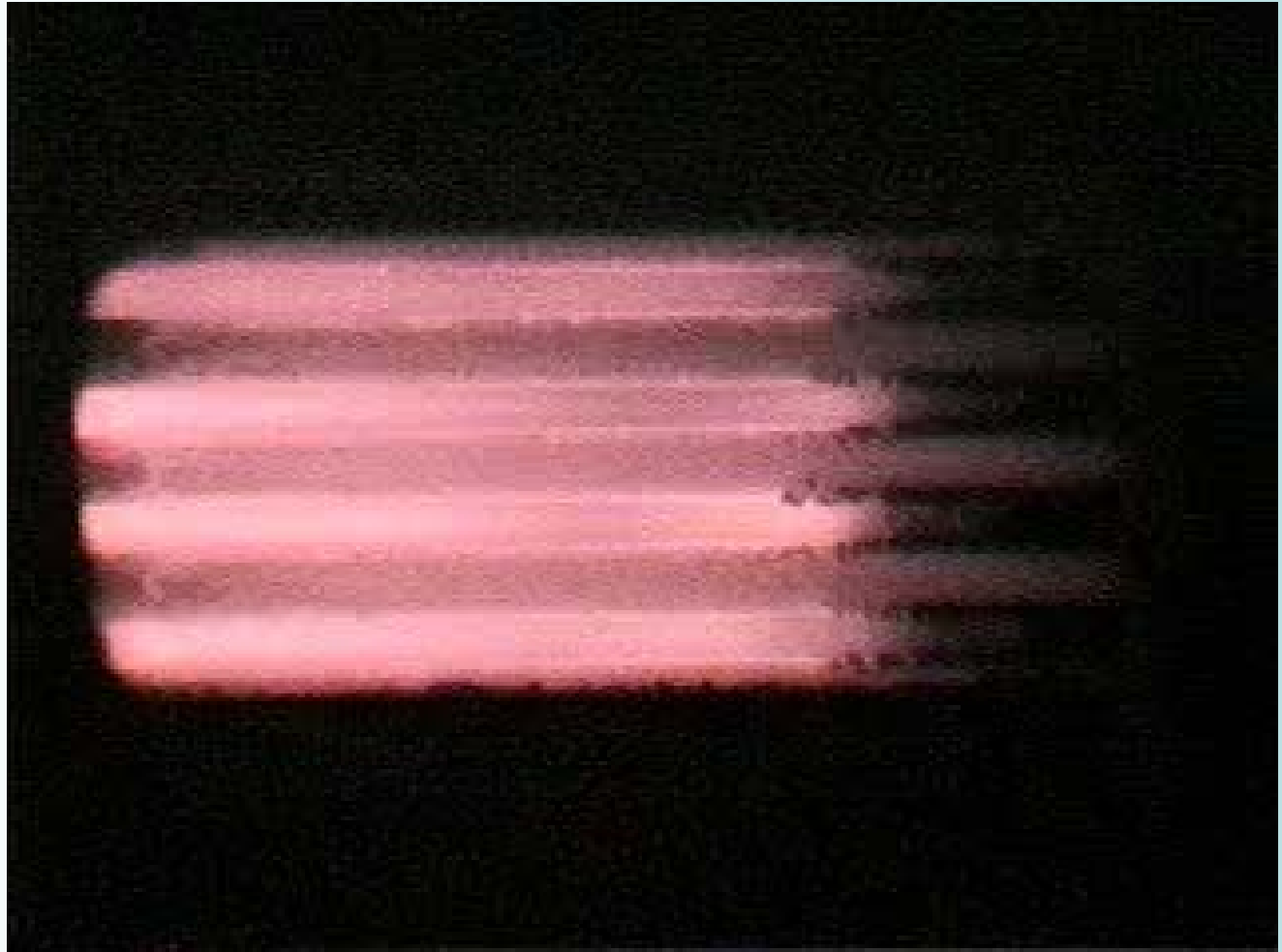
Regeneration of DPF
(PM mass:
 $28\text{mg}/\text{cm}^3$)



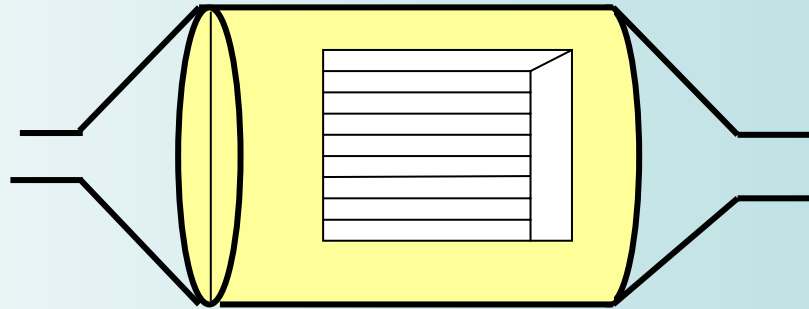
Inlet Velocity
 3.1 m/s



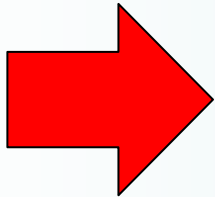
Inlet
Temperature
 799°C



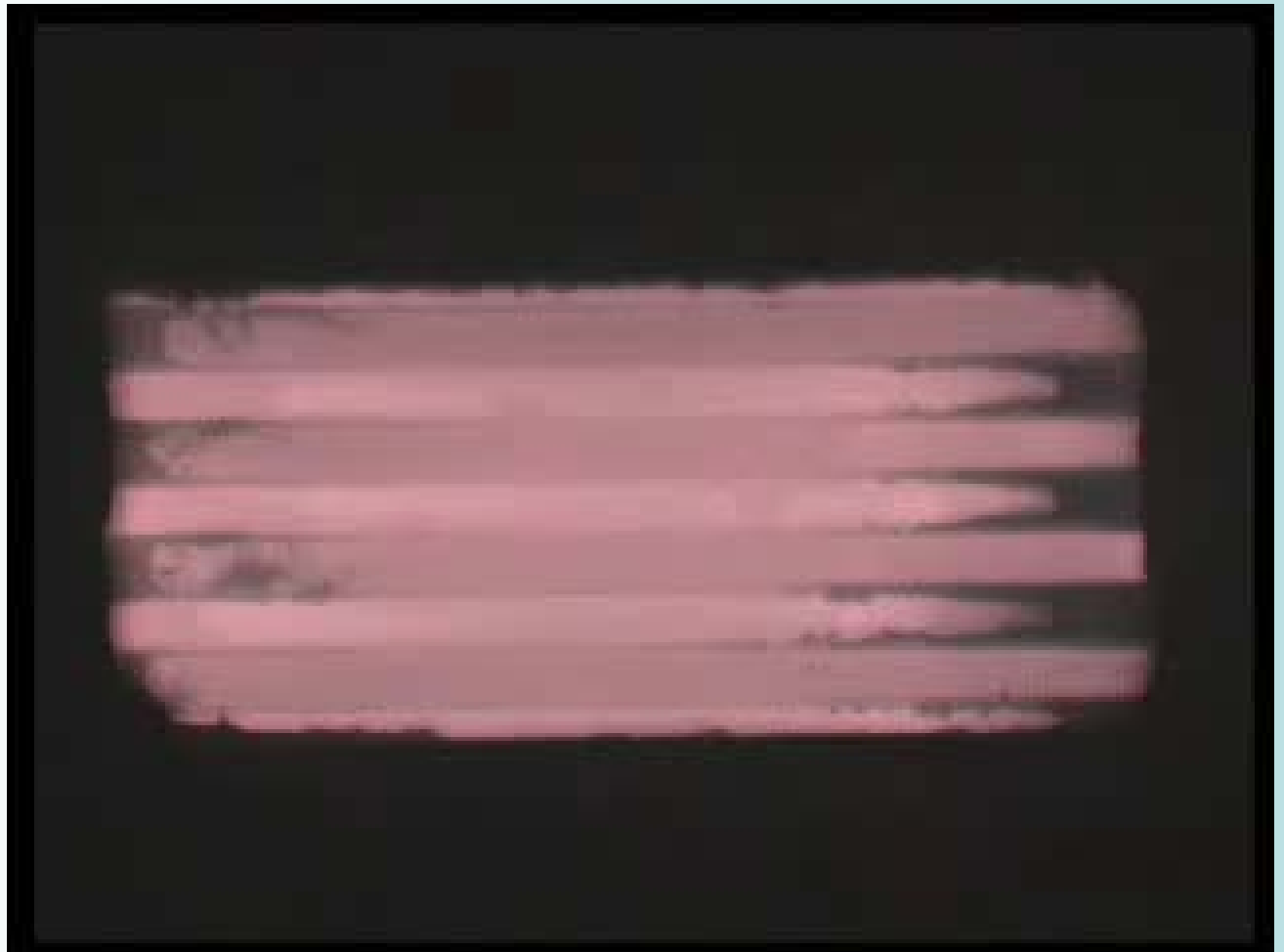
Regeneration of DPF
(PM mass:
 $38\text{mg}/\text{cm}^3$)



