Komori T. / Sumitomo Chemical Co.Ltd. Japan

Newly-developed Diesel Particulate Filter - Sumitomo DPF

Introduction

The usage of Diesel Particulate Filters (DPF) has contributed to decrease the particulate matter in exhaust gas of diesel cars for over 10 years since PSA started to apply it in its passenger cars, and has become a standard diesel exhaust gas after-treatment device. While the development of deNOx technology is still ongoing, also the technical requirements for DPF are becoming more demanding, e.g. smaller size, higher performance and lower price.

Silicon carbide (SiC) is currently used as the main material for DPF due to its high thermal stability. On the other hand, aluminium titanate (AT) is recognized as an alternative material to SiC and one of the best candidates for the next generation of DPF, because of its good technical performance and the more cost-effective production compared with SiC manufacturing. Sumitomo Chemical Co., Ltd. has newly developed its advanced AT material taking advantage of its proprietary technologies cultivated in manufacturing inorganic materials such as alumina products.

Latest market requirements for DPF are mainly low pressure drop in order to reduce the fuel penalty, and high ash capacity in order to increase its life time. The author, who had invented Octo-square SiC-DPF, continued challenging further innovative designs of DPF in Robert Bosch GmbH and finally reached hexagonal cell geometry with his colleagues.

In order to fulfill the above-mentioned recent requirements, Sumitomo Chemical has newly developed its innovative AT-DPF (hereinafter called "SC-AT"). The combination of improved material properties and advantageous hexagonal cell geometry makes this innovation outstanding; The newly-developed SC-AT shows 1) higher thermal shock resistance, 2) higher ash capacity, and 3) extremely lowered pressure drop.

Herein, basic performance of SC-AT is introduced as follows.

Pressure drop performance

Figure 1 shows the result of pressure-drop behavior under soot-loading condition comparing Octo-square SiC, and SC-AT with square- and hexagonal- type, called "Hex" hereafter, which were measured with cold flow bench system. The usage of Hex design leads to a remarkably lower pressure drop due to its higher effective filtration area.

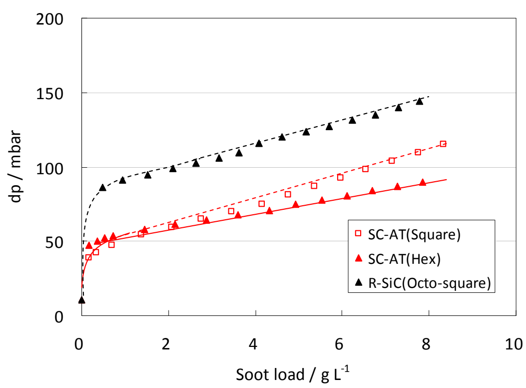


Fig.1 Pressure-drop under soot loading in cold flow bench. DPF size: D5.66"× L6".

Filtration efficiency

Figure 2 shows soot filtration efficiency results in Hex-designed SC-AT, and Octosquare- SiC. The efficiency was measured by counting soot particle number in cold flow bench system. Although SC-AT shows lower pressure drop, both efficiency was comparable.

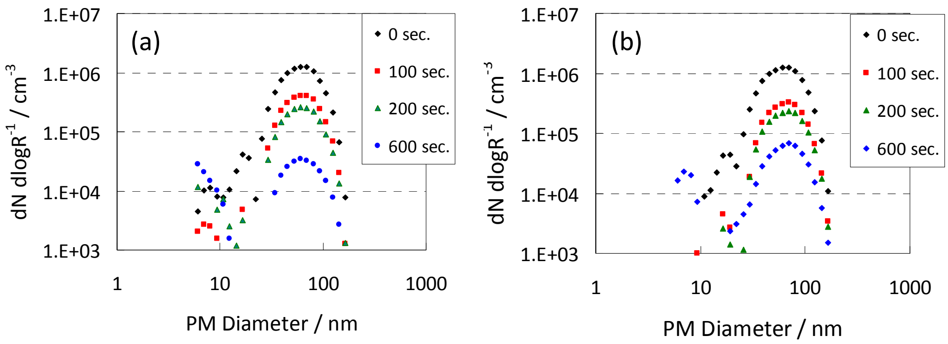


Fig.2 Filtration efficiency results of (a) SC-AT and (b) SiC. DPF size: D5.66”× L6”.

