A new SiC-based DPF for the Automotive Industry

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TYK Corporation

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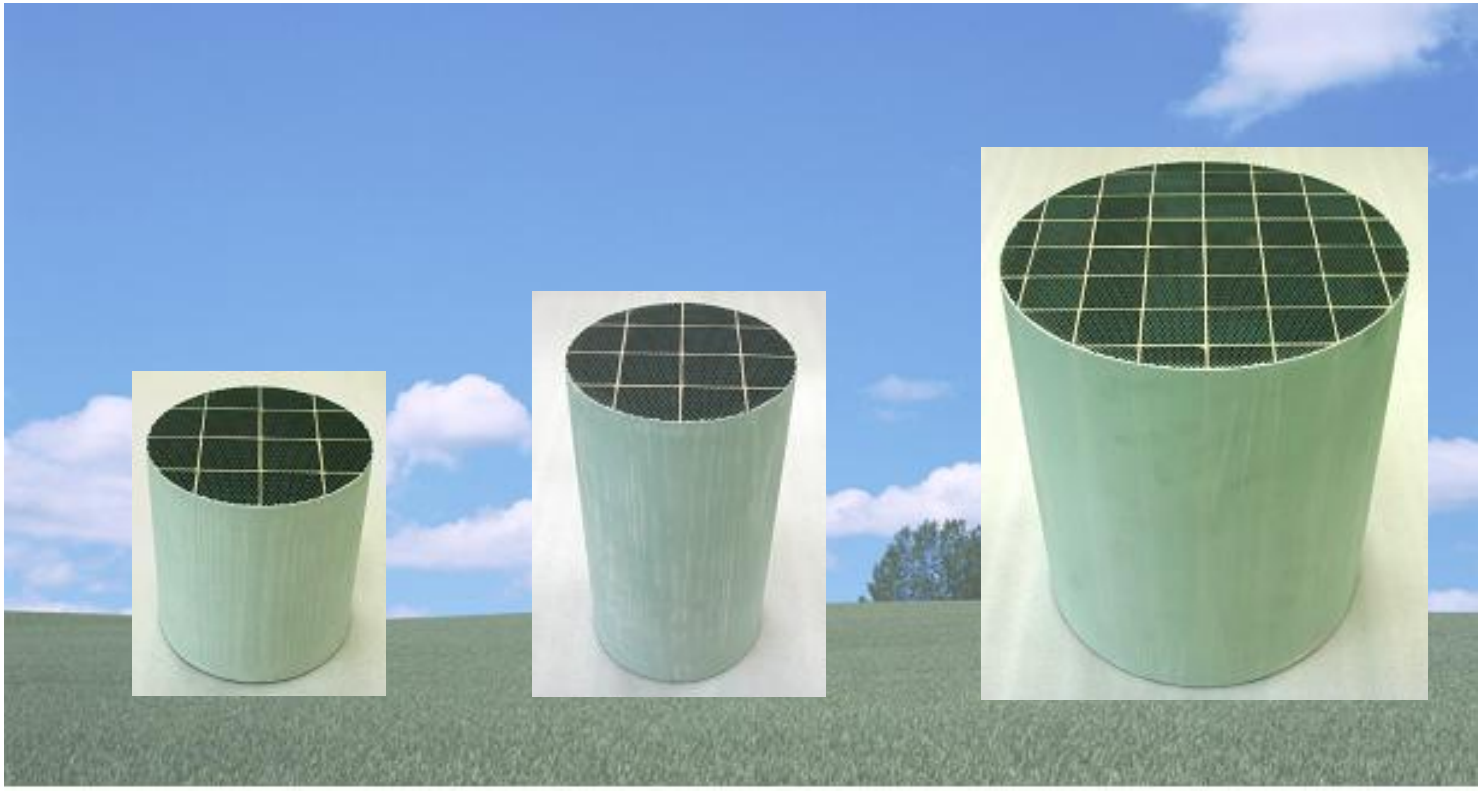
The TYK 's SiC-DPF

TYK started production of silicon carbide ceramics filters for Diesel Particulate Filter (DPF) in 2007.



The new technology enables the controlling of porosity and pore size distribution of the filter material with comparatively high flexibility, and the cost reduction as compared with the normal sintering process.

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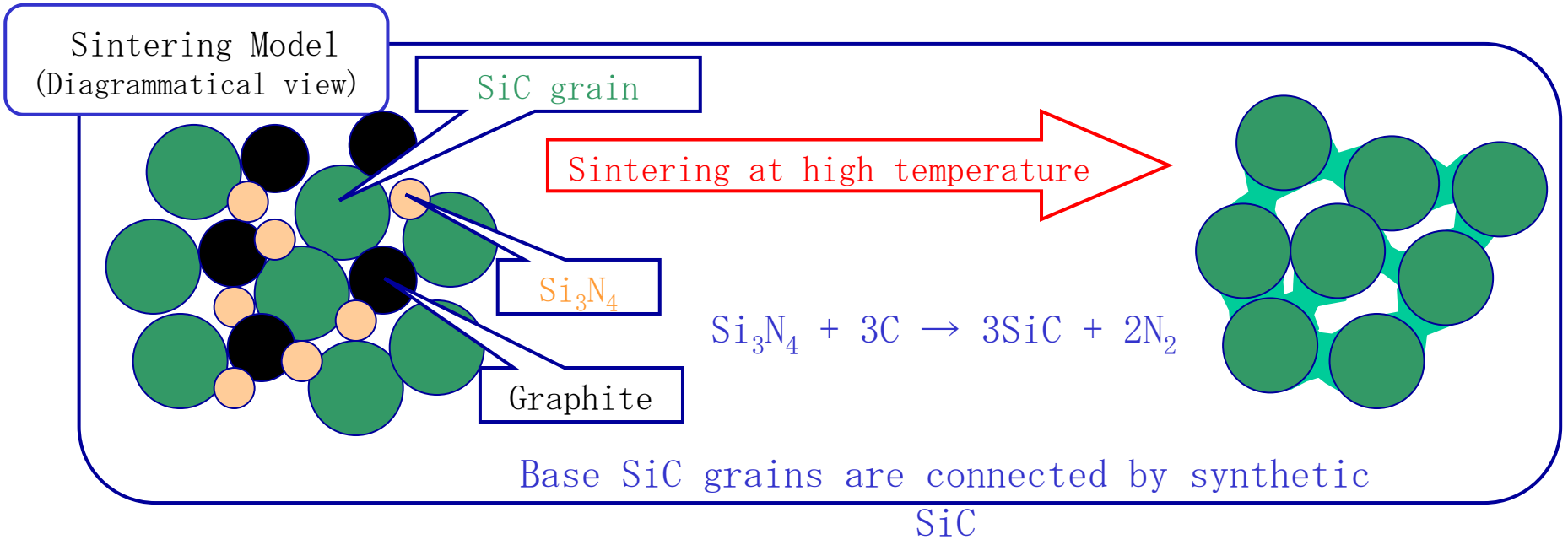
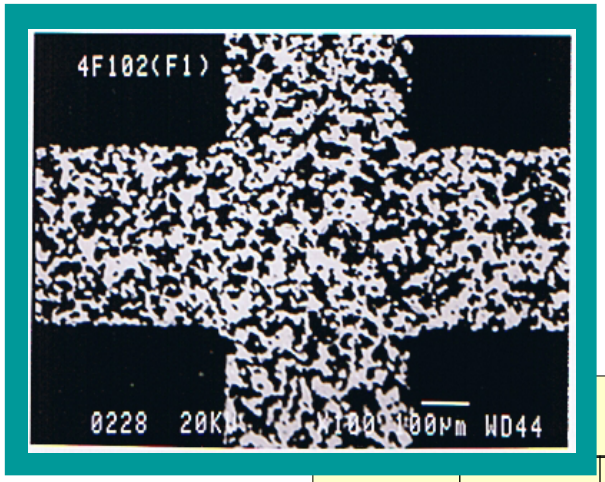
TYK material's sintering reaction

