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Evaluation of Pressure Drop during Filtration of Gasoline Particulate Filter

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Recent Progress in Japan

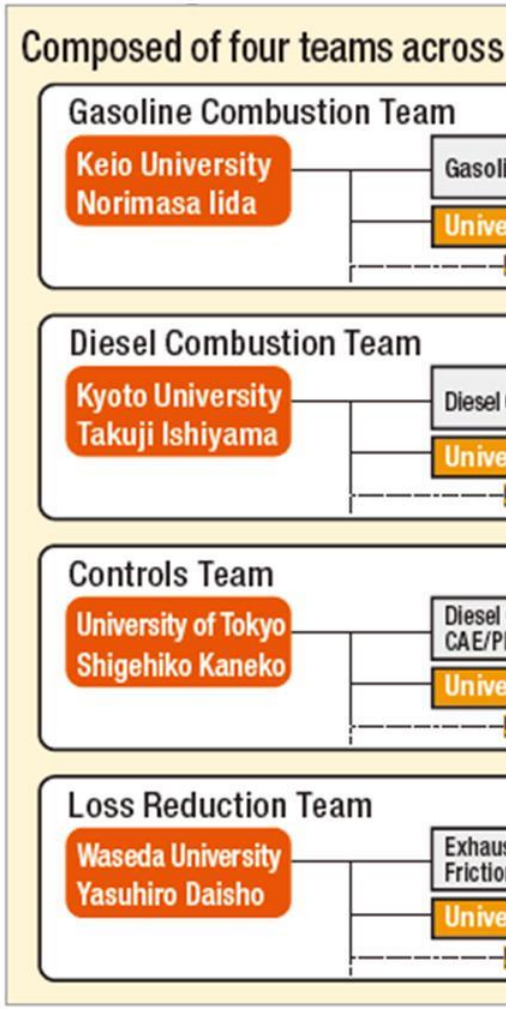
(1) National Project in Innovative Combustion Technology (2014-2018)

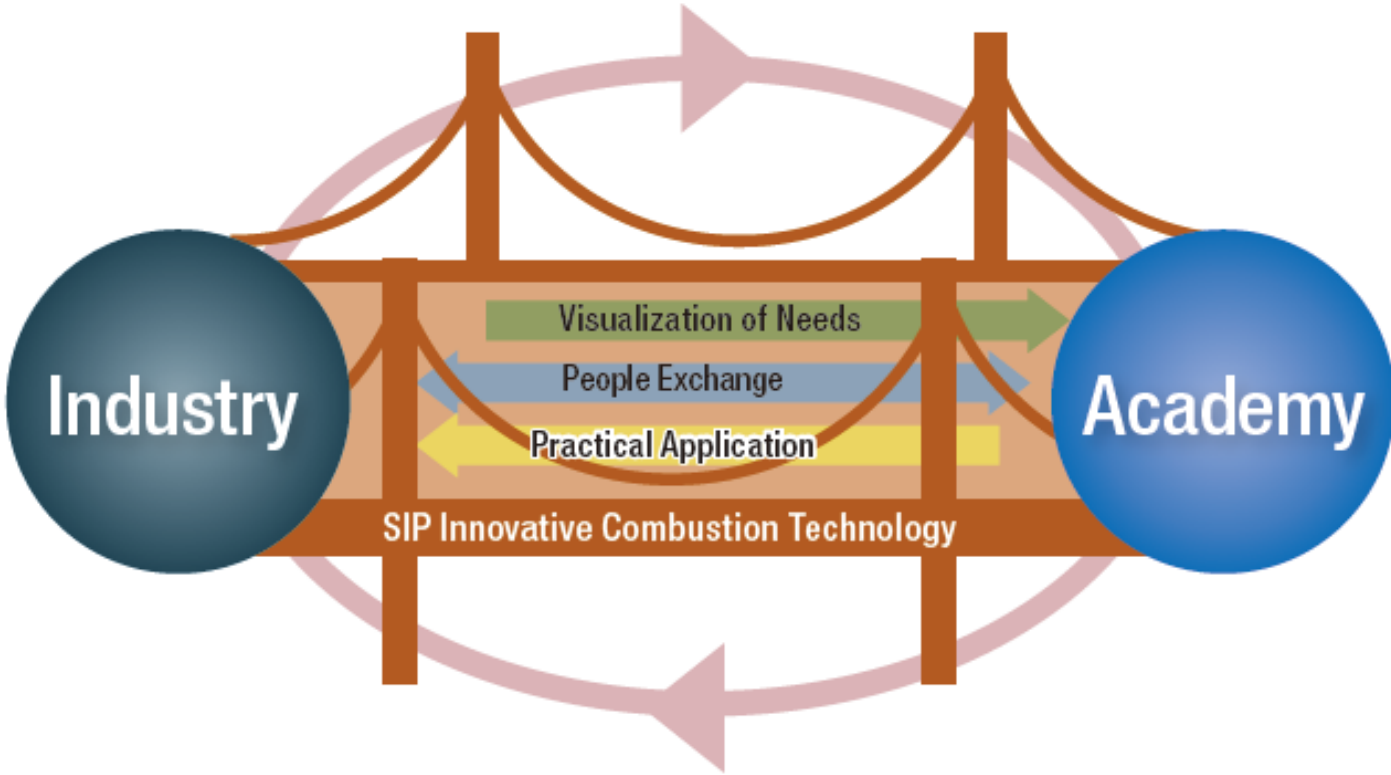
- Program in Cross-ministerial Strategic Innovation Promotion (SIP)
- Achieving 50% thermal efficiency of automotive ICE
- 4 teams (gasoline, diesel, exhaust gas control, loss reduction)