Soot Mass Limit (SML)

Drop-to-idle test was demonstrated for Octo-square-SiC and Hex-SC-AT with engine test bench. After soot was loaded onto DPF (8 ->10 ->…. g/L), Drop-to-Idle condition was performed for loaded DPF. In order to check several defects in DPF after the test, soot leak was detected by smoke-meter. Figure 3 shows the results of SML. Smoke meter indicates that its higher value corresponds to more defects in DPF. SC-AT shows higher SML than SiC, revealing high thermal shock resistance.

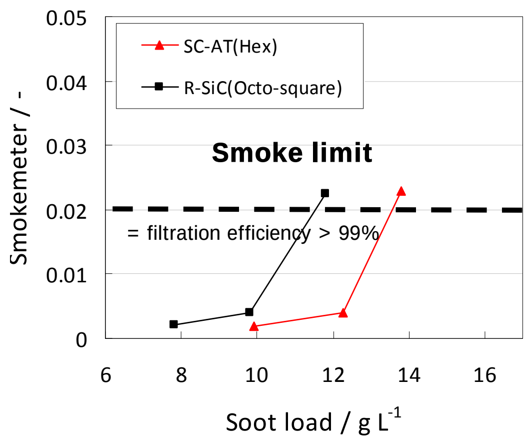


Fig.3 Blow-off results after SML test. DPF size: D5.66”× L6”.

Conclusion

SC-AT shows

- ✓ High thermal shock resistance.
- ✓ High ash capacity.
- ✓ Remarkably lower pressure drop.
- ✓ Comparable Filtration efficiency.
- ✓ Higher SML.

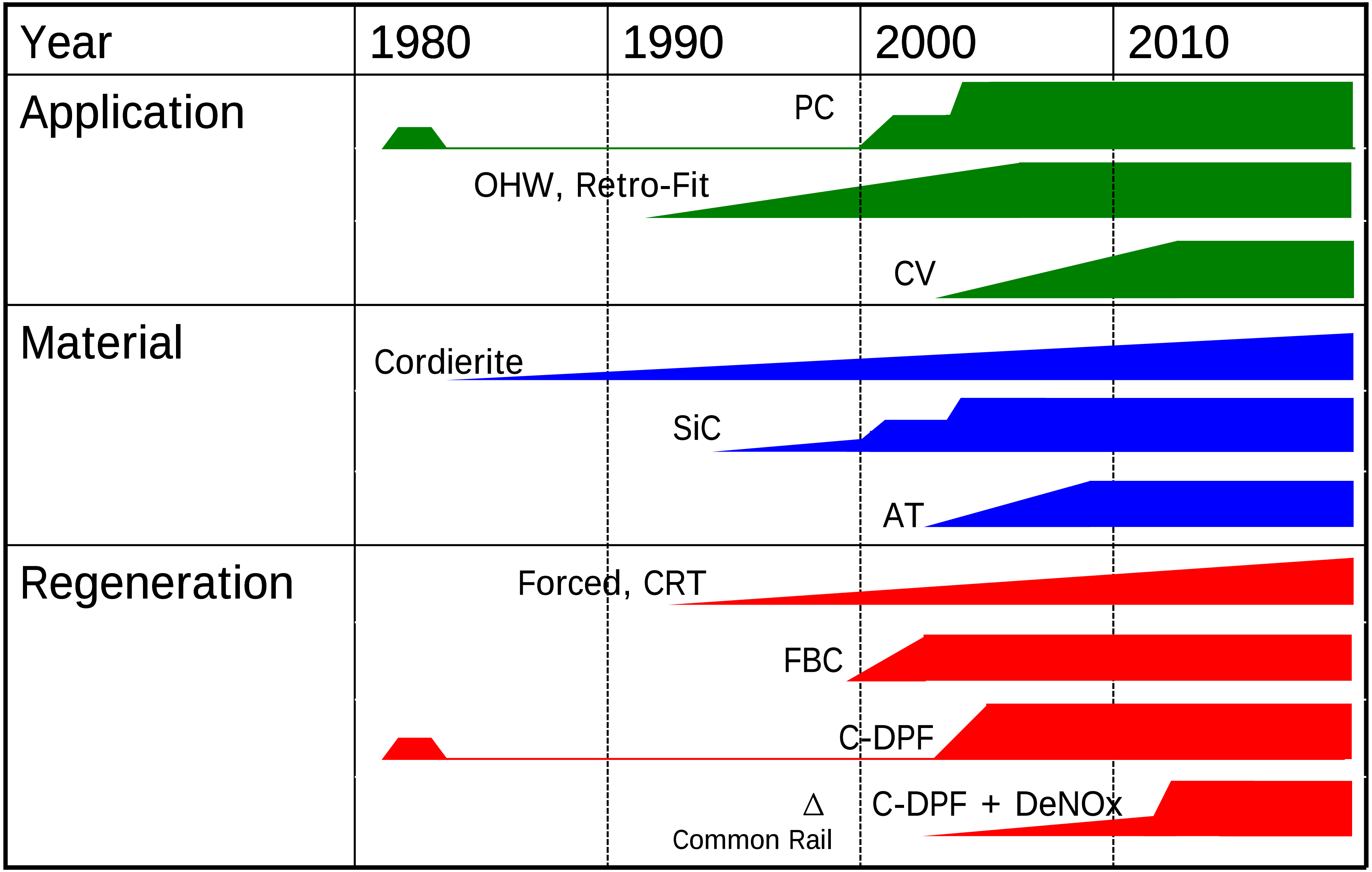
Newly-developed Diesel Particulate Filter