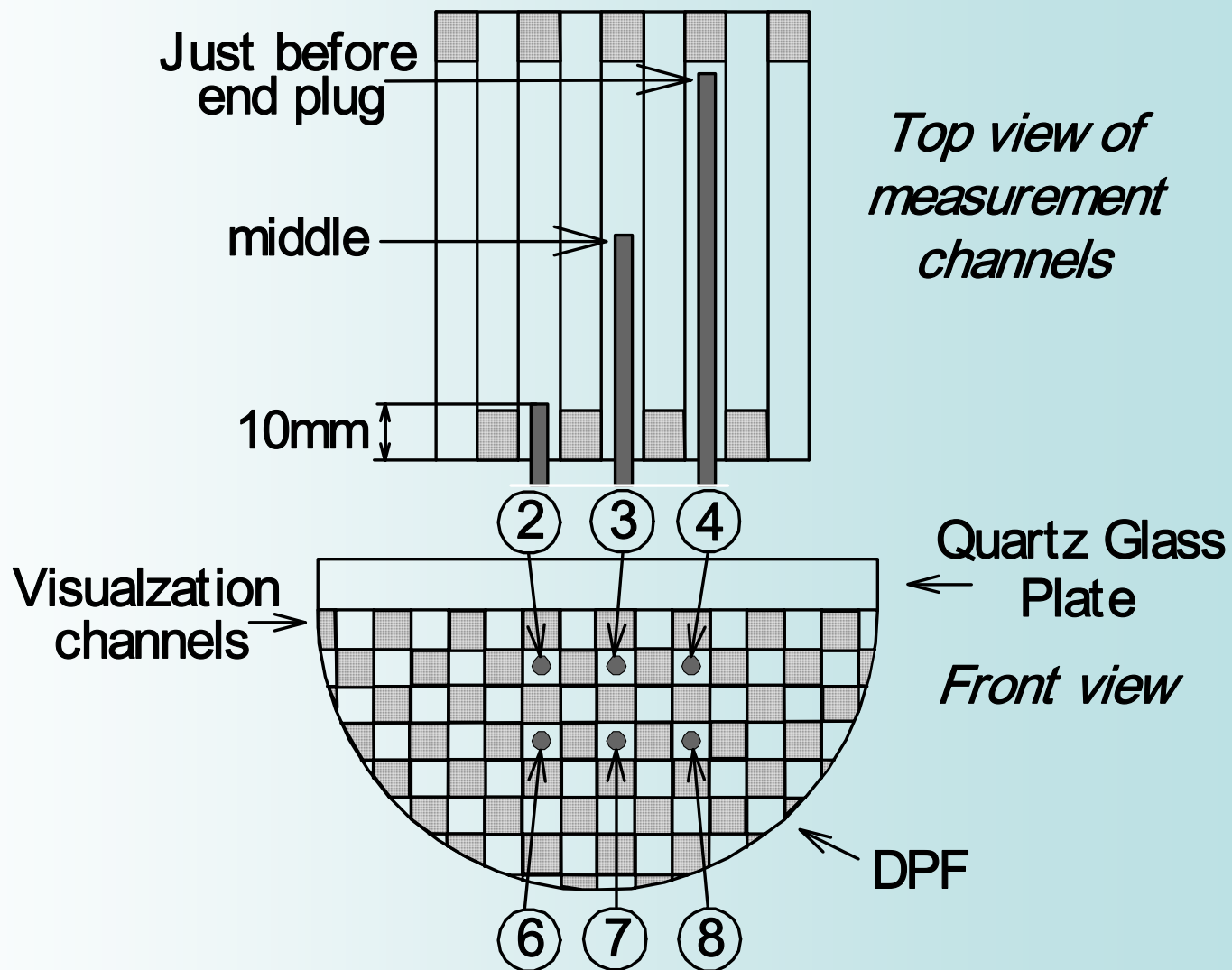
Inlet Velocity
 3.1 m/s



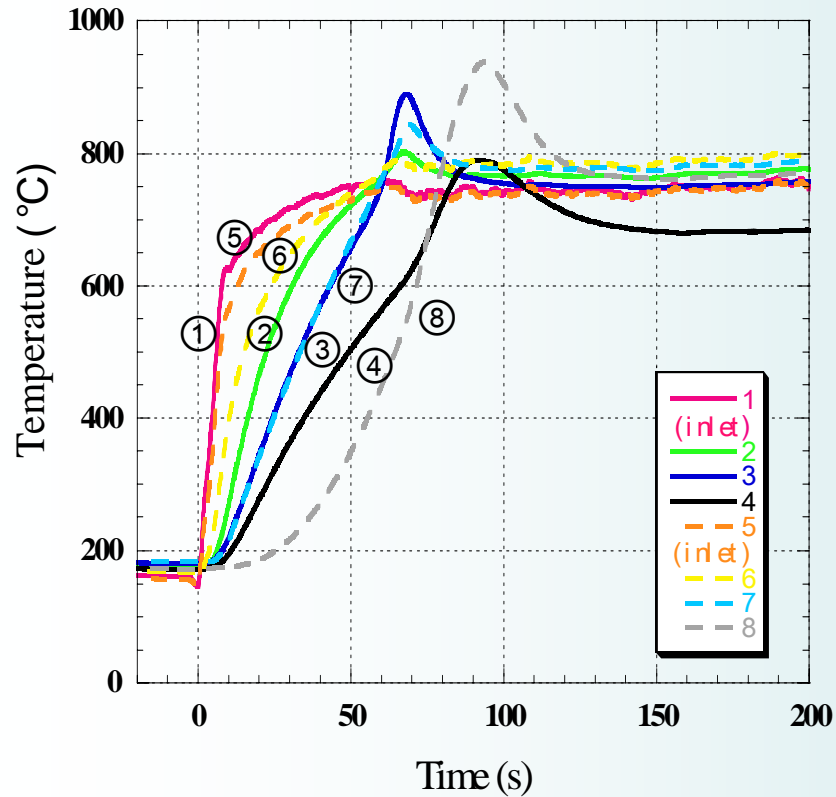
Inlet
Temperature
 658°C



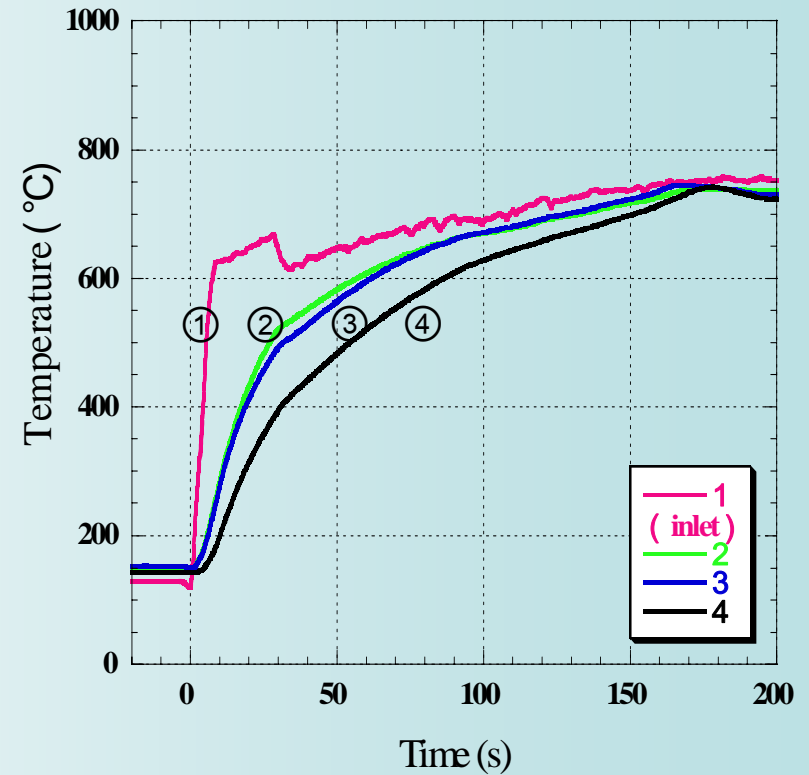
Measurement of Temperature



Variation of Temperature with Time

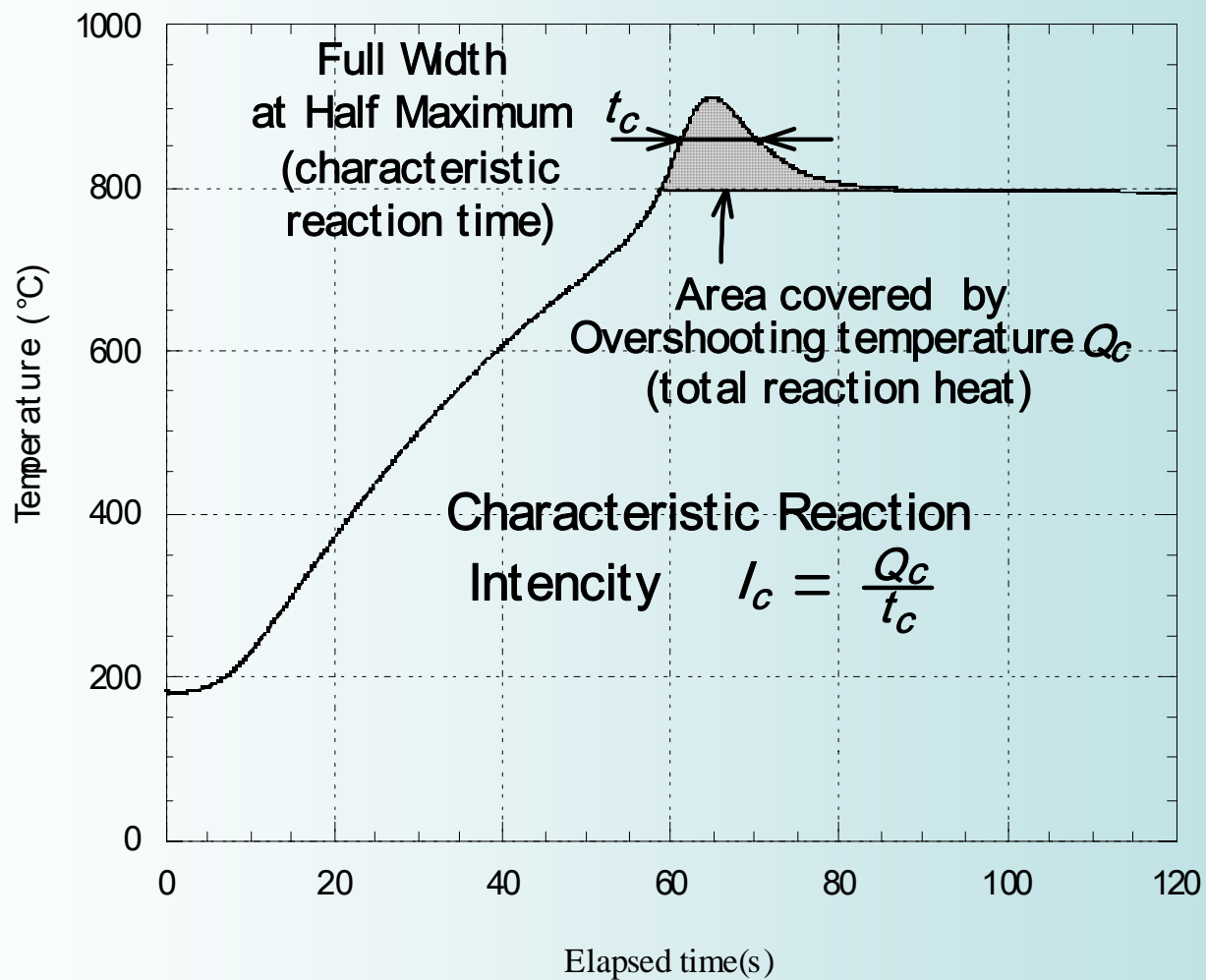


propagating-reaction regeneration

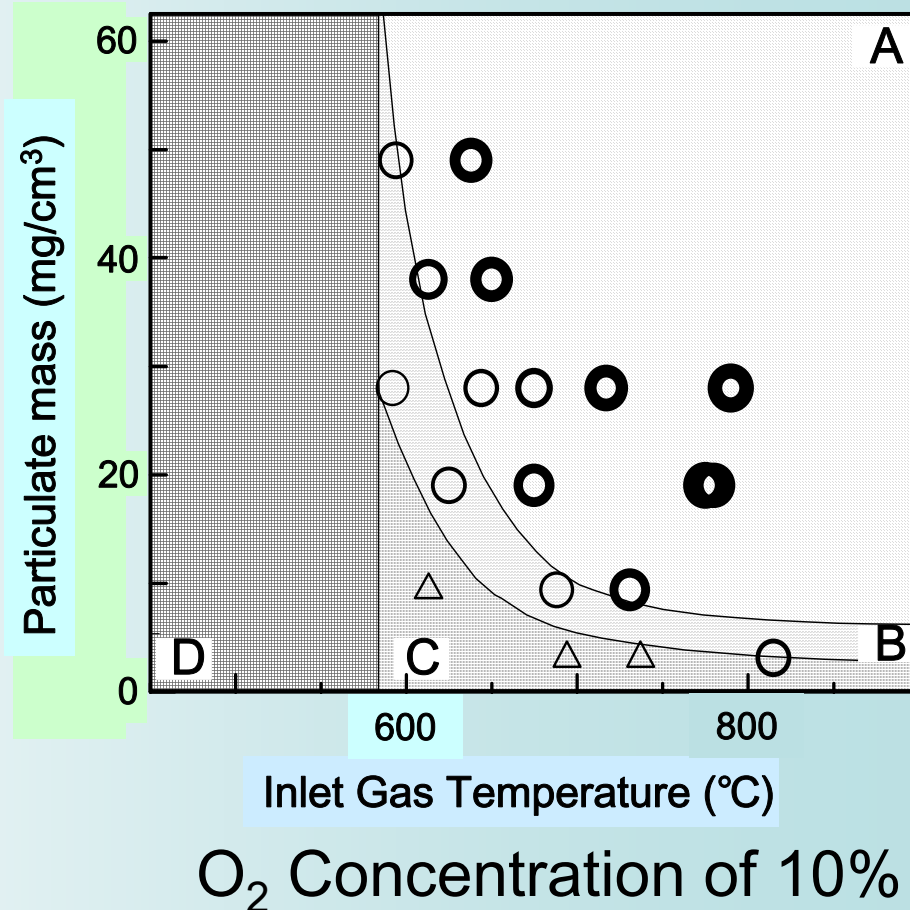
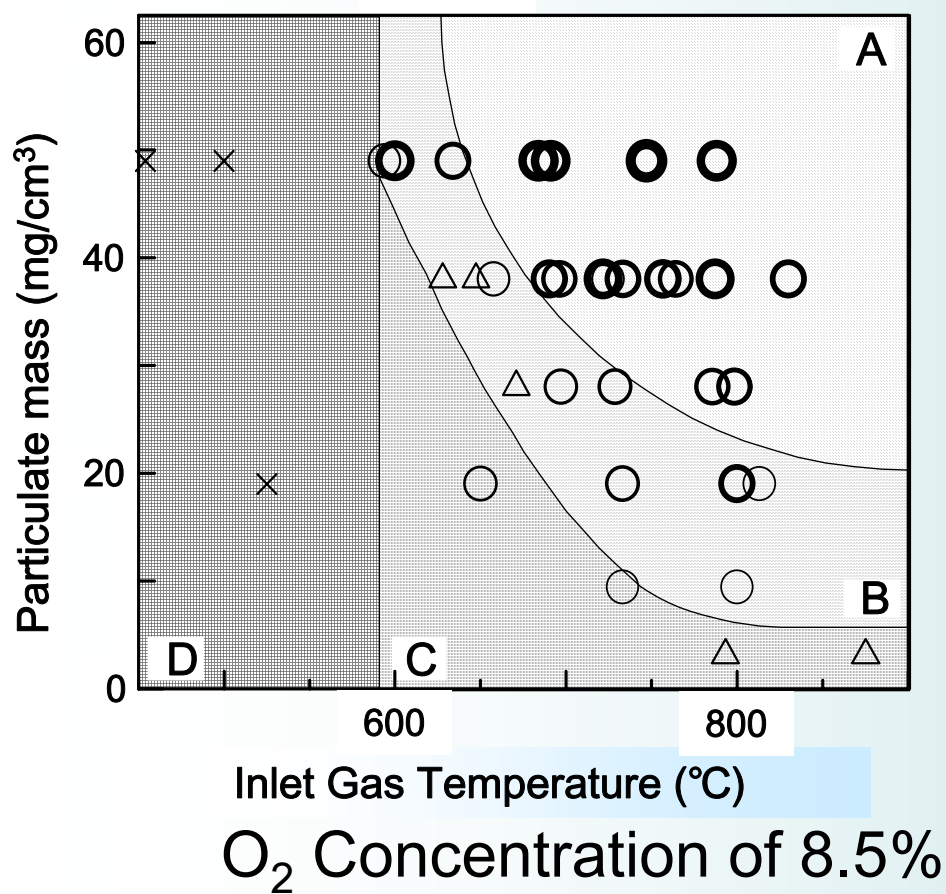