(2) New organization, AICE (Automotive Internal Combustion Engines)

- Consisting of 9 automobile companies and 2 organizations
- Goal is to utilize research achievement and accelerate the development activities of each automaker

AICE New Program in 2018-2019





Industry ⇒ Academy: Visualize Common Needs in Industry

Academy ⇒ Industry: Provide Basic Knowledge

Academy ⇔ Industry: Sustained Exchanges in Human Resources/Needs/Seeds

https://www8.cao.go.jp/cstp/panhu/sip_english/9-12.pdf

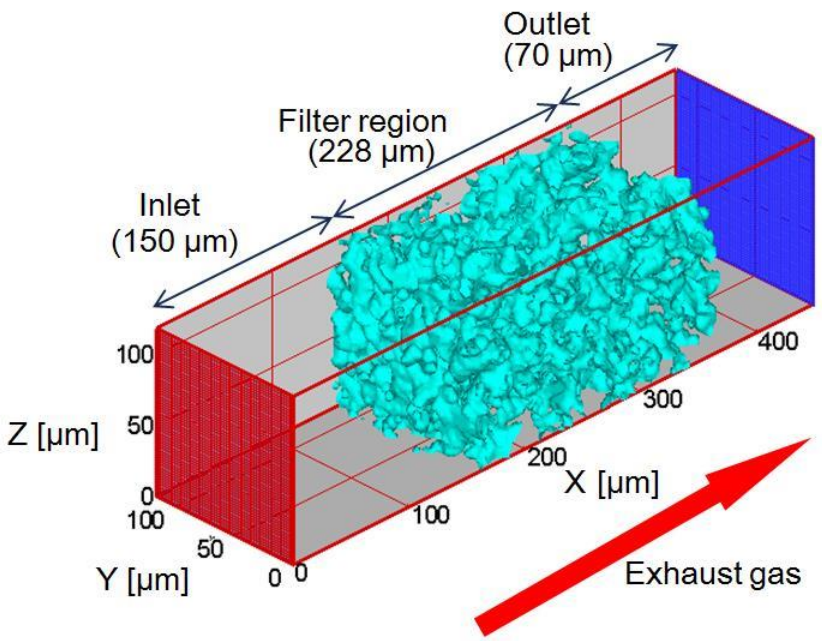
Background and Objective

- Recently, GDI (gasoline direct injection) vehicles are replacing traditional port fuel injection vehicles
- Particle emissions exceeding Euro 6 diesel limit (6×10^{11} #/km)
- Gasoline particulate filter (GPF) is needed, but properties of gasoline particulates would be different from those of diesel particulates

In this study, we simulated soot filtration by lattice Boltzmann method. We discussed amount of deposited soot and pressure drop. The substrate structure of GPF was obtained by X-ray CT technique. We focused on soot size, filtration velocity, exhaust gas temperature, and soot concentration.