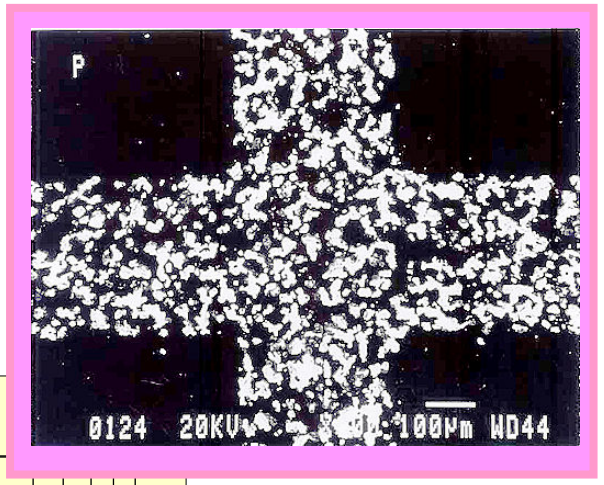


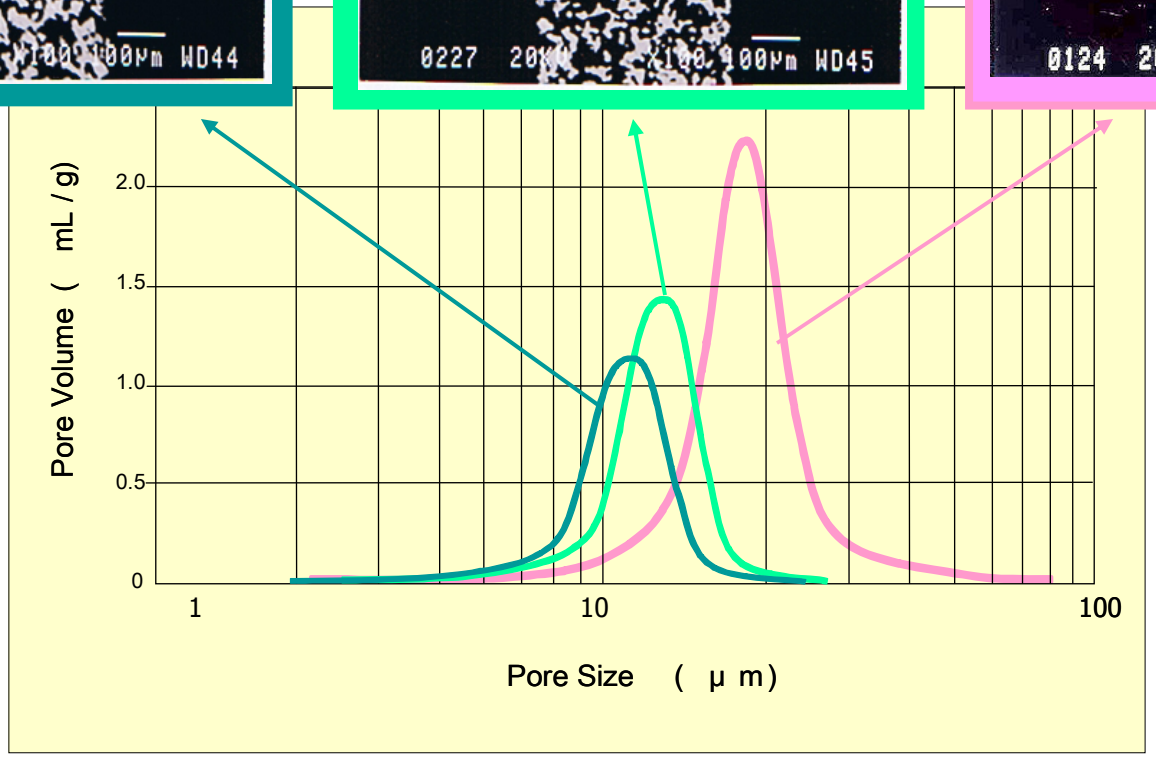
- Possible to sinter at lower temperature, so excessive grain growth

- Possible to make small size pore and sharp pore distrib

Pore size control technology







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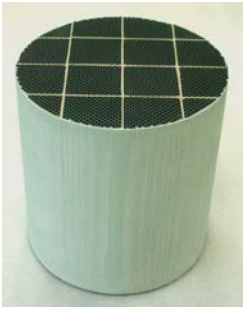
Properties of DPF Test Samples

Table 1. Properties of DPF Test Samples

	Filter-A (Developed)	Filter-B (Commercial)
Cell Density / cpsi	169	178
Wall thickness / mm	0.38	0.36
Porosity / Vol%	42	42
Mean Pore Size / um	12	11
Bending Strength / MPa *	9.8	7.6
Initial Pressure Drop / kPa**	4.7	4.6