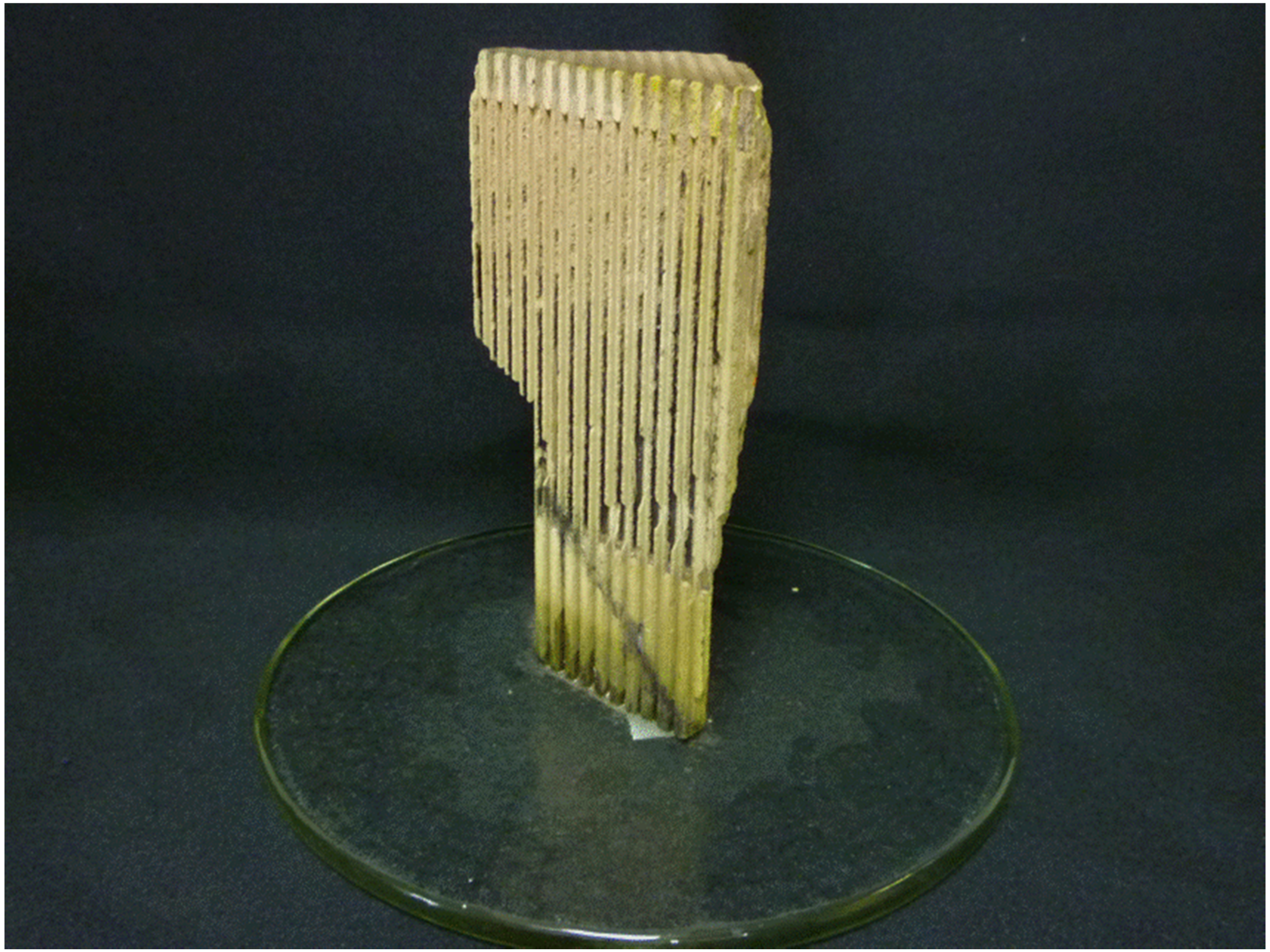
- Sumitomo DPF "SC-AT" -

Sumitomo Chemical Co. Ltd.
DPF Advisor
Teruo KOMORI

Contents

1. History of DPF Development





1. History of DPF Development

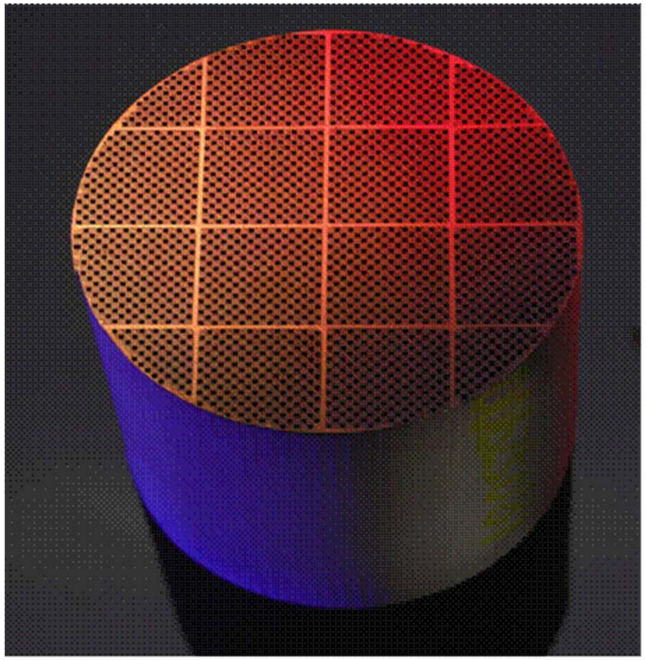
1-1. Basic Development

1986 Start Basic Research of SiC-DPF
Feasibility Study in Comparison with Cordierite DPF

1987 Start Joint Development for PC-DPF