Numerical Domain and Conditions

448 μm(X)×120 μm(Y) ×120 μm(Z)



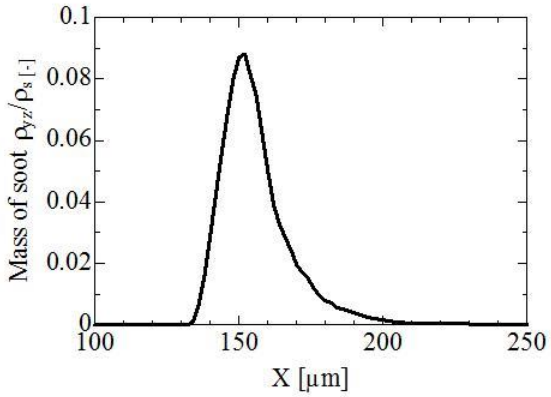
Numerical domain

Case	V [cm/s]	Temp. [℃]	Mass Fra. [-]	Soot size [nm]
1	2.0	500	0.001	80
2	1.0	500	0.001	80
3	4.0	500	0.001	80
4	1.6*	350	0.001	80
5	2.4*	650	0.001	80
6	2.0	500	0.0001	80
7	2.0	500	0.01	80
8	2.0	500	0.001	60
9	2.0	500	0.001	100

$\rho V = \text{const.}$

Soot Deposition Region and ΔP

$$\rho_{yz} = \Sigma_y \Sigma_z \rho_s(x, y, z)$$

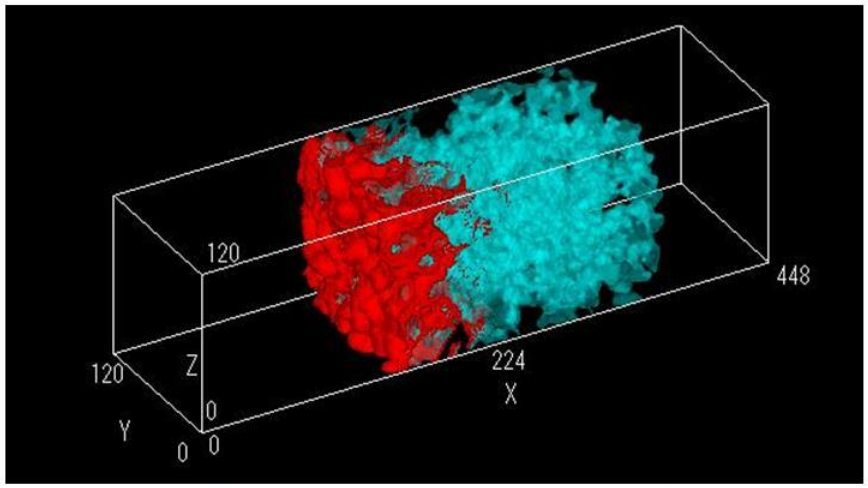


Depth filtration

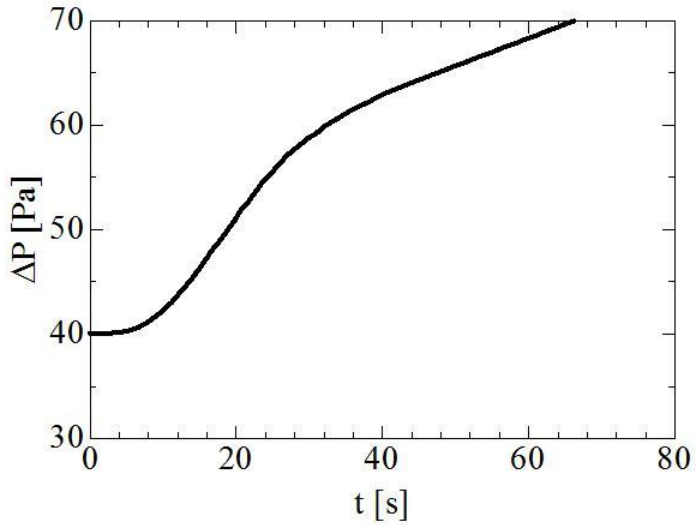
- Soot is deposited inside the filter wall
- Pressure drop increases very rapidly

Surface filtration

- Soot is deposited only on filter surface
- The linear increase of ΔP is observed