* Size: 2cell × 3 cell × 40mm, Span: 30mm, Load speed: 0.5mm/min

** Size: D5.66inch × L6inch, Air flow: 9.5Nm^3/min



Pore size distribution

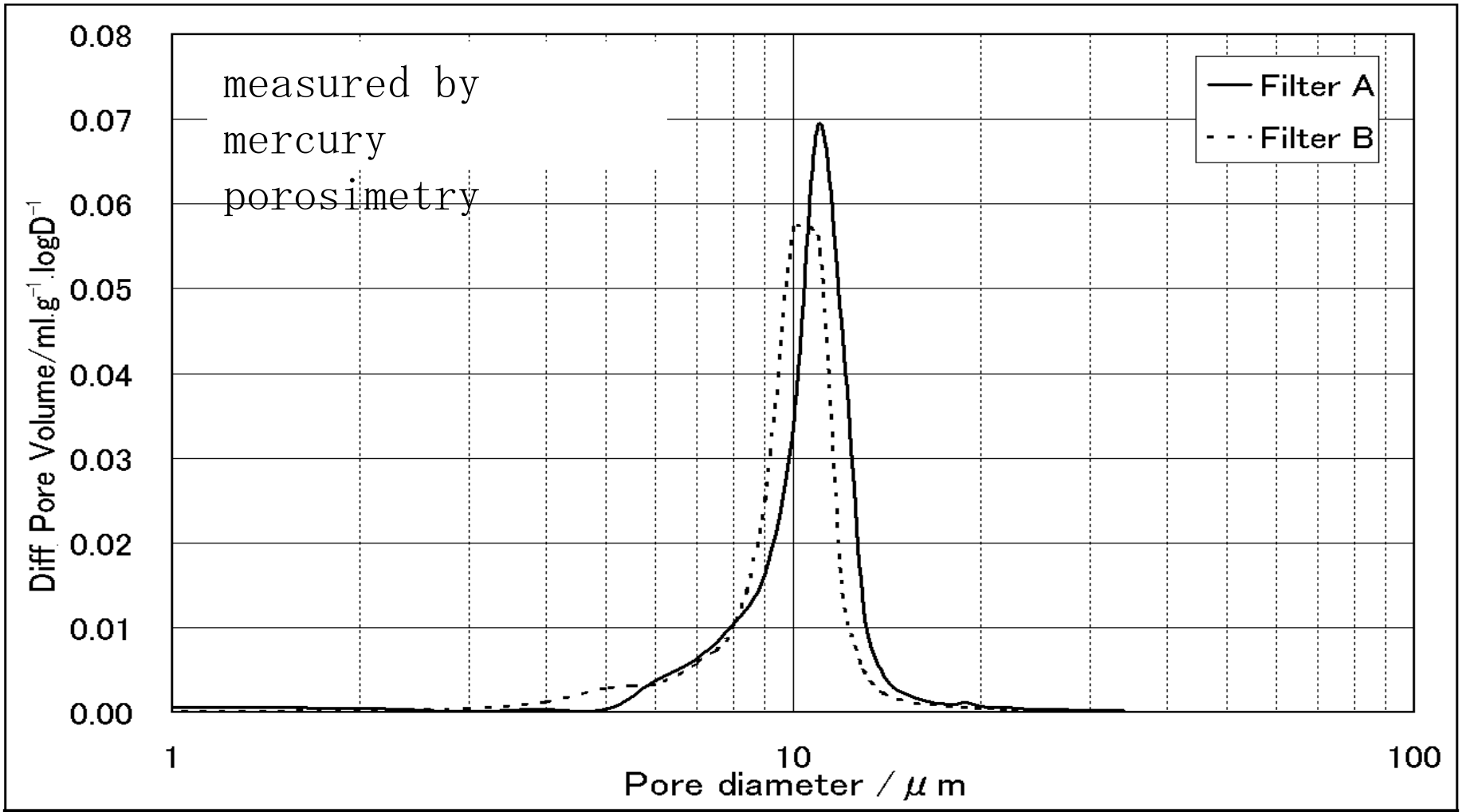


Fig.1: Pore size distribution of DPF test sample

X-ray diffraction

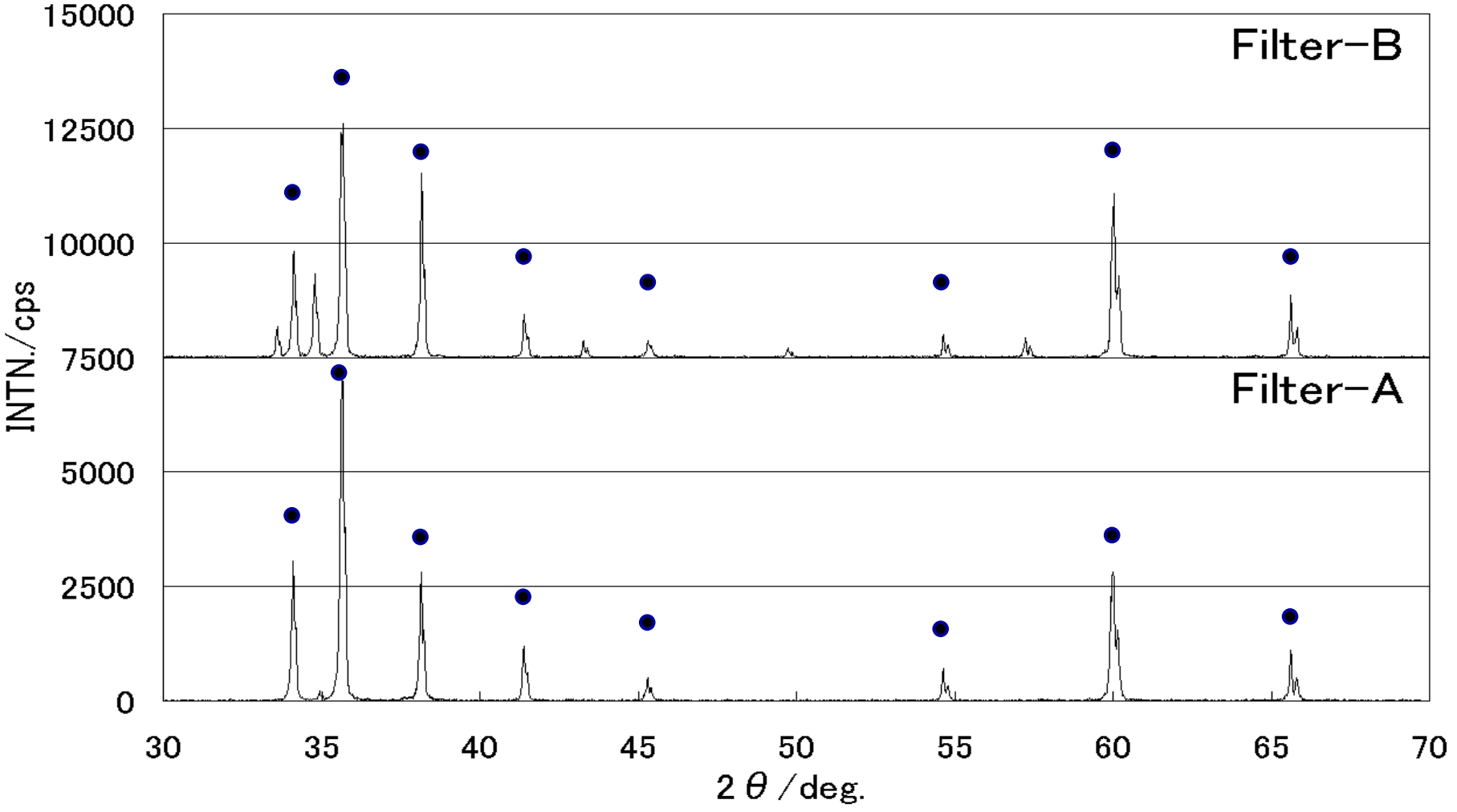
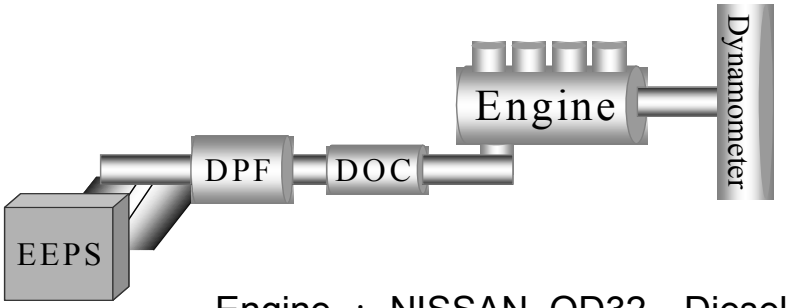


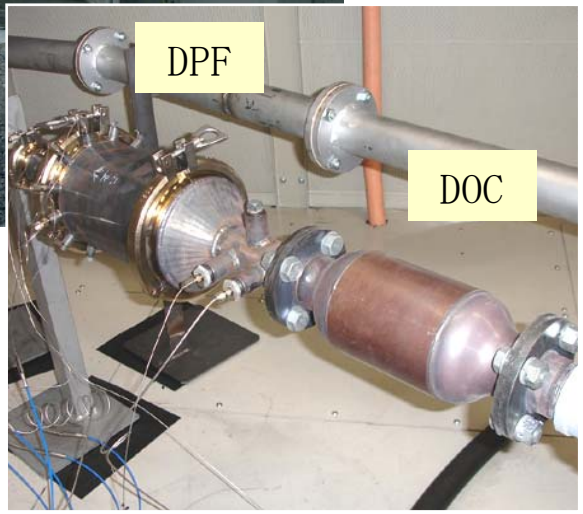
Fig.2: X-ray diffraction

Engine Bench Testing

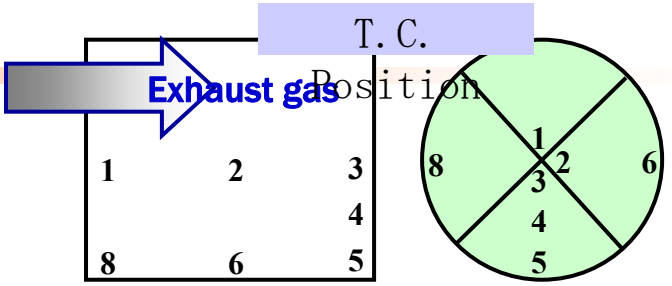
Engine Bench (TYK R&D)



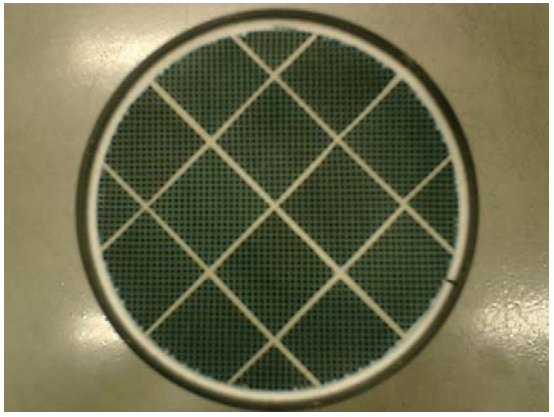
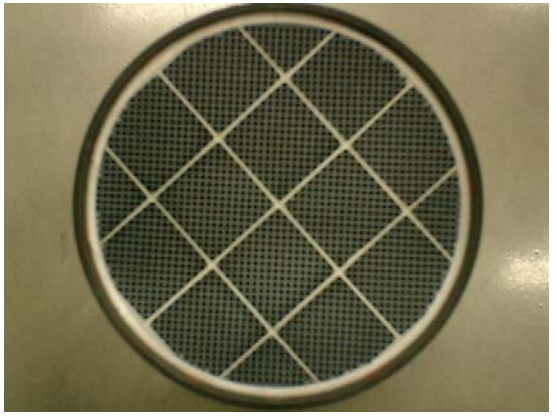
Engine : NISSAN QD32 Diesel
(KG-VWGE24)
OHV 4 cylinder 3.153(L)
N/A
Max. Power : 72kW/3200rpm
Max. Torque : 216Nm/2000rpm
Fuel Injector Pomp : Bosch



Drop To Idle Test (DTIT)



Sample description

	Filter A	Filter B
Cell Density (cpsi)	169	178
Wall Thickness (mil)	15.0	14.2
Porosity (%)	42	42
Mean Pore Size (um)	12	11
Size	5.66 ” – 6”	5.66 ” – 6”
Exhaust end surface		

Drop To Idle Test (DTIT)