uniform-reaction regeneration

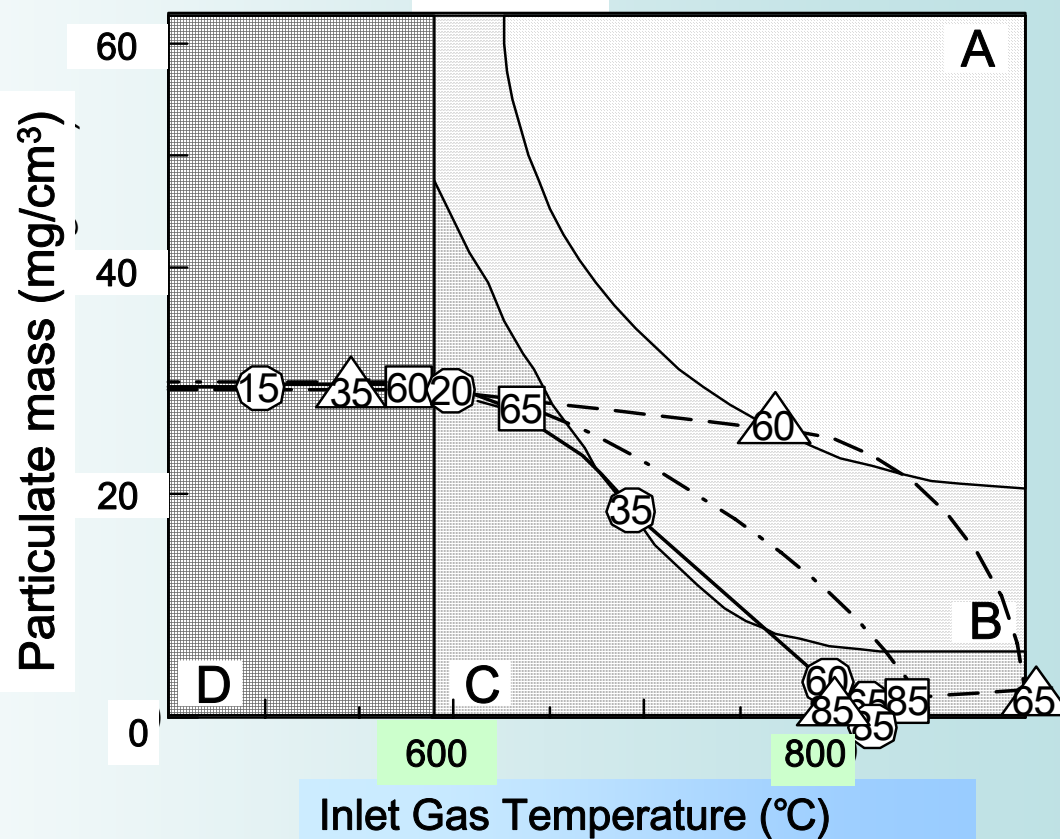
Definition of Reaction Intensity



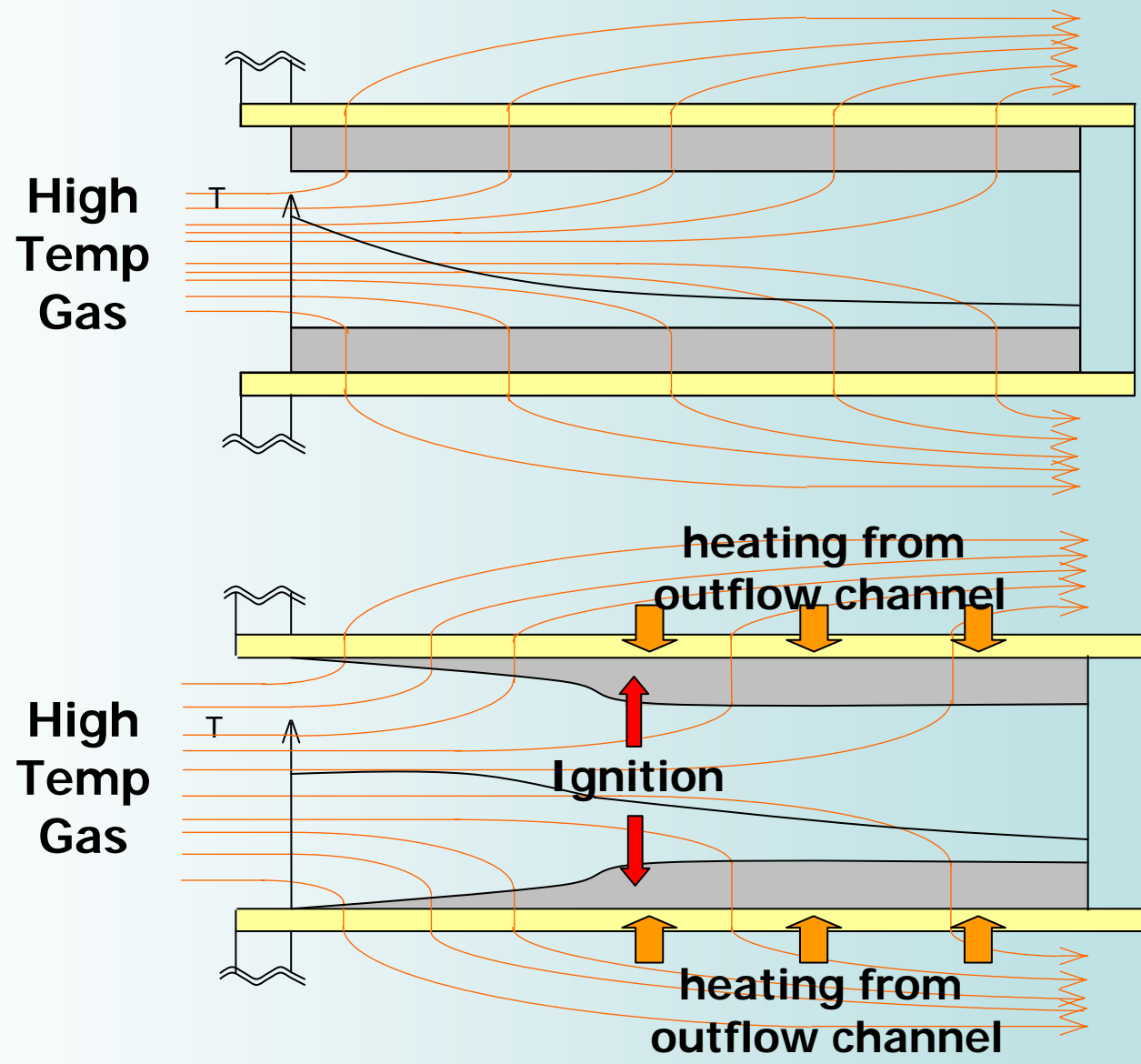
Reaction Diagram

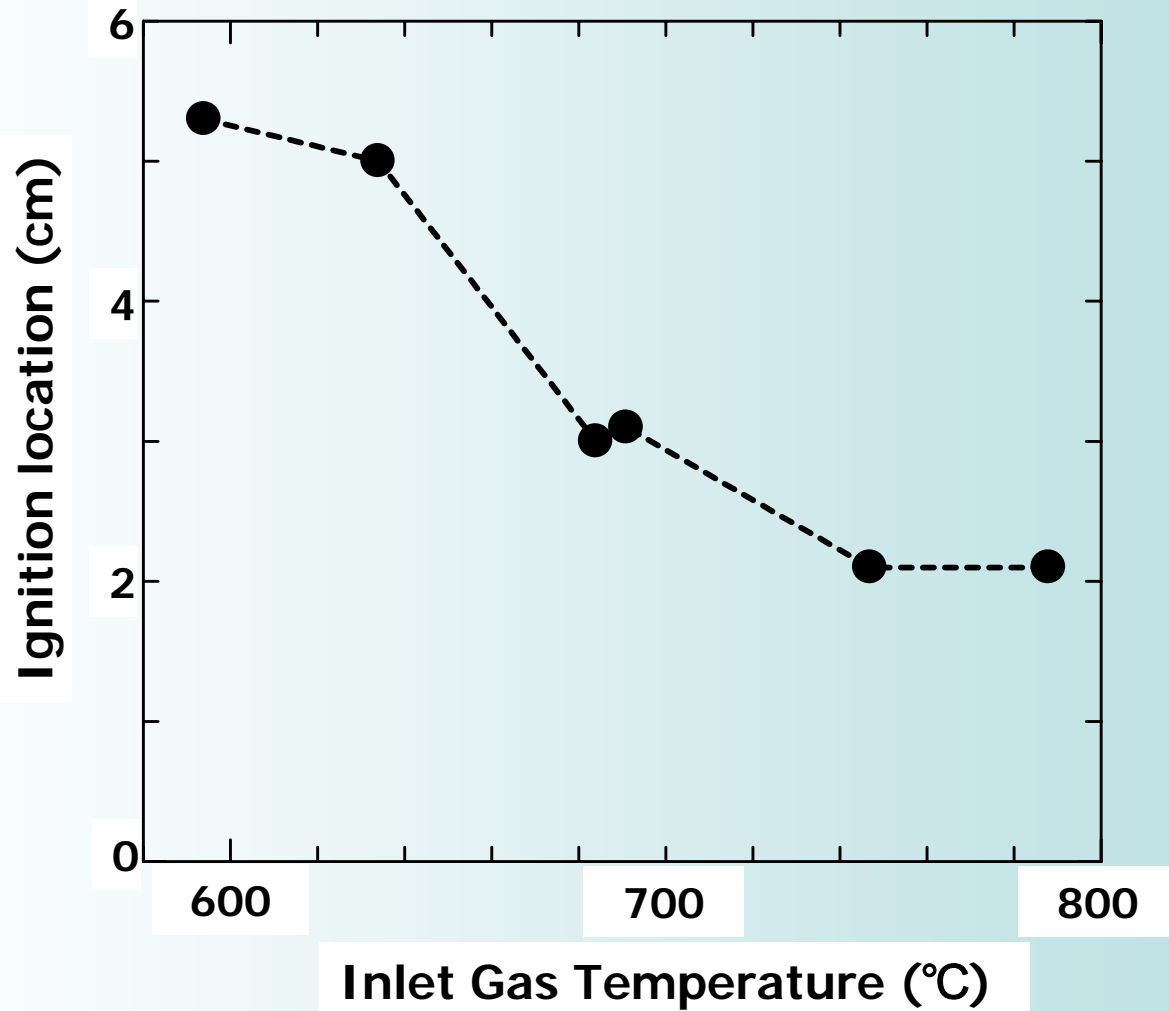


Reaction Diagram and Propagation Mechanism



Ignition and Propagation Mechanism

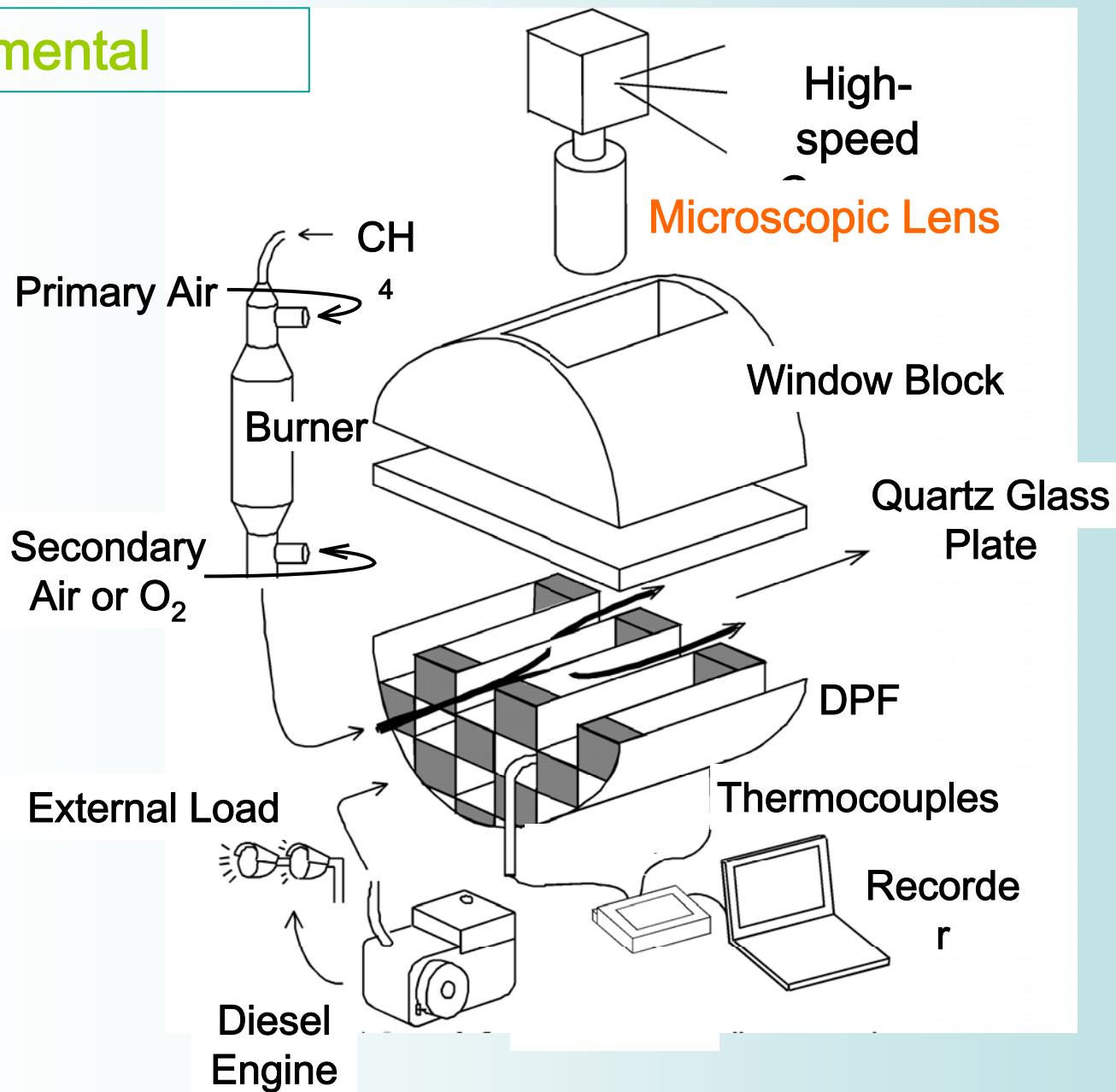


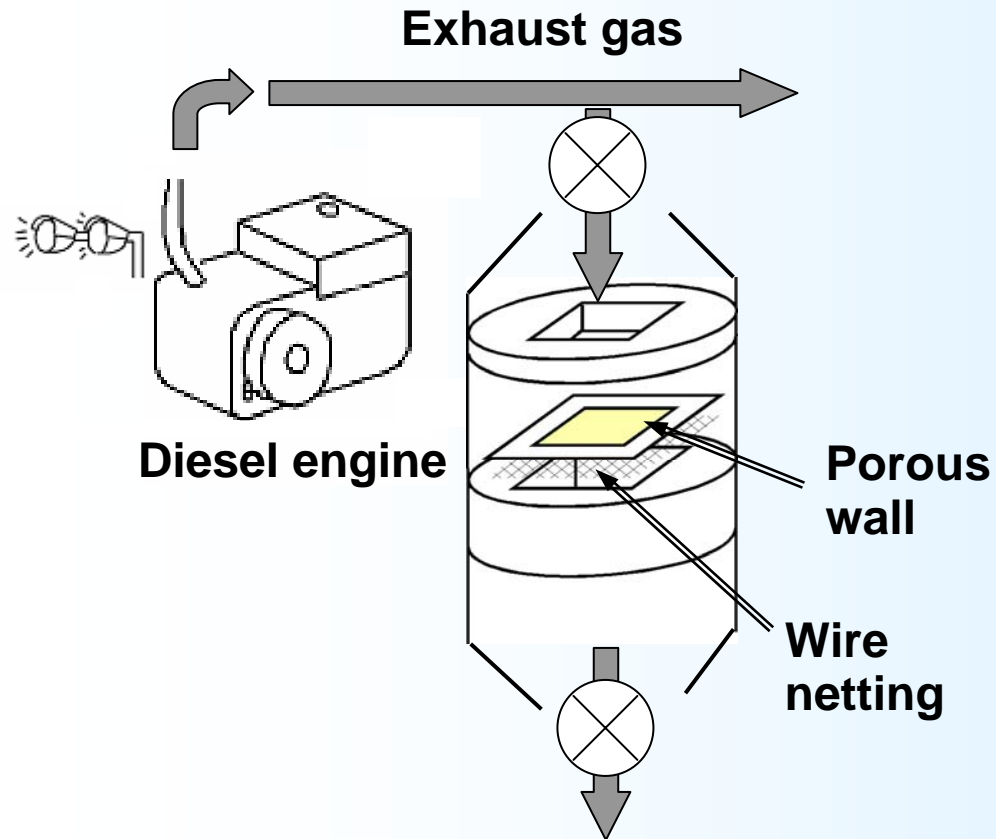
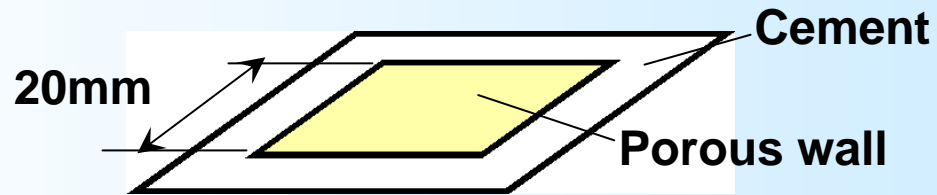