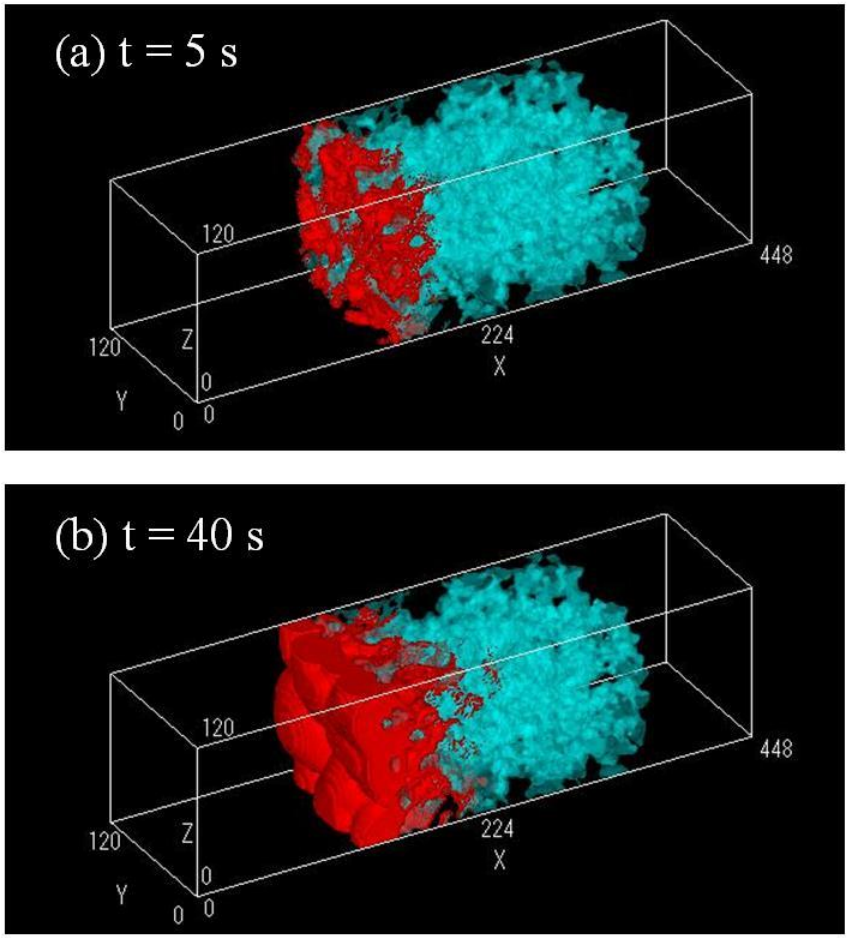


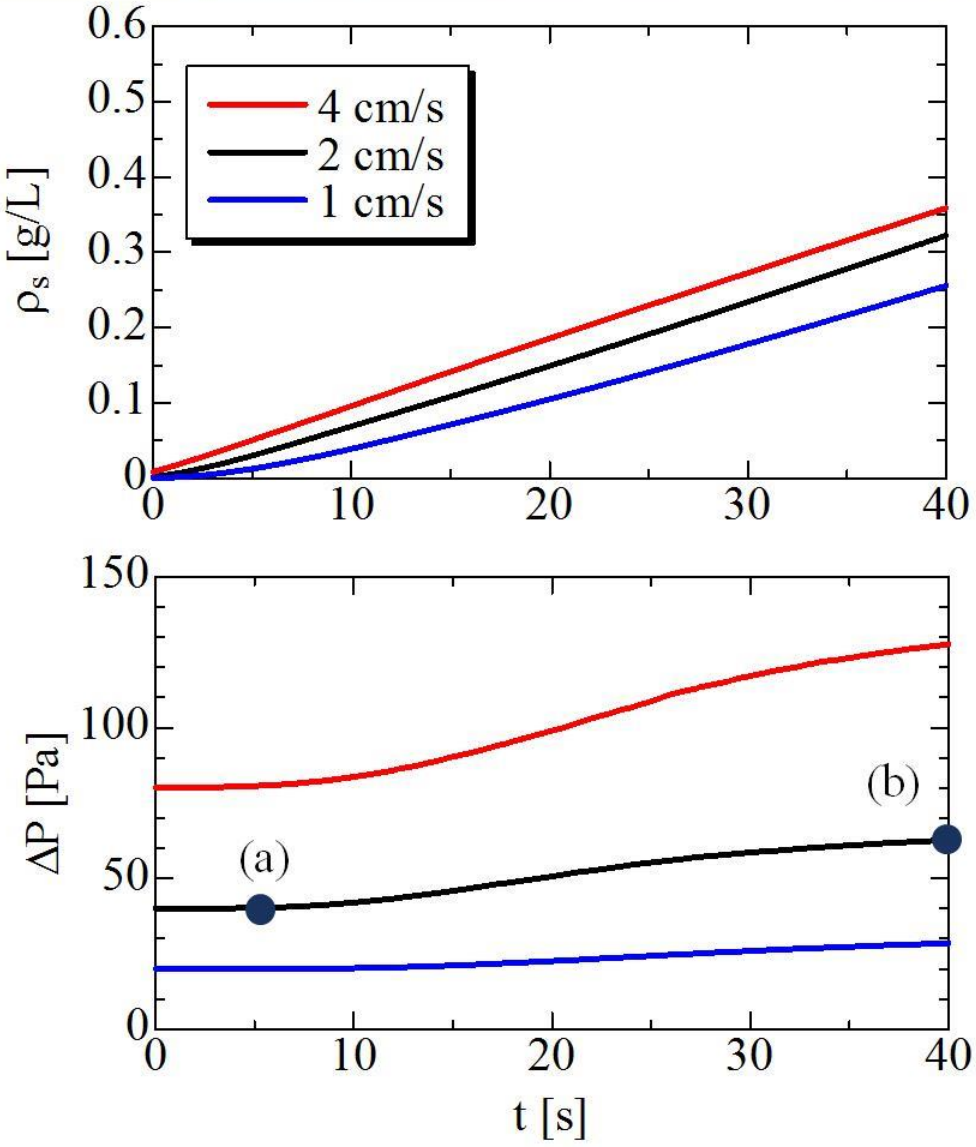
Soot deposition region



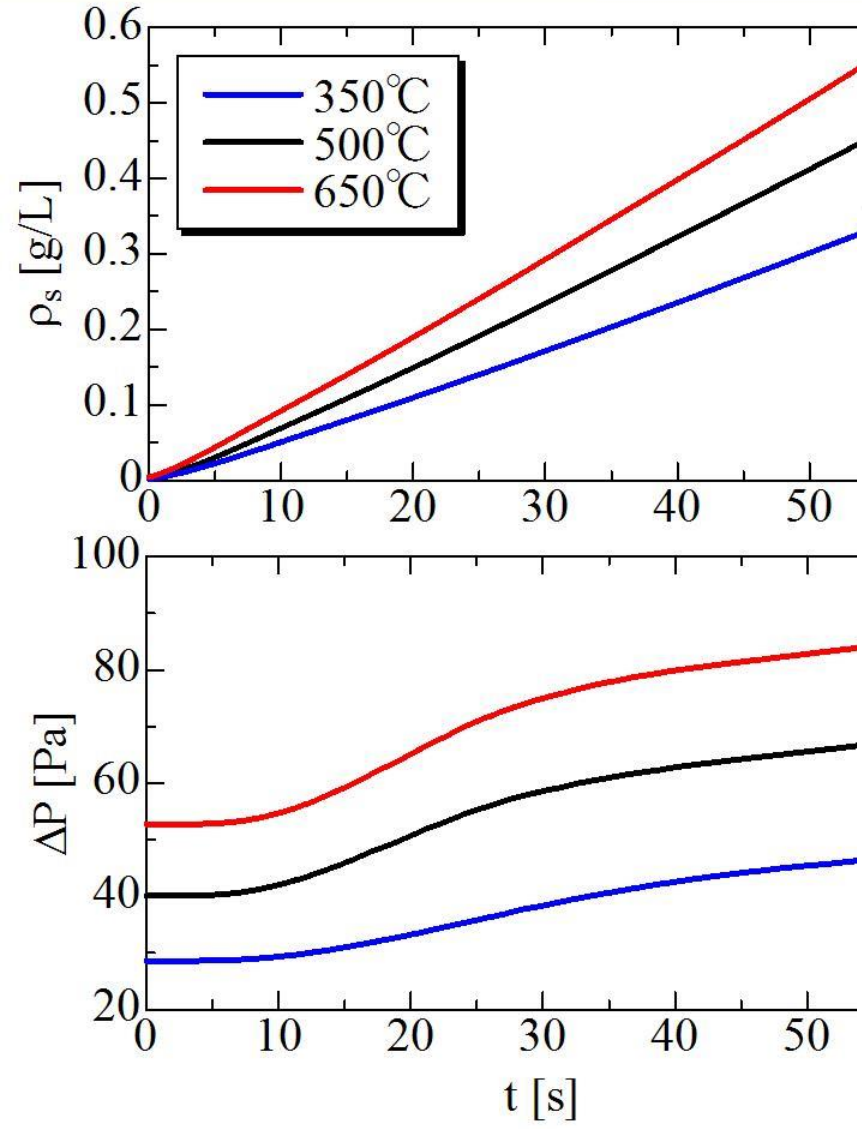
Time-variation of pressure drop