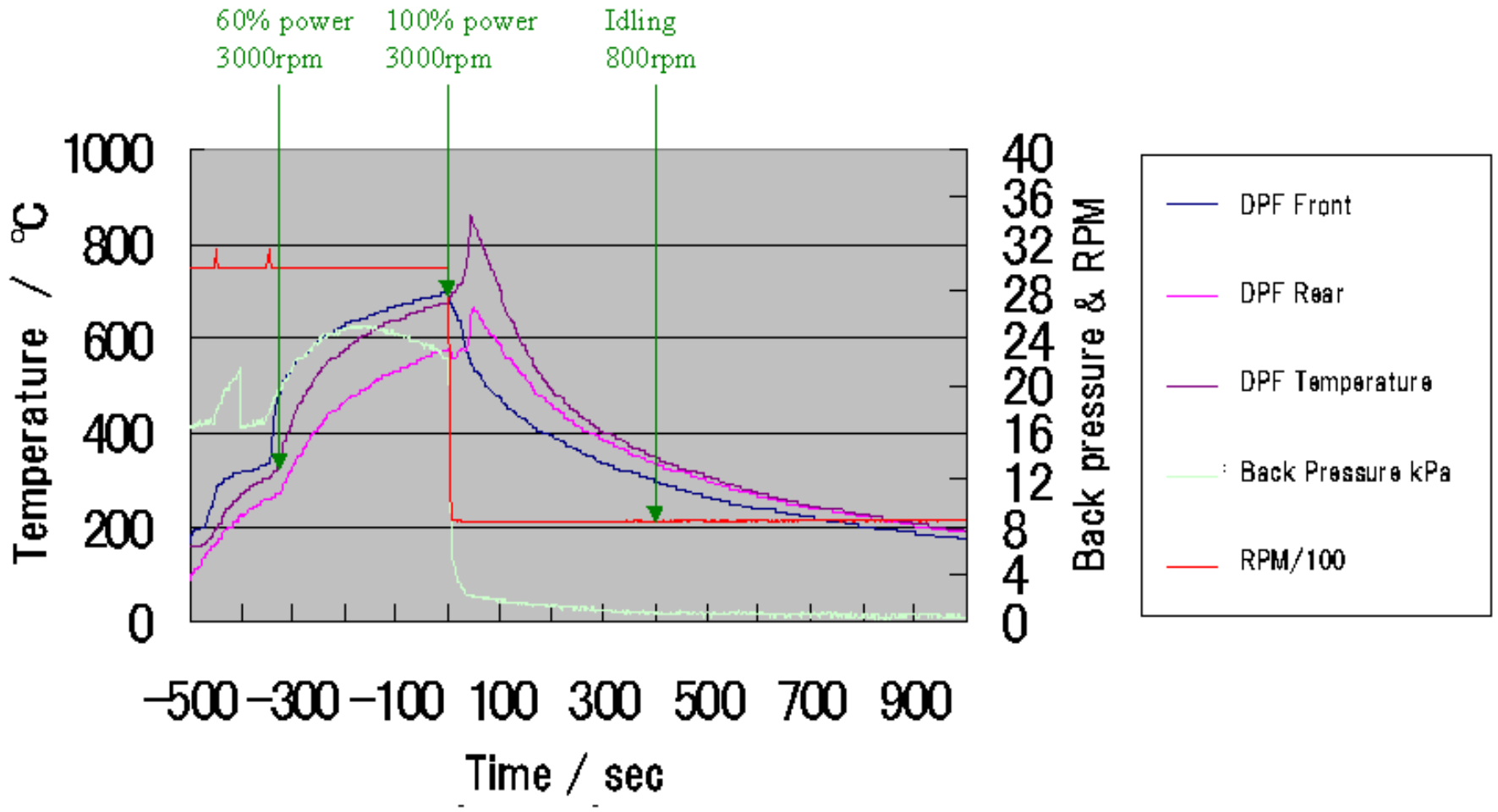


Fig.4: Drop to Idle test

Drop To Idle Test (DTIT)

Table2. Summary of DTIT Result

	Max temperature/℃	Combustion efficiency	Weight/g	Crack
Filter-A(Developed)	880	78	3040	no
Filter-B(Commercial)	900	69	2818	no