1991 Start Joint Development of CV-DPF
(burner regeneration)

1993 Complete basic technology of
Segmented SiC-DPF
Success in Field Test
in Tokyo-metropolitan bus



1. History of DPF Development

1-2. Market Development

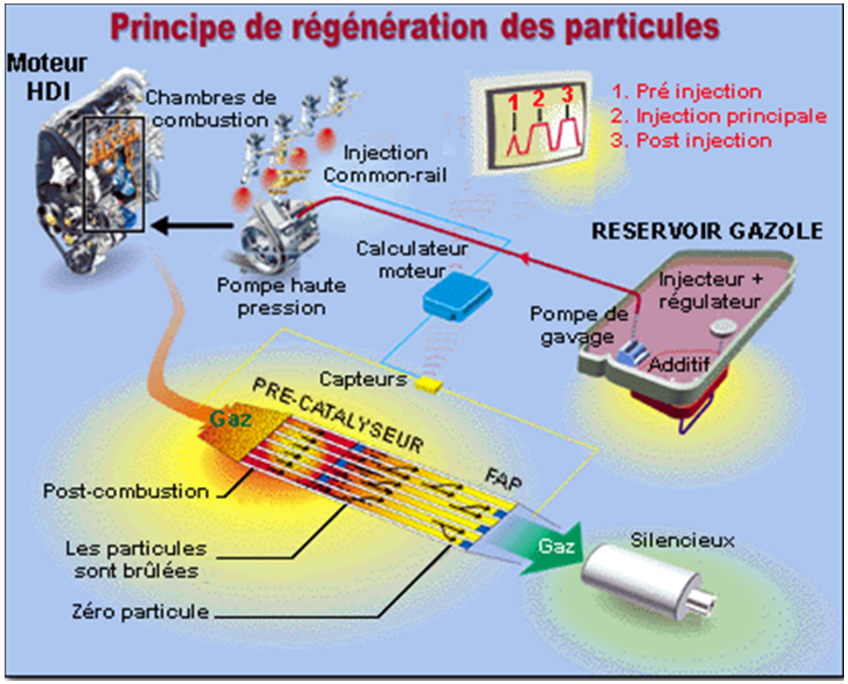
1994 Start marketing in JP OHW, CV, Retro-fit

1996 Start marketing world-wide OHW, CV, Retro-fit + PC

1998 Start Joint Development with PSA