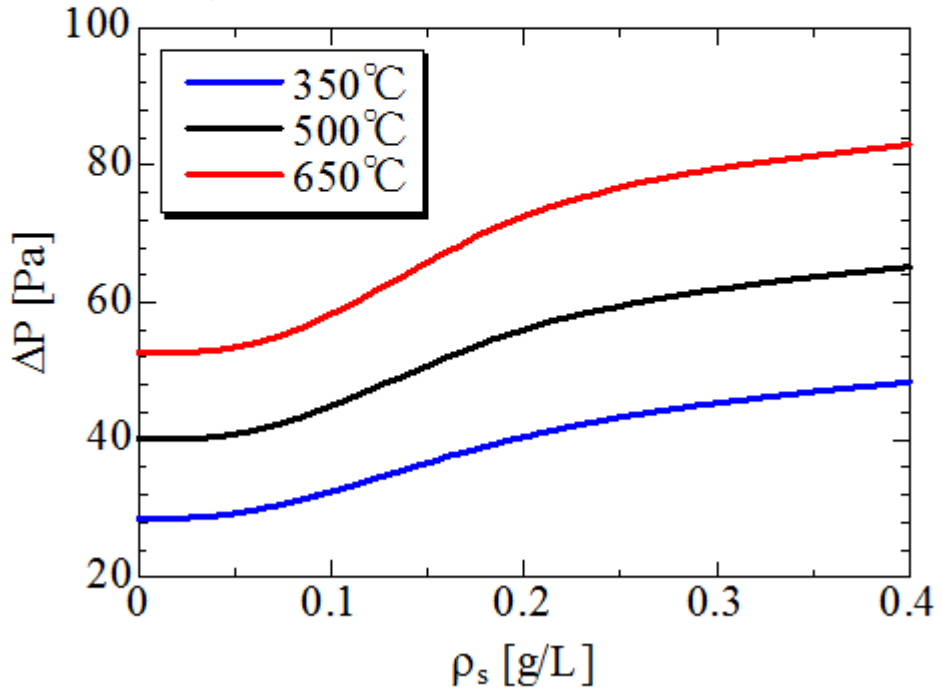
Effect of Filtration Velocity



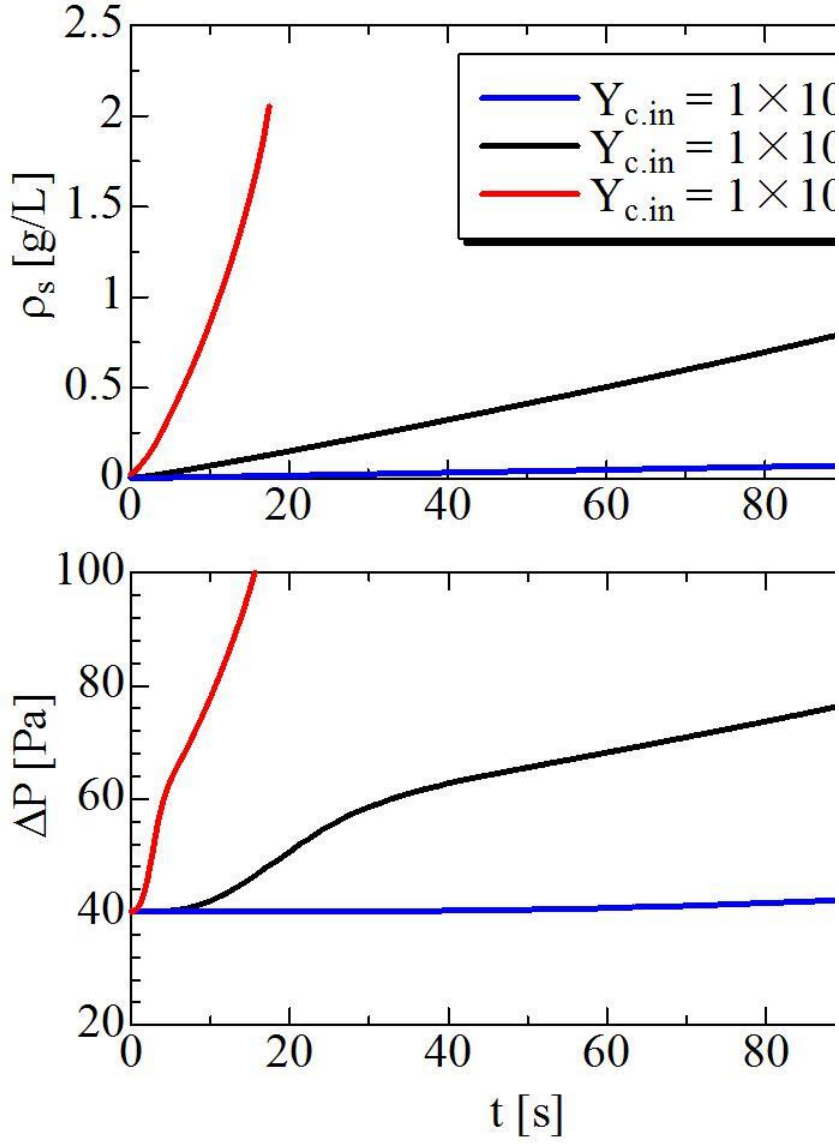


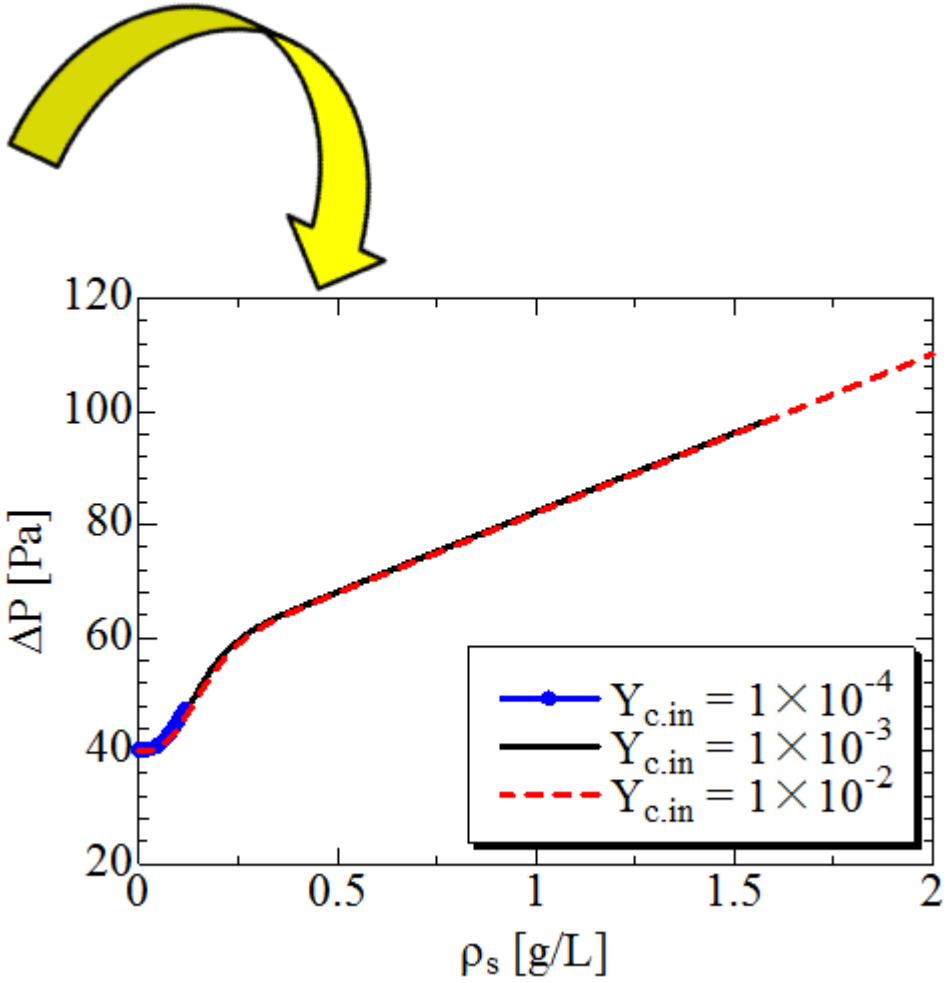
Effect of Temperature



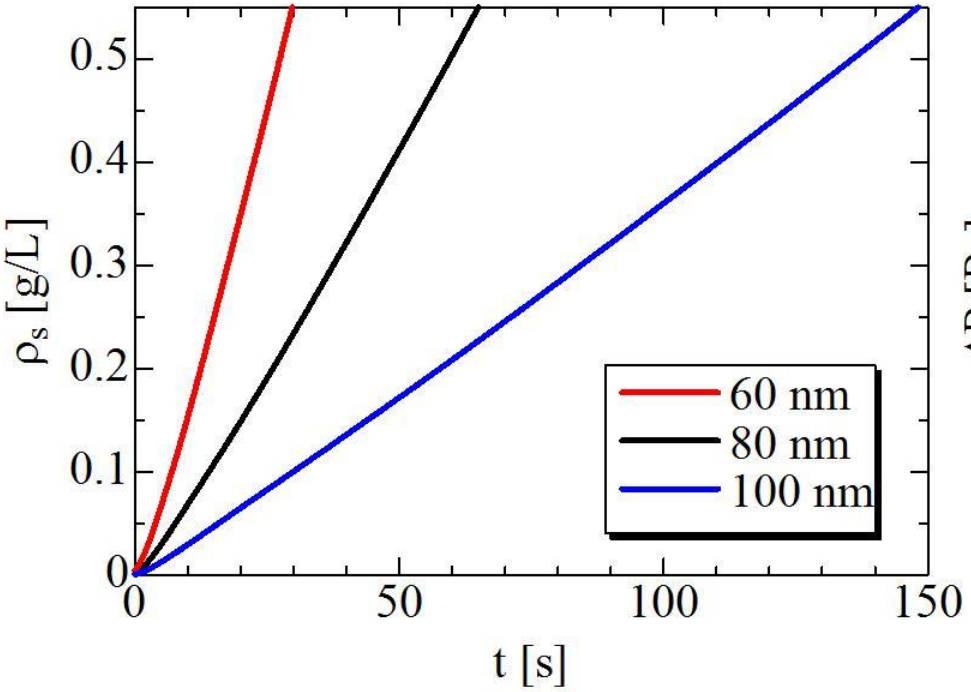