※Weight: Initial DPF involve canning weight

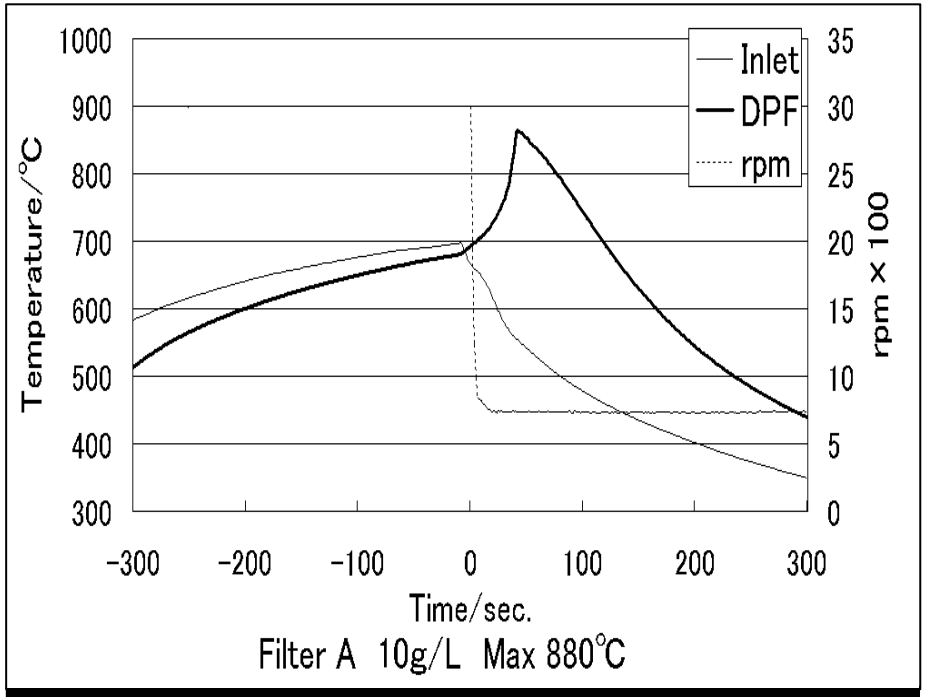


Fig.5: DTIT Chart of Filter-A

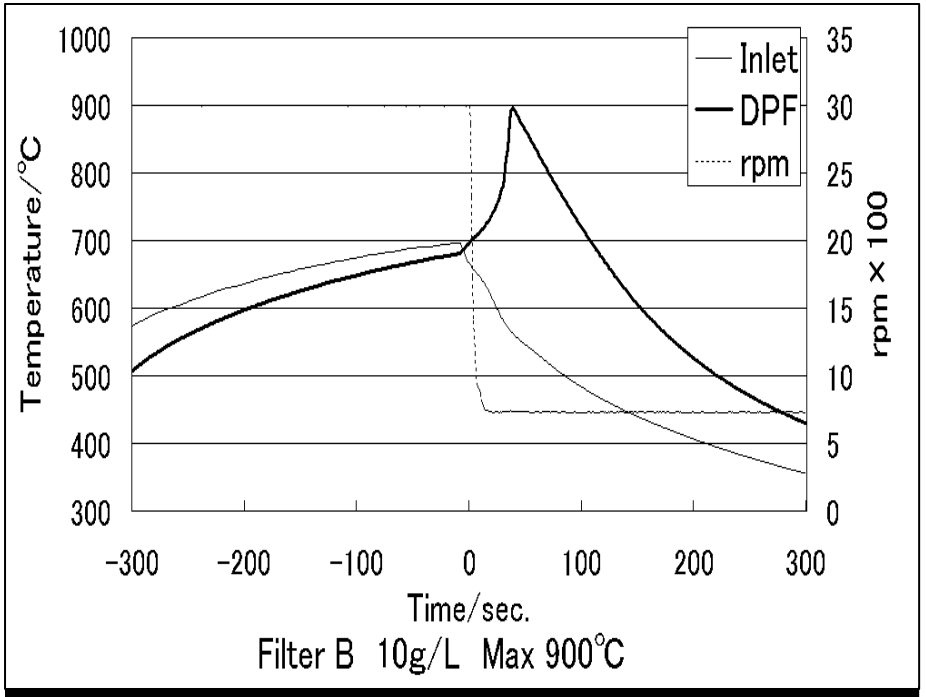
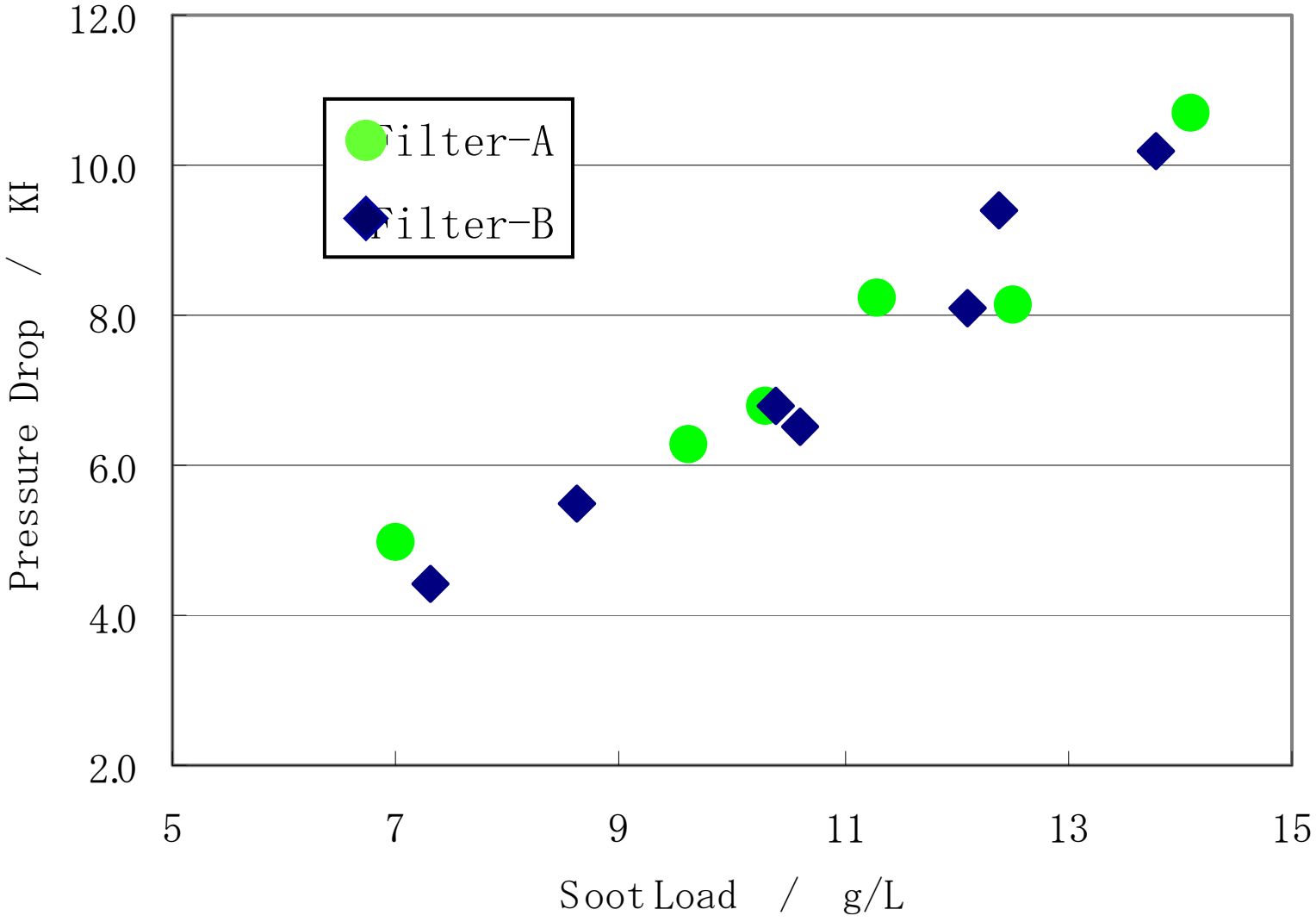
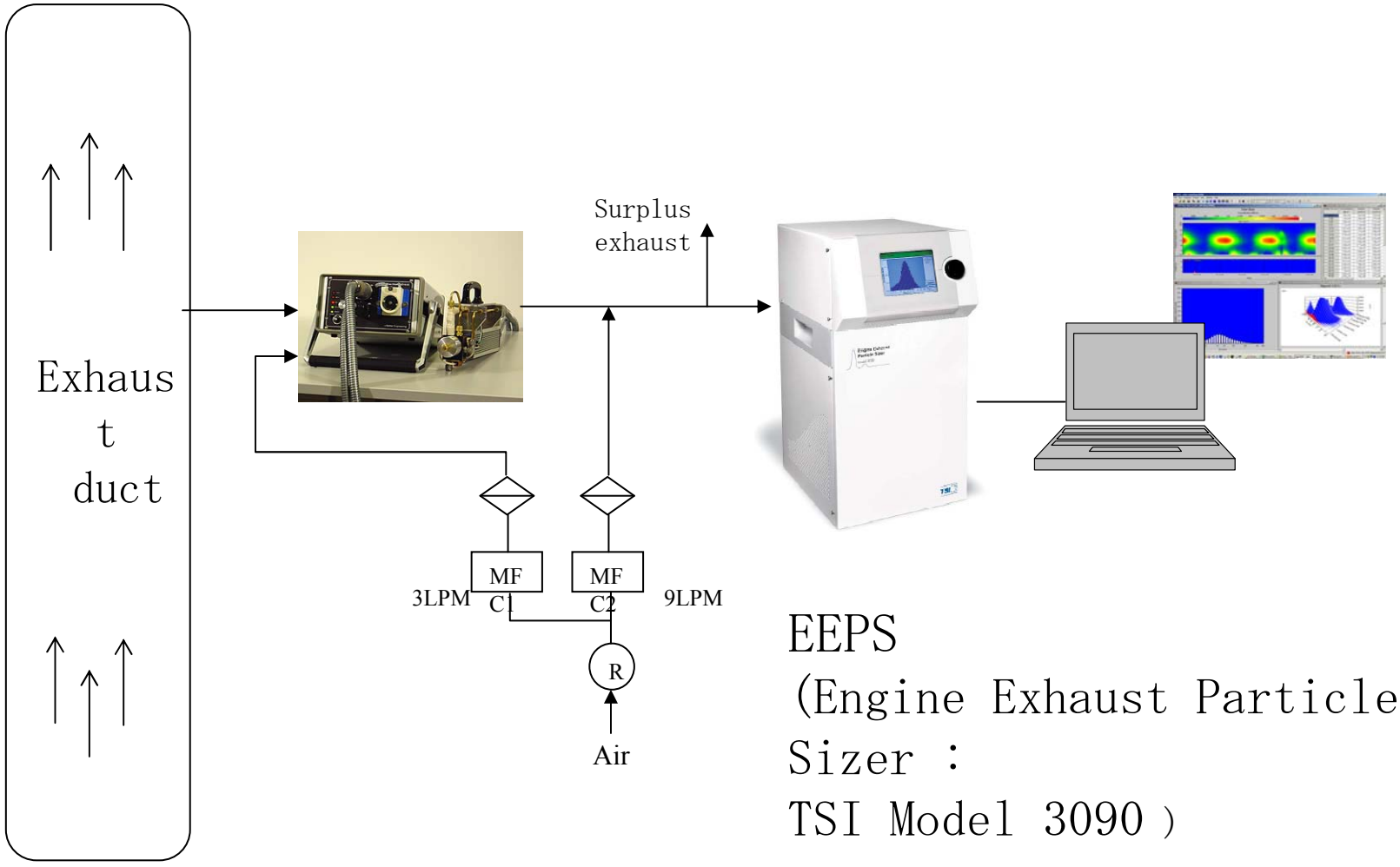


Fig.6: DTIT Chart of Filter-B

Pressure Drop v.s. Soot Load



Filtration Efficiency Test



EEPS
(Engine Exhaust Particle Sizer : TSI Model 3090)