Variation of ignition location from the entrance

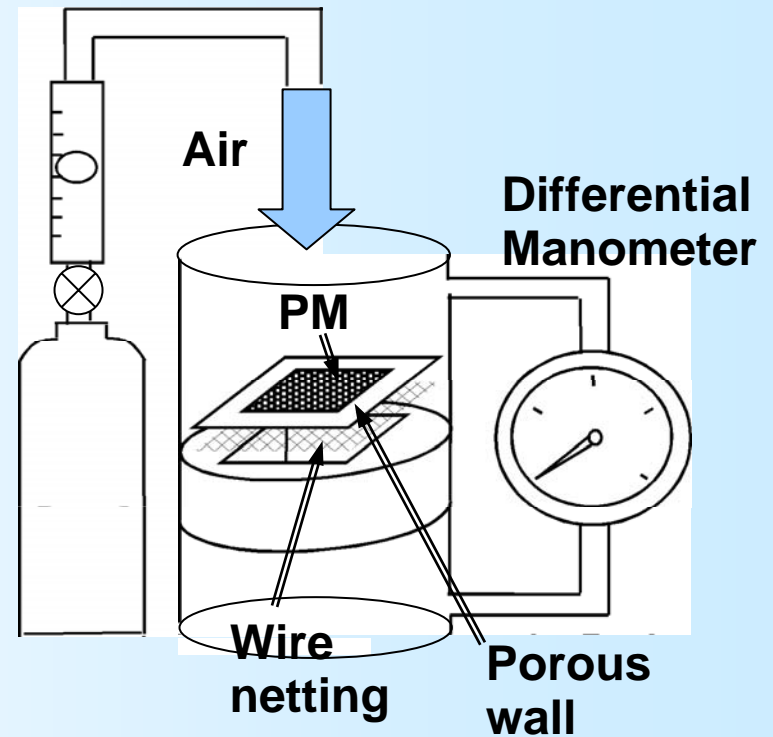
II. Microscopic Observation

Experimental Setup





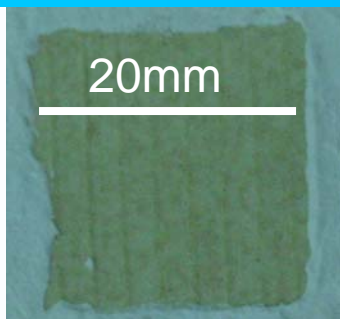
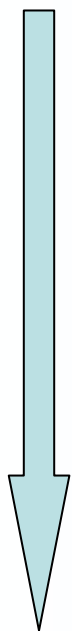
Particulate Trapping



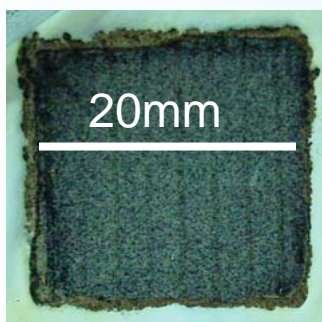
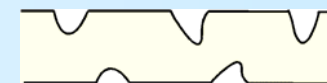
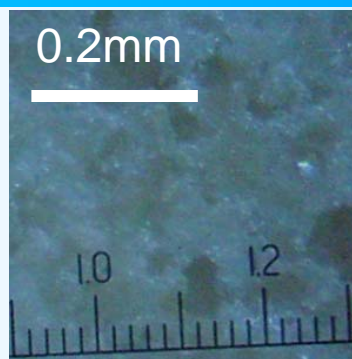
Measurement of Pressure Drop

Experimental Setup for Pressure Drop Measurement

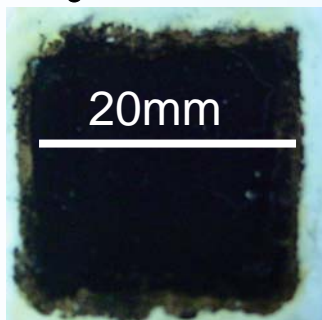
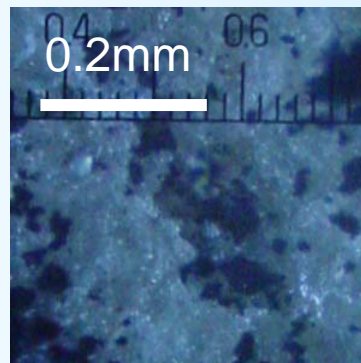
Particulate-mass increase