Effect of Soot Concentration

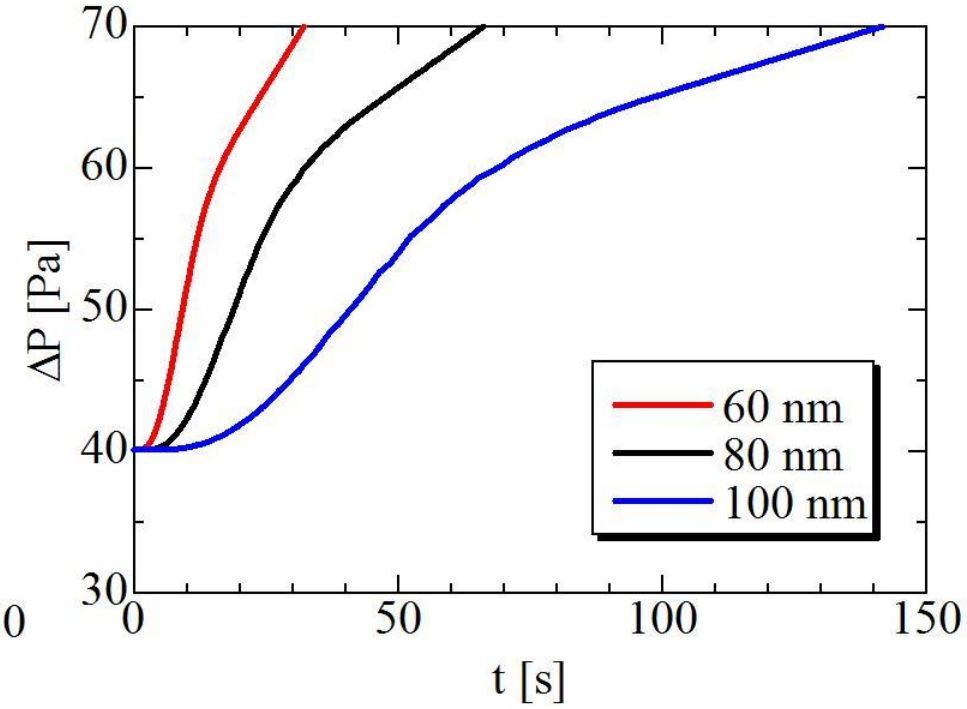




Effect of Soot Size



Time-variation of soot amount



Time-variation of pressure drop

Summary and Future Work

- Numerical simulation of soot filtration by GPF
- Effect of soot size, filtration velocity, exhaust gas temperature, and soot concentration
- Soot size of 60, 80, 100 nm

	Diesel	Gasoline (GDI)	Check
soot size	large	small	✔
exhaust temperature	low	high	✔
filtration velocity	low	high	✔
soot concentration	low (with DPF)	high	✔
filter pore size	10 μm	?	
filter porosity	40 – 60%	?	

END