Initial filtration efficiency

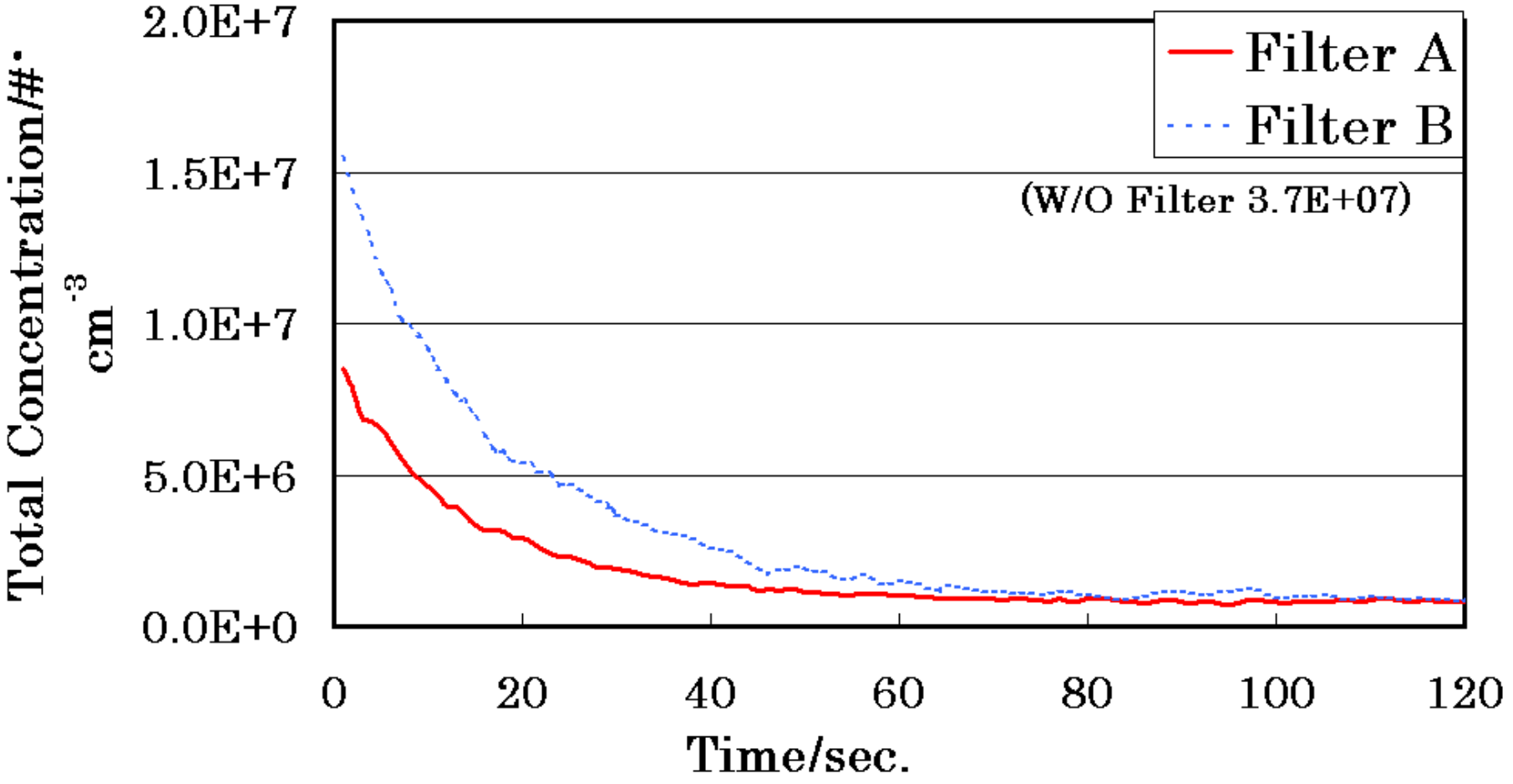


Fig.7: Total concentration of particle which leaked from the outlet side of DPF in the initial 2 minutes.

Initial Filtration Efficiency

Concentration and size distribution of leaked particle.

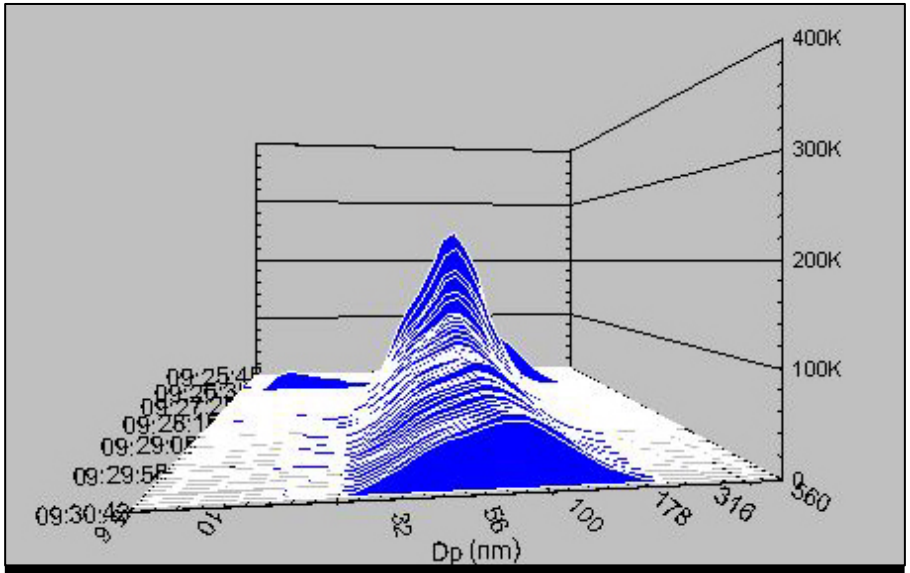


Fig.8: Concentration and size distribution （Filter-A）

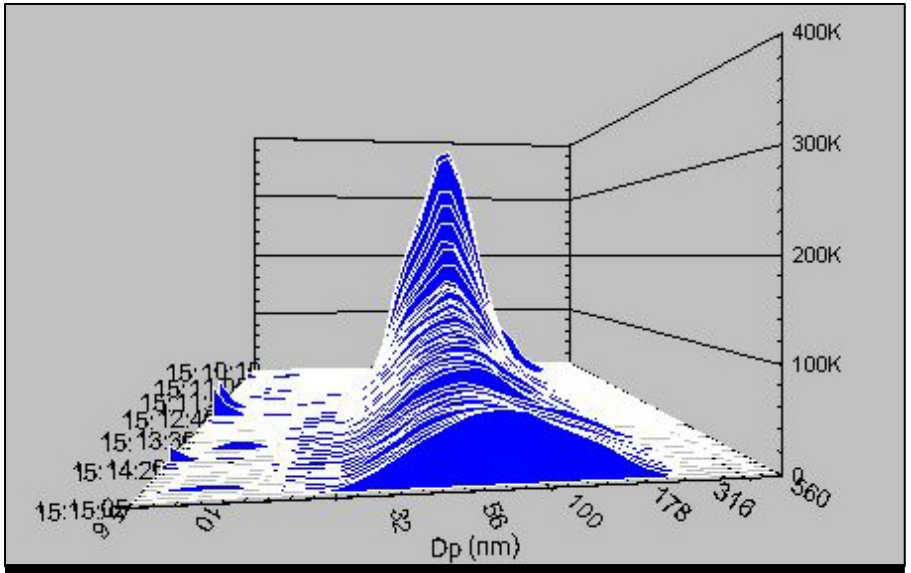


Fig.9: Concentration and size distribution （Filter–B）

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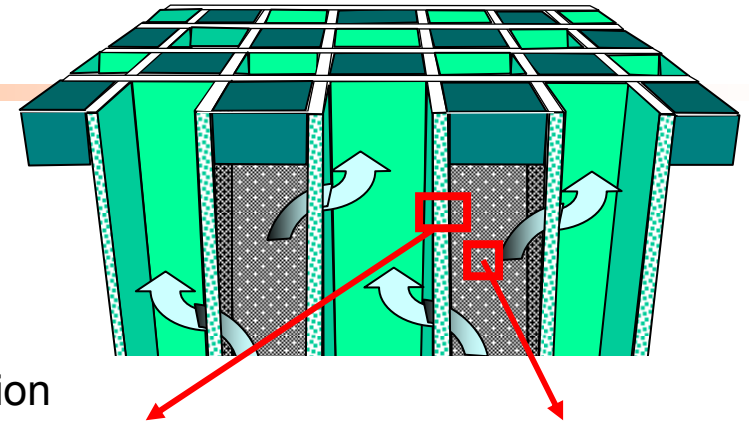
Microstructure of Filter Wall