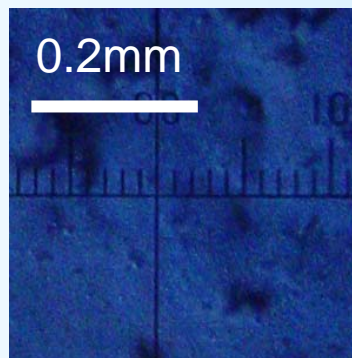
No Particulate



$\frac{4}{3}$ mg/cm³



$\frac{6.9}{3}$ mg/cm³

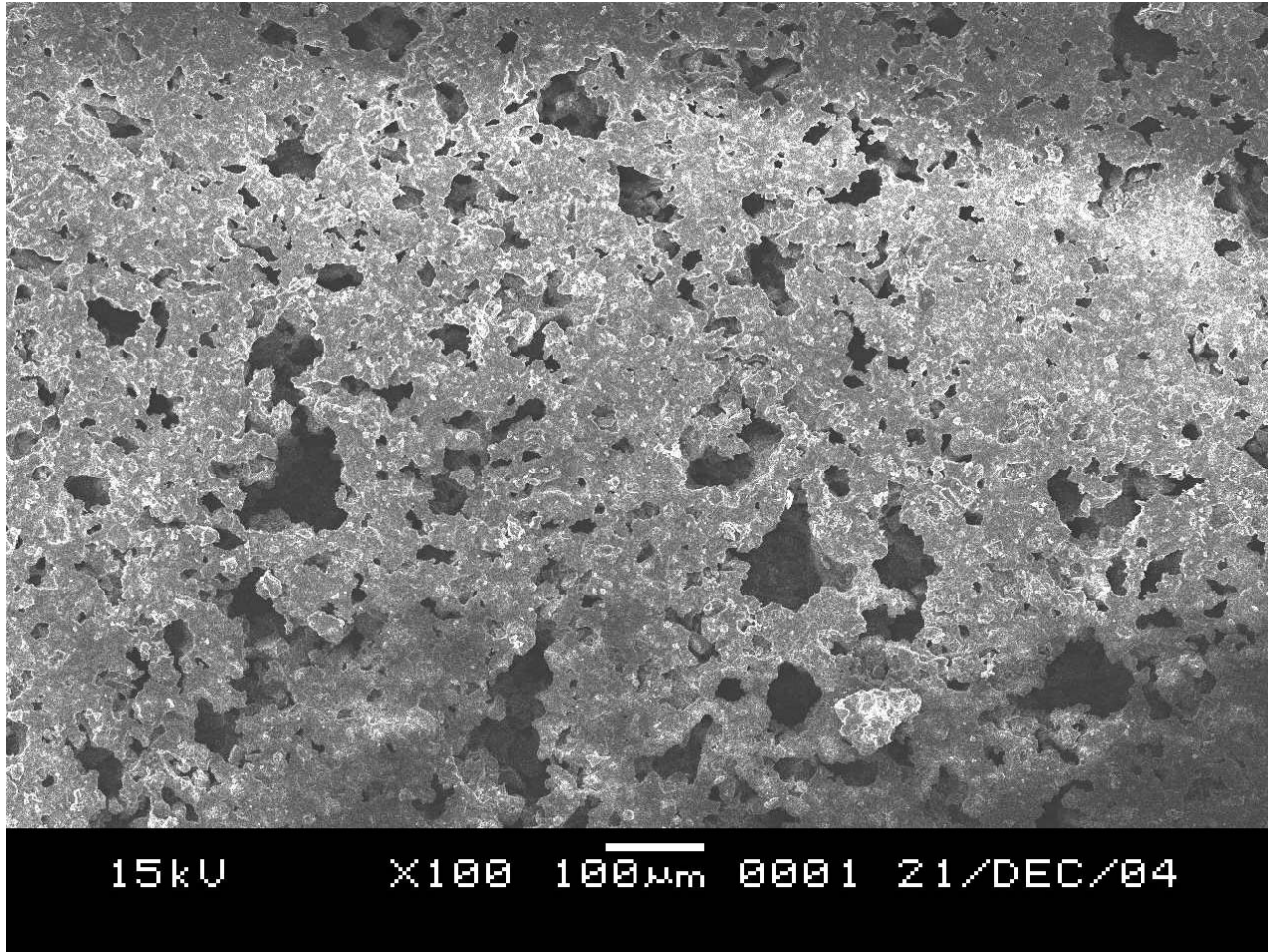


Macroscopic

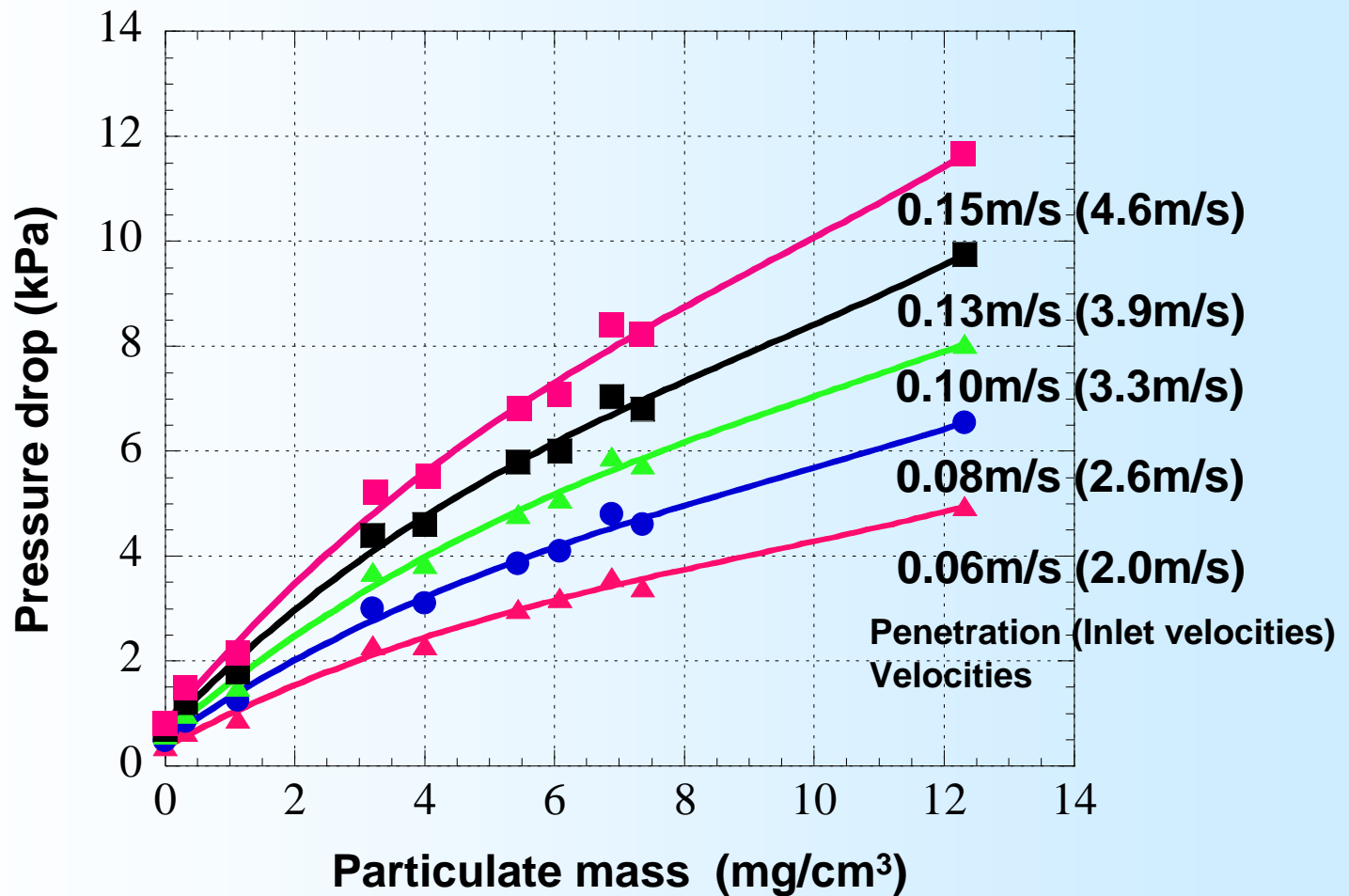
Microscopic View

Schematics

View
Photographs of Particulates trapped on the DPF wall

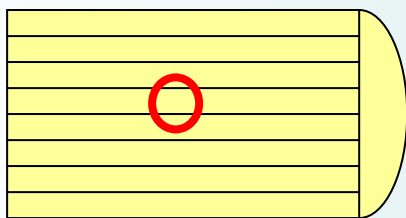


SEM Image of the DPF wall surface



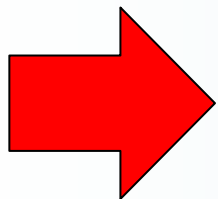
Pressure Drop through DPF wall

Microscopic Observation in Regeneration of DPF (PM mass: $9.4\text{mg}/\text{cm}^3$)