SEM Photos :
After the initial 2 minutes filtration



Gas flow direction

Filter-A

Filter-B

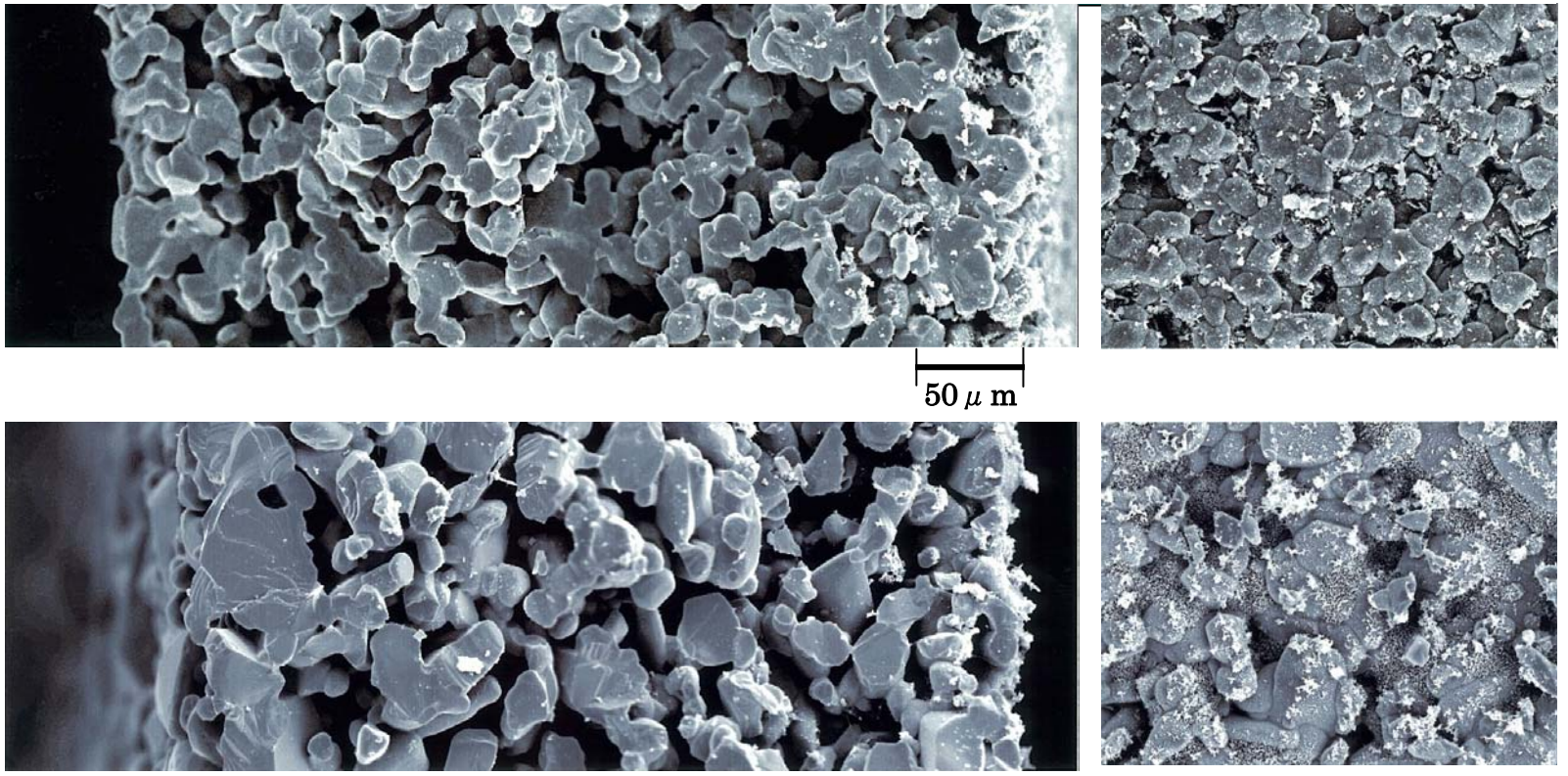
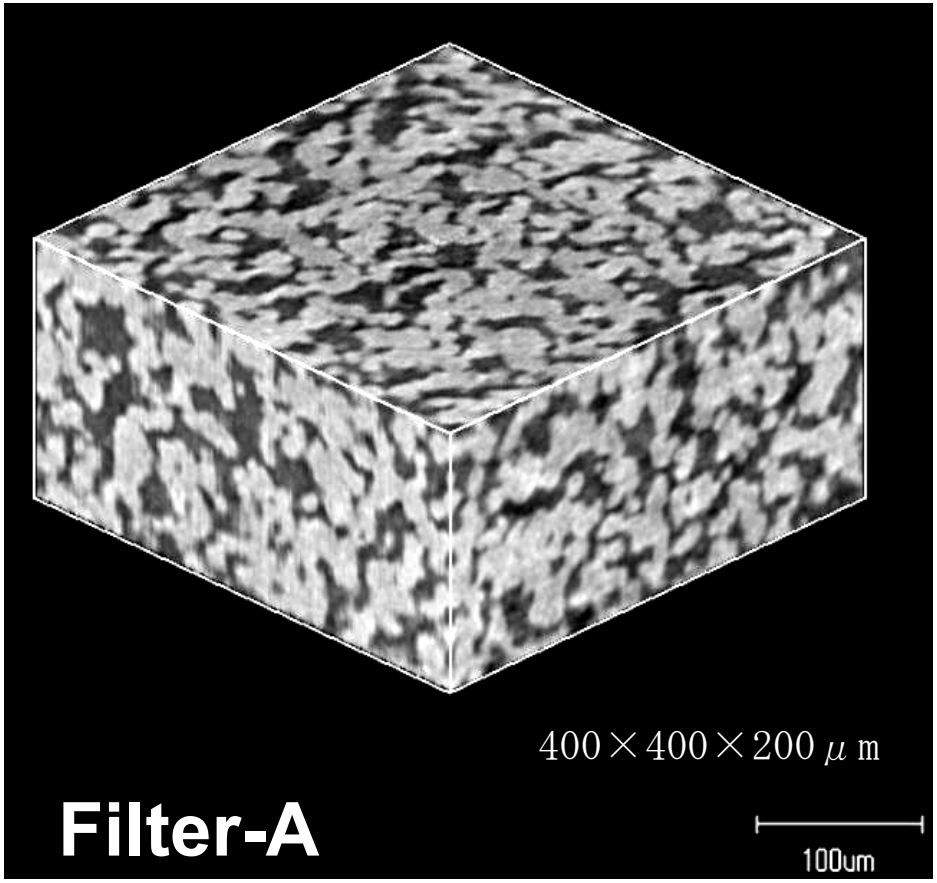
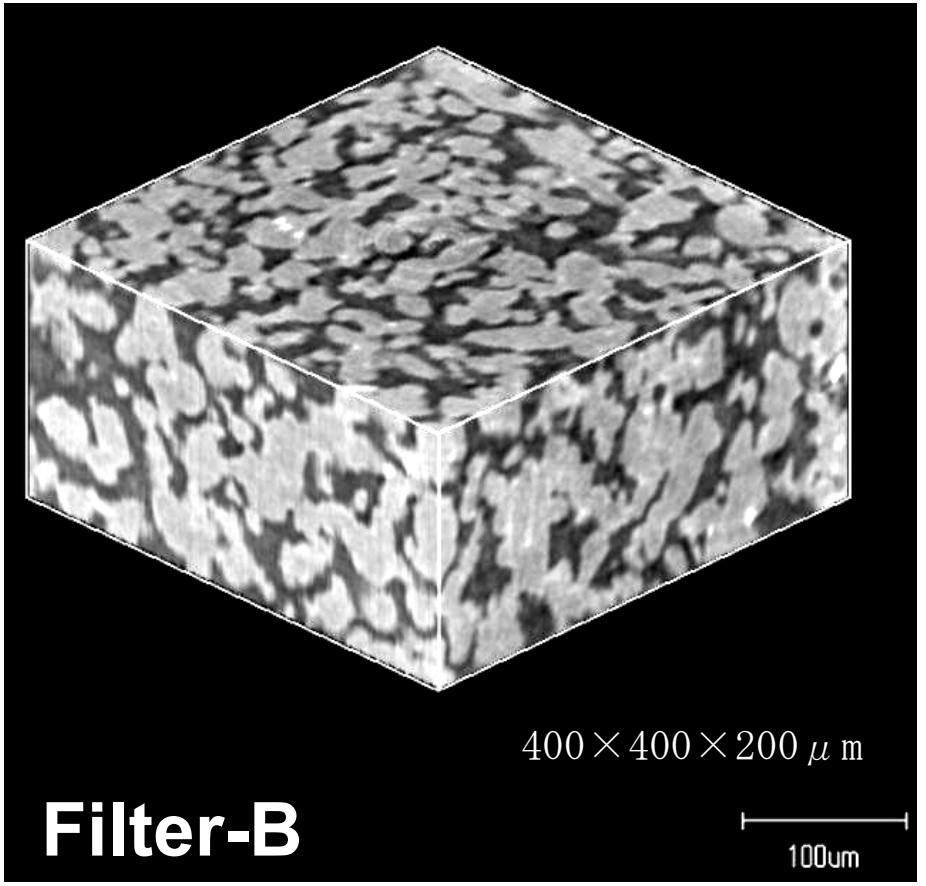