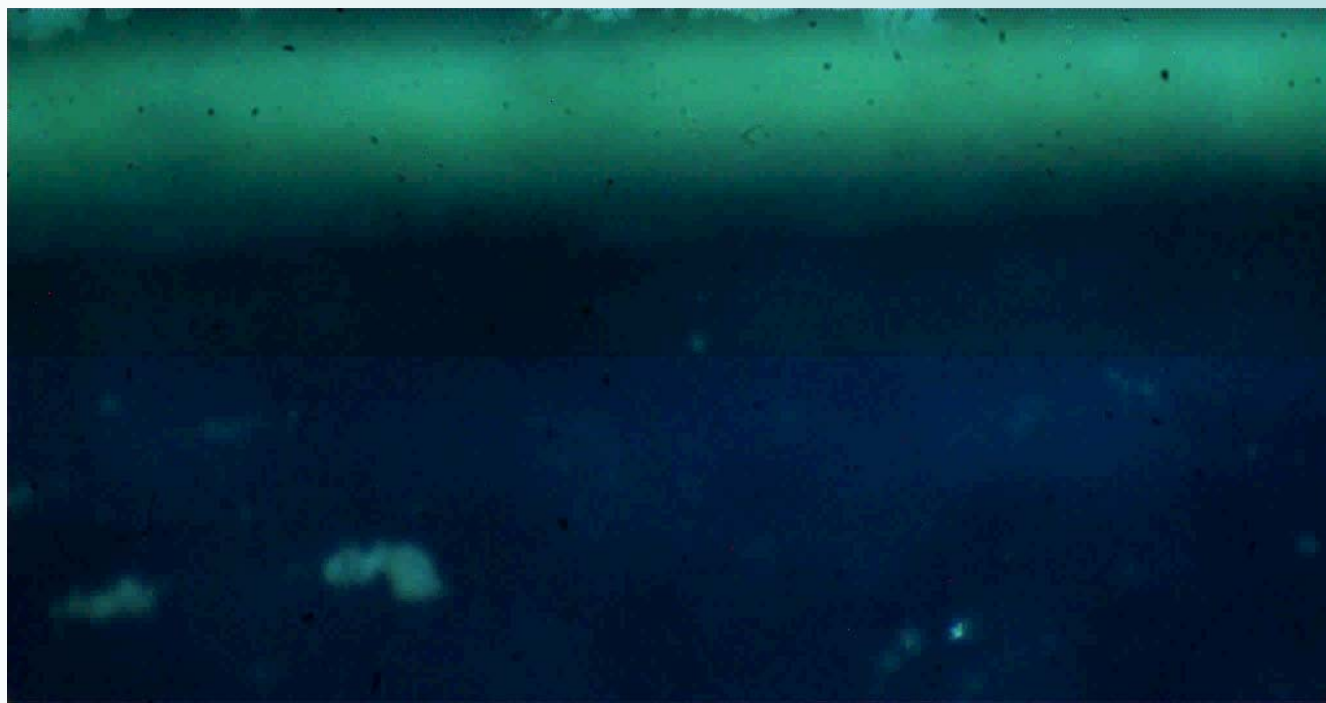


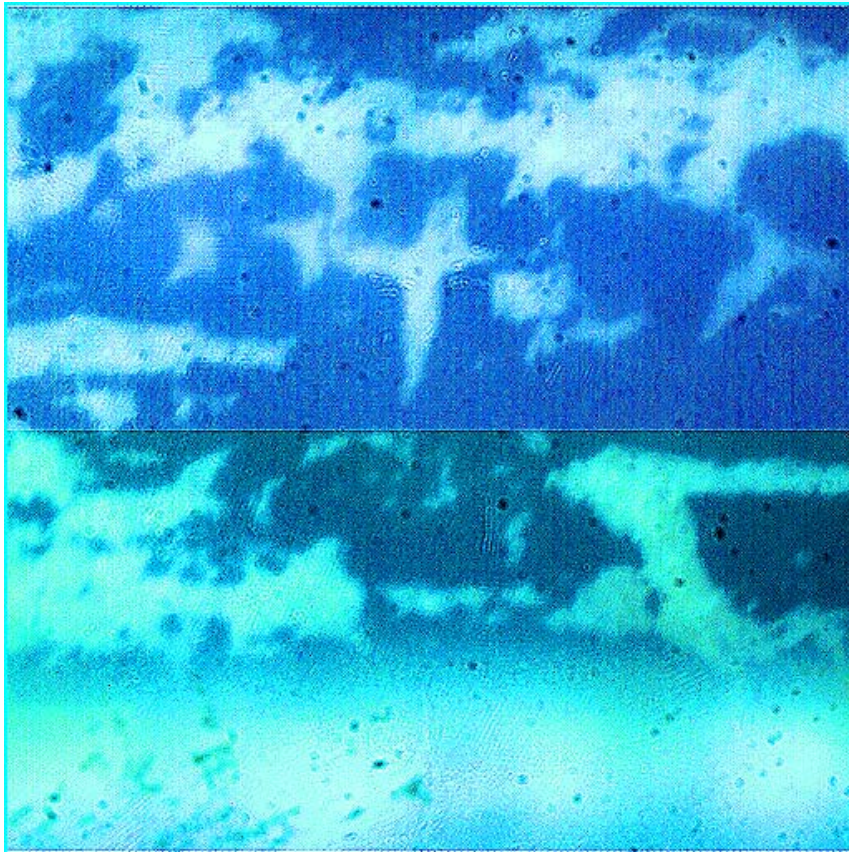
around middle

Inlet Velocity
4.4 m/s

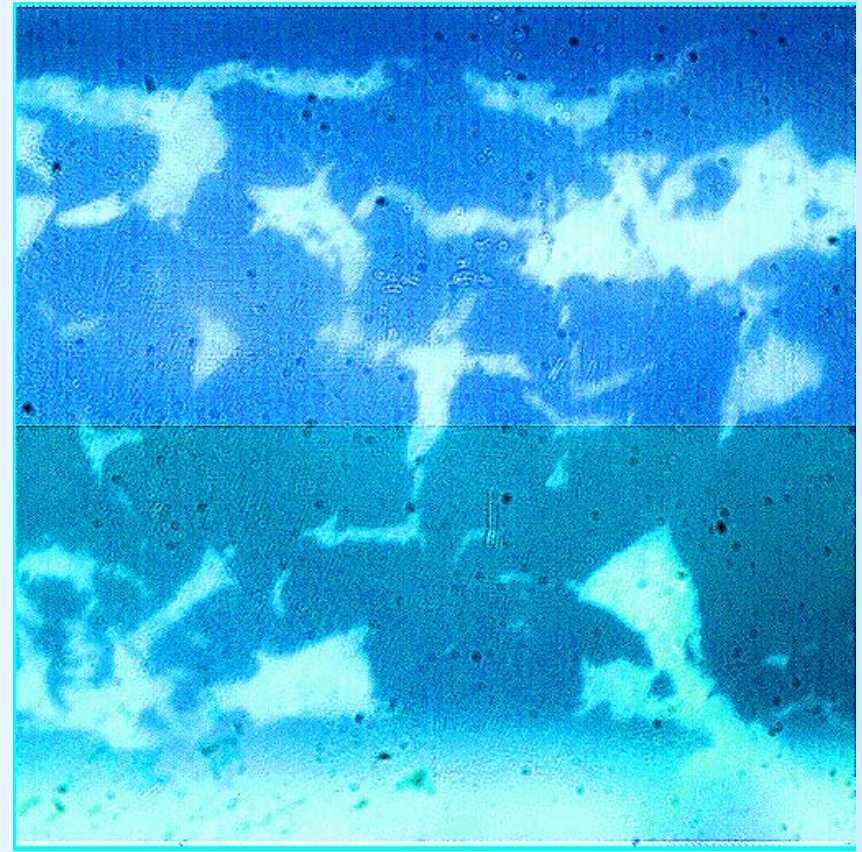


Inlet Temp.
 688°C



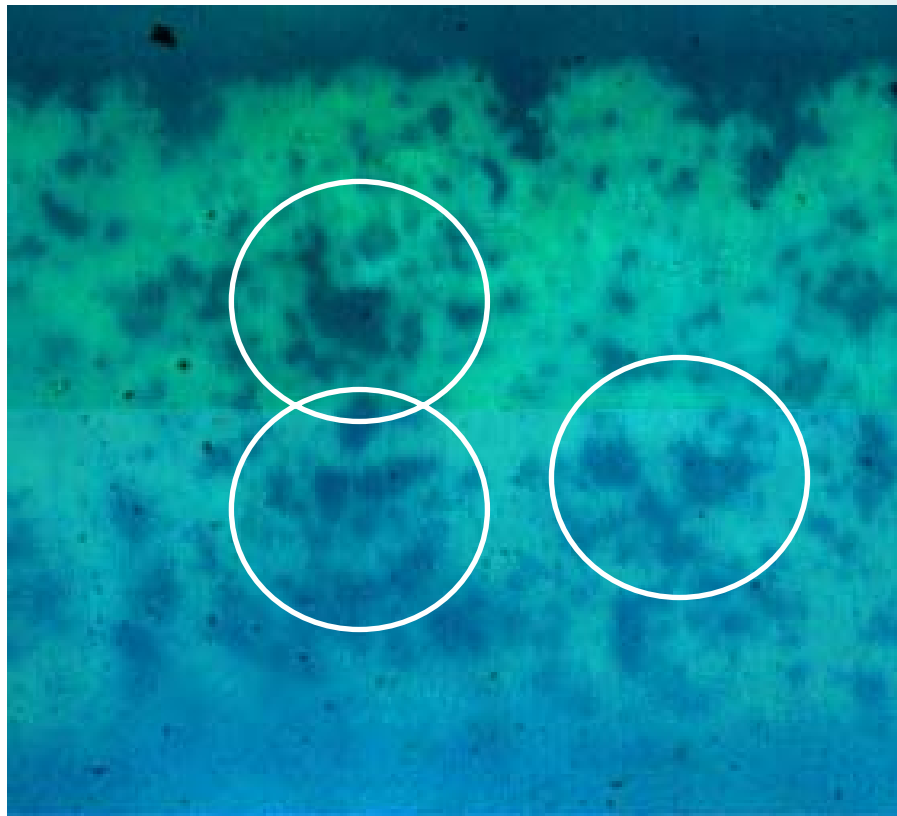


**Inlet Temp.; 579°C, Velocity; 3.6m/s,
Particulate Mass; 9.4 mg/cm³**

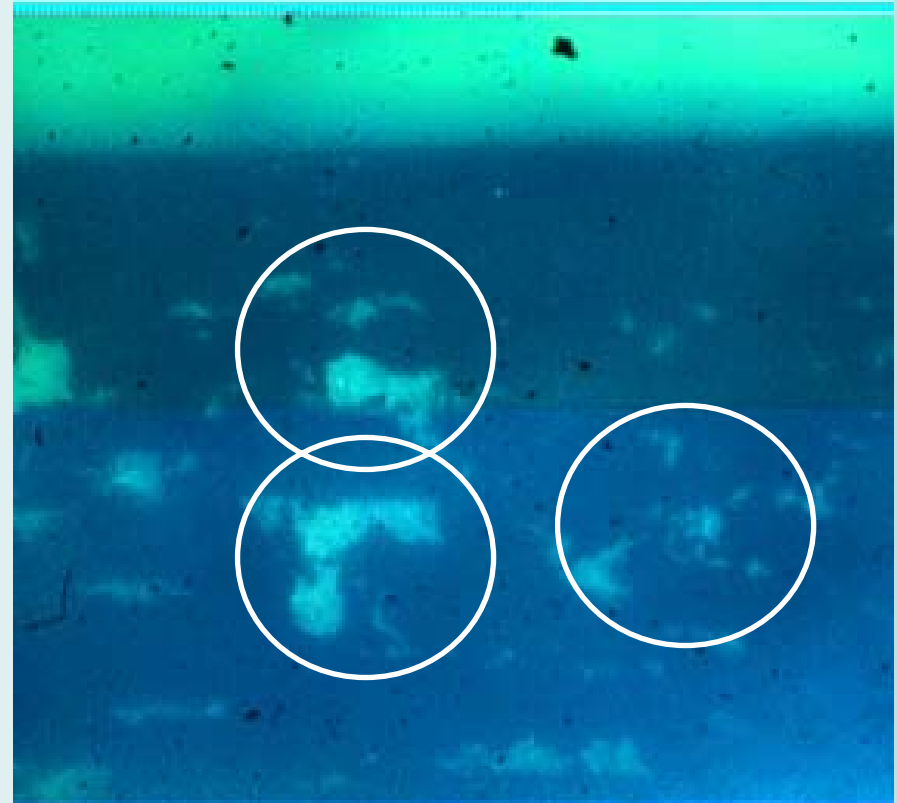


**Inlet Temp.; 572°C, Velocity; 3.6m/s,
Particulate Mass; 9.4 mg/cm³**

**Reproducibility for Regeneration of
DPF**

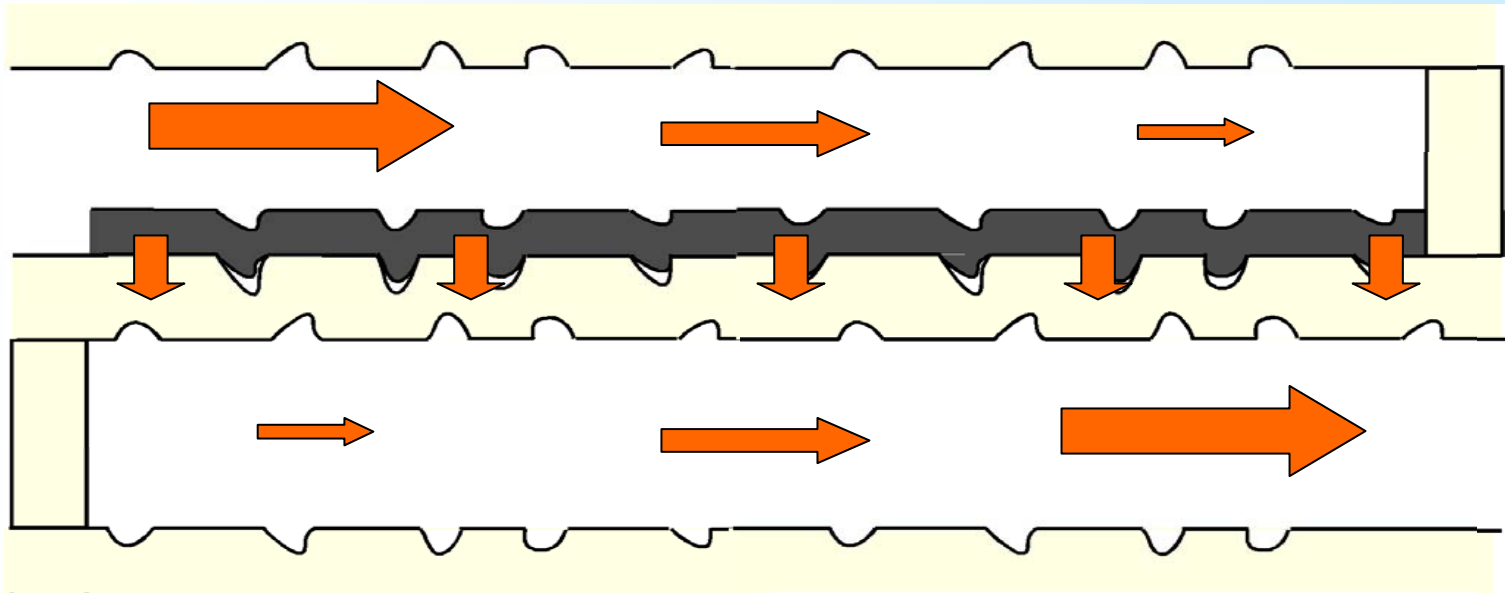


Beginning of
Trapping



Beginning of
Regeneration

Trapping Location and Regeneration Starting Location

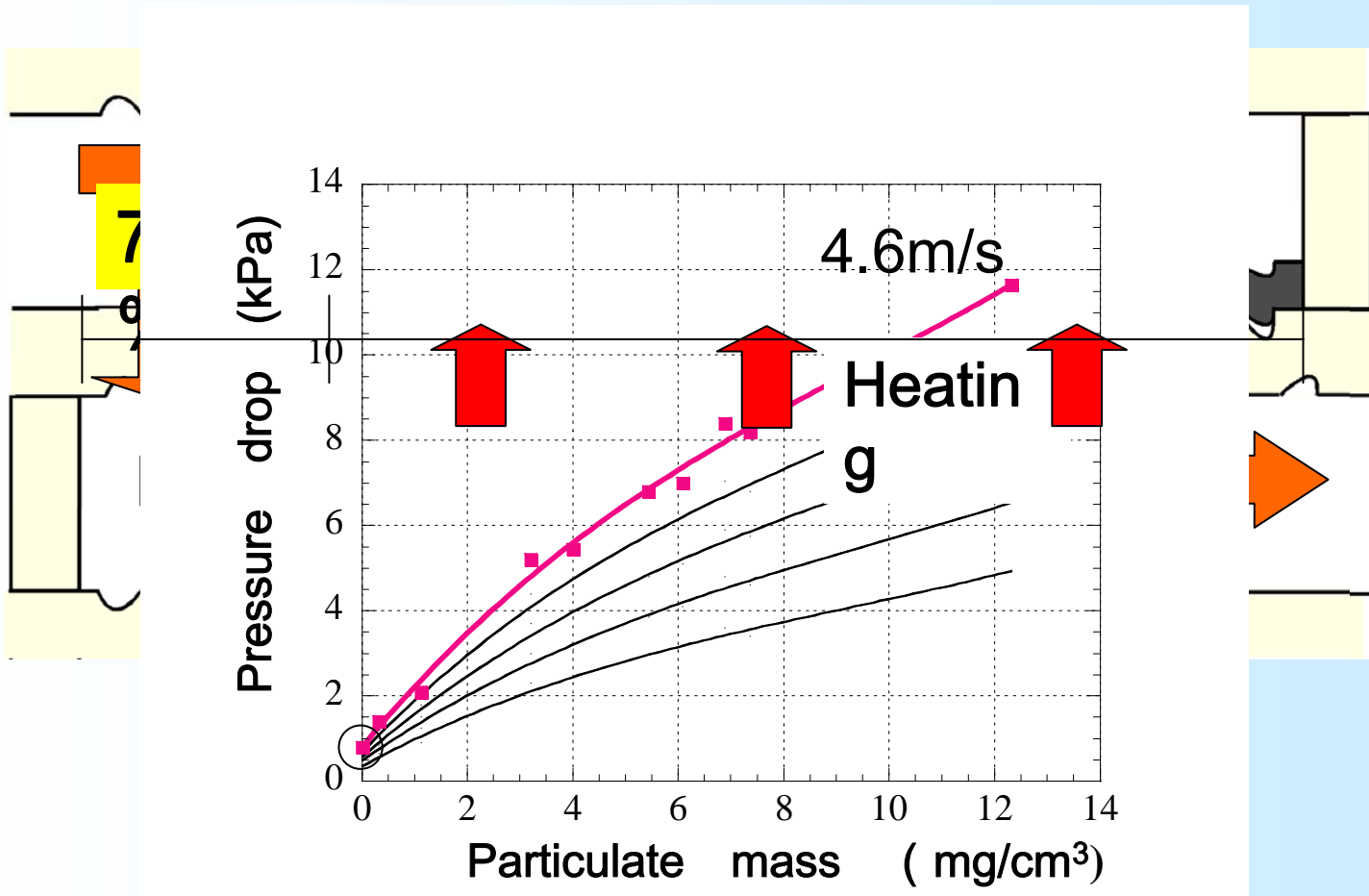


Temp.

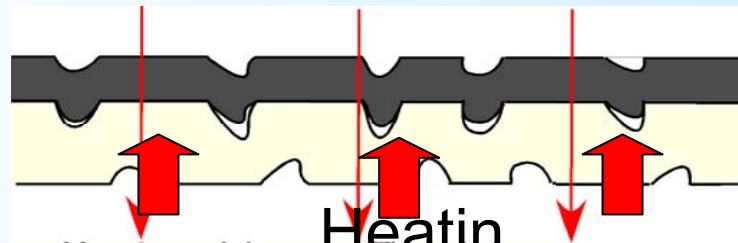


Mechanism of Regeneration