Fig.10&11: SEM of DPF-wall surface and cross section

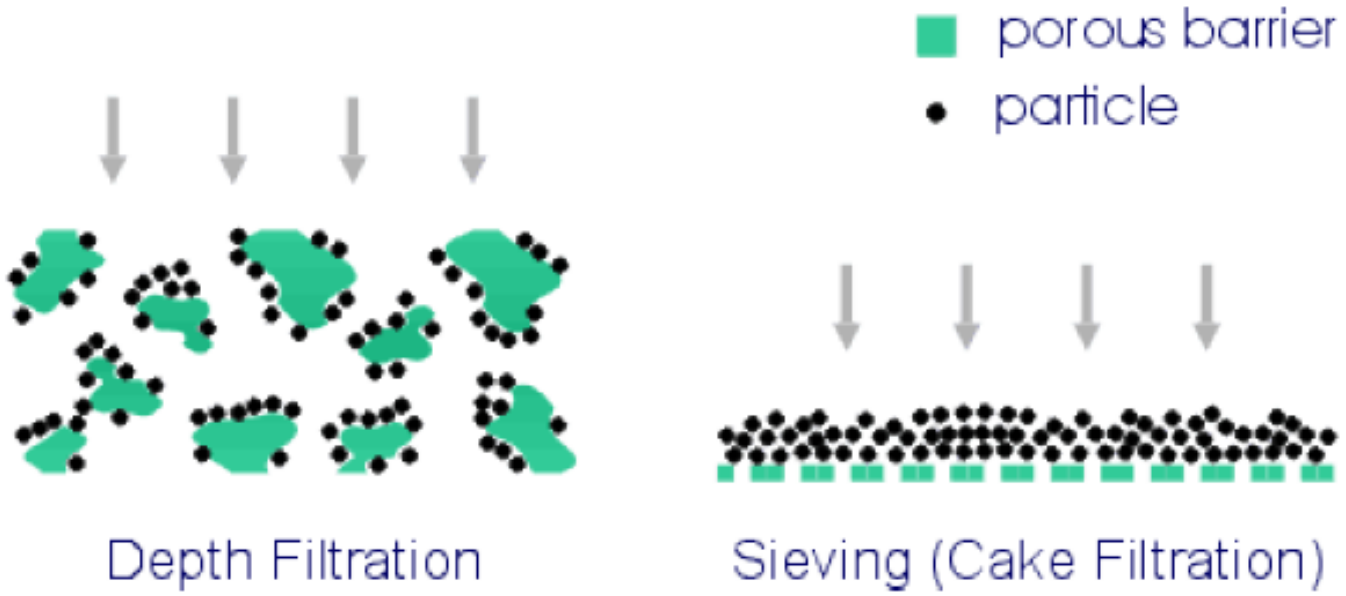
Microstructure of Filter Wall

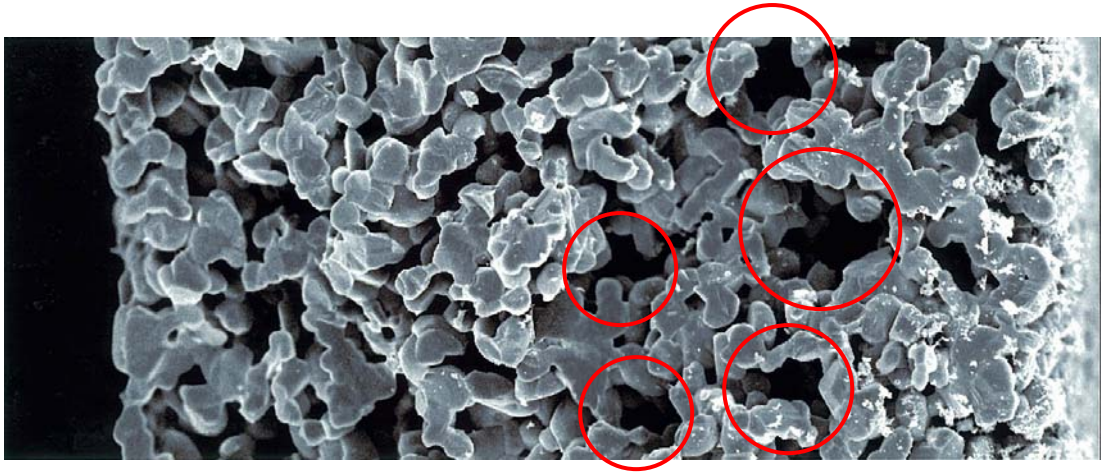
X-ray CT 3-Dimensions image on the fresh filters

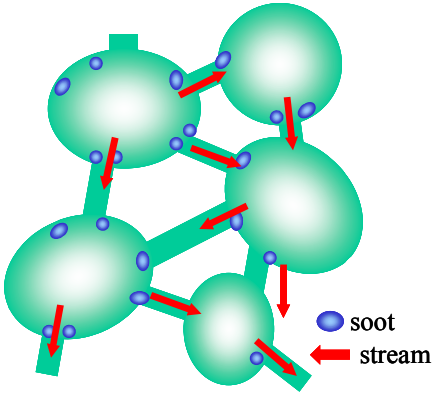




Microstructure of Filter Wall







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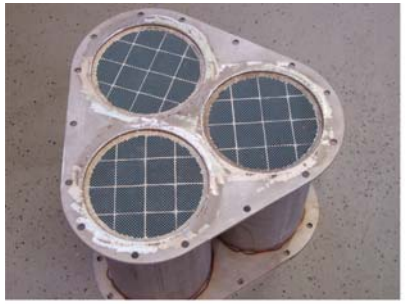
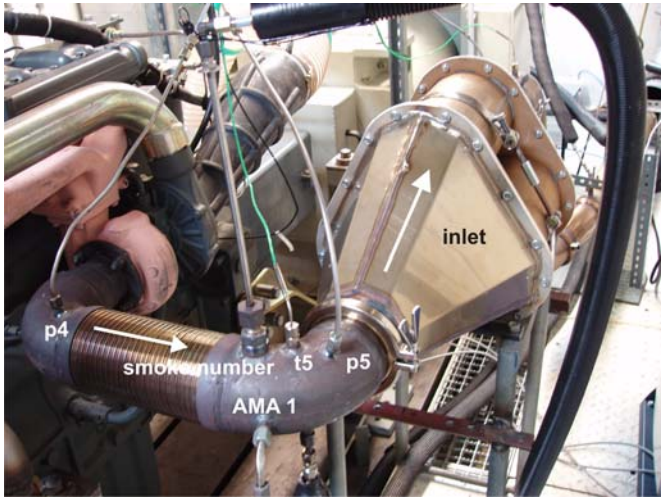
VERT VFT1 Result





Filter

Main dimensions	φ143.8mm×L254mm (4L) ×3pcs
Cell number	169cpsi
Wall thickness	16mil (0.4mm)
Porosity	42%

Engine

Engine type	D 924TI-E A2 by Liebherr SA
Displacement	6,64 L
Rated power output	137 kW
Maximum torque	760 Nm at 1200...1400 rpm

Trapping efficiencies of counts 20nm-320nm

	Particle size spectra nm	Particle number before filter cm^{-3}	Particle number after filter cm^{-3}	Filtration efficiency %
Before regeneration	Integrated	6,917,749	996	99.986
	20-40	965,032	343	99.964
	40-80	2,408,606	166	99.993
	80-160	2,580,243	377	99.985
	160-320	963,869	110	99.989
After regeneration	Integrated	6,577,985	1,223	99.981
	20-40	732,458	163	99.978
	40-80	2,179,589	352	99.984
	80-160	2,557,854	416	99.984
	160-320	1,108,084	292	99.974

Conclusion

- The newly developed SiC-based filter which are brought about from the special sintering process has high purity crystal phase.

- This new filter shows preferable tendency of properties for regeneration and robustness having lower peak temperature and higher combustion efficiency.

- The new filter has an uniform pore structure on the wall surface and complicated flow-pass structure inside the wall.

- Therefore, it shows superior initial filtration efficiency compared to commercial product.

Thank you for your attention !

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