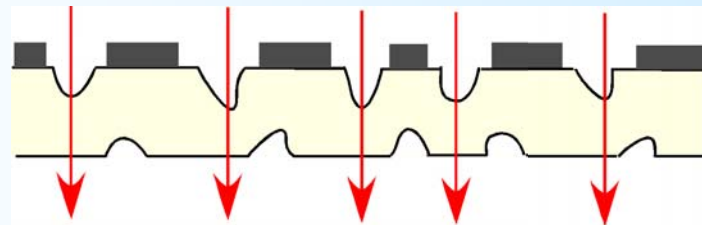
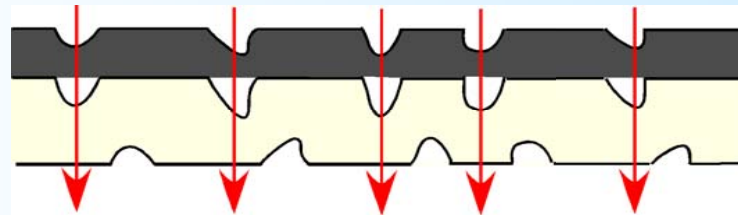
Particulate mass; $9.4\text{mg}/\text{cm}^3$, Velocity; $4.4\text{m}/\text{s}$



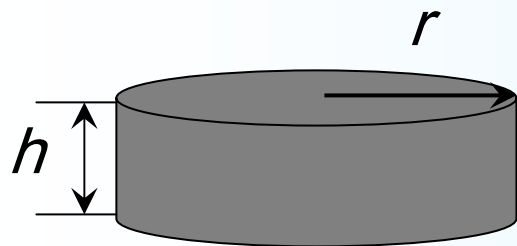
Mechanism of Regeneration



g

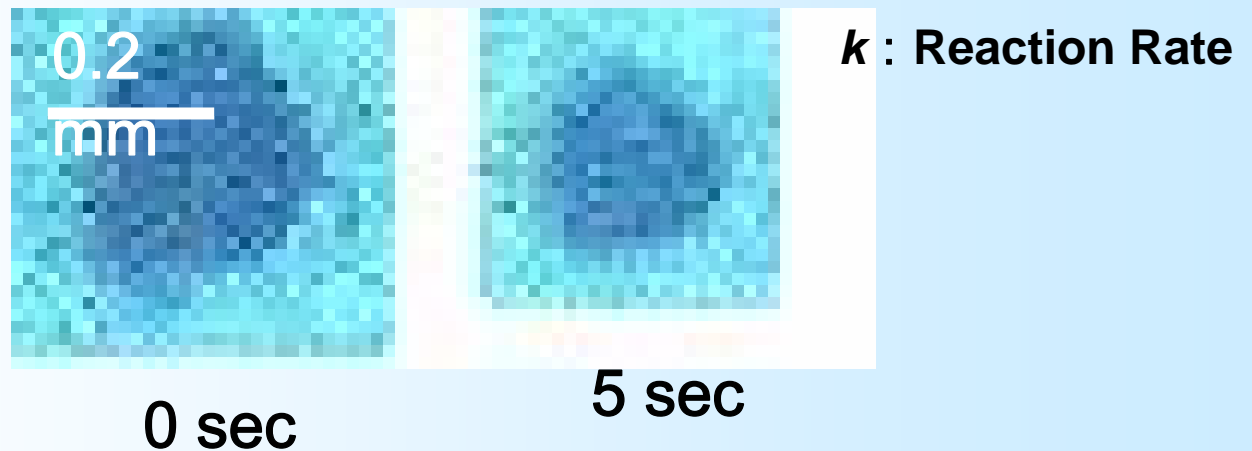


Mechanism of Regeneration

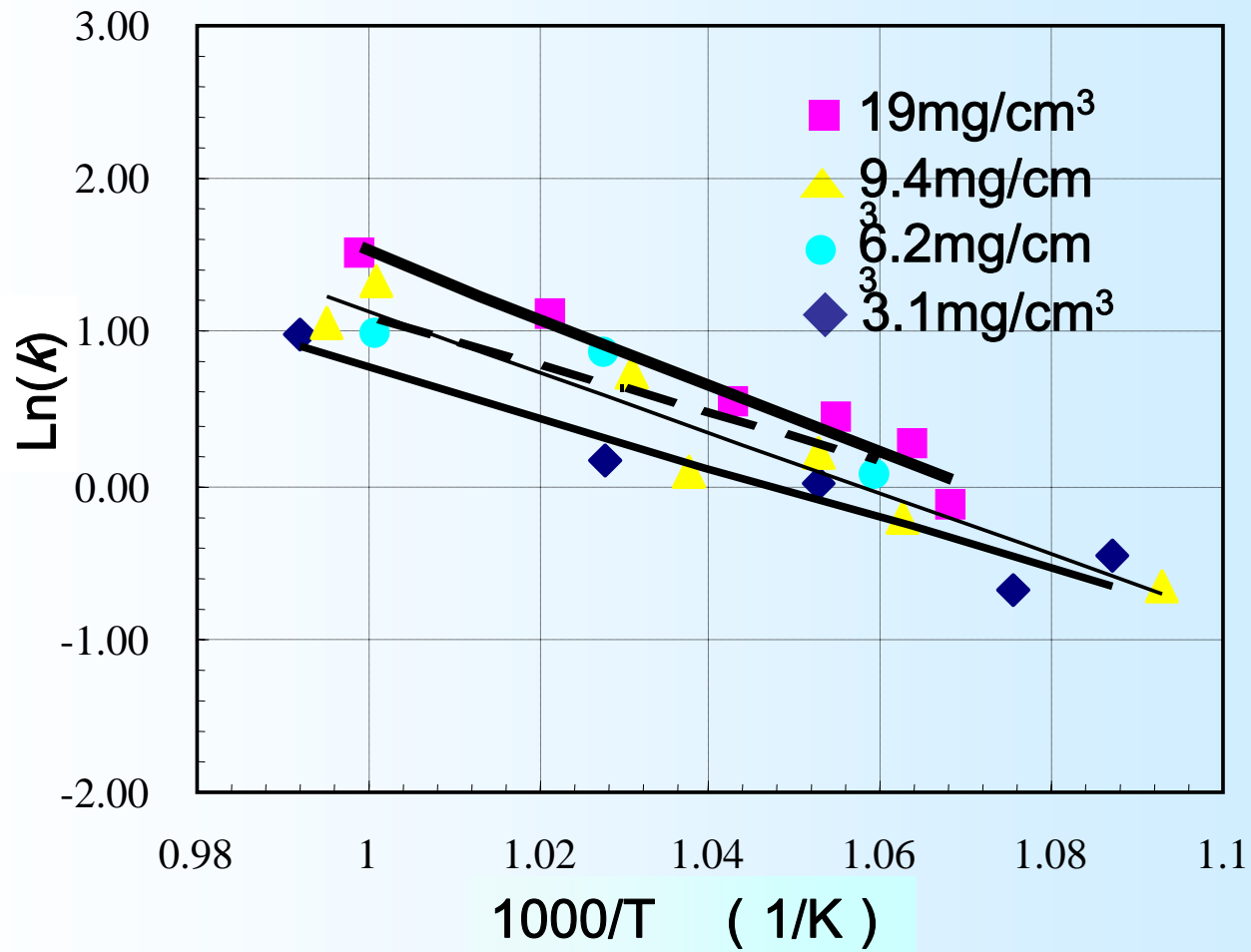


Constant Height of h
Uniform Density ρ

$$-(2\pi rh)k = \frac{d(\rho\pi r^2 h)}{dt} \quad \longrightarrow \quad -\frac{2\pi}{\rho}k = \frac{d(\pi r^2)}{dt} \frac{1}{r}$$



Arrhenius Plot



Arrhenius Plot

Concluding Remarks I

- (1) Trapping and regeneration process could be clearly seen.
- (2) Basically, there are two kinds of reaction mechanisms with a high brightness reaction zone and without such a clear reaction zone.
- (3) These reaction mechanisms are described by a reaction diagram using the inlet gas temperature and the particulate mass.
- (4) The ignition and the propagation mechanisms are well understood using the reaction diagram.

Concluding Remarks II

- (1) Regeneration starts from the location of large-scale craters. In the beginning of trapping, only the crater collects particulates.
- (2) From microscopic observation, it is disclosed that basically, the heterogeneous reaction occurs in regeneration.
- (3) The reaction rate will be enhanced by making fine craters on the DPF wall surface
- (4) Catalysis coating on the crater surfaces is very useful to enhance the reaction rate.

Microscopic
Observation of
Trapping