Establish Pilot Plant

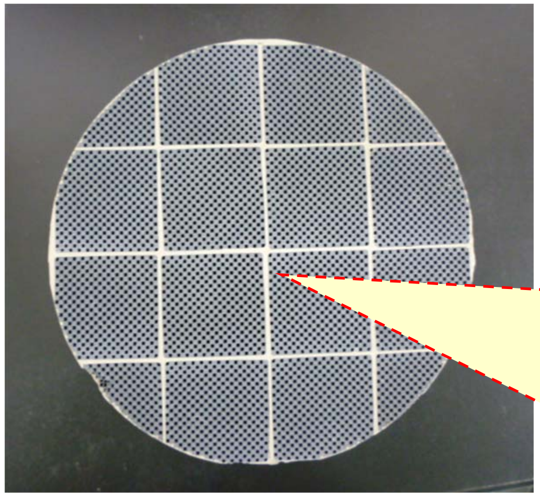
1999 PSA Decision to Use SiC-DPF



1. History of DPF Development

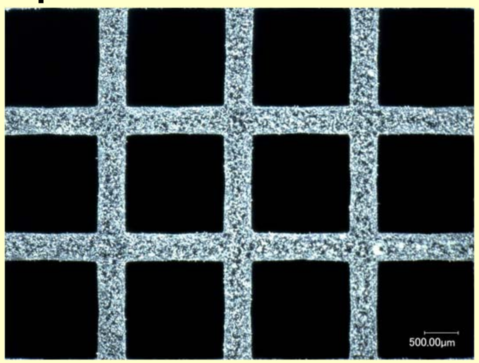
1-3. Mass production & Market expansion

2000	Start Mass Production for PSA
	Launch First Series Vehicle with DPF
2000-2001	Install Mass Production Line in France
2002	Start of Production in IDFS
	Invention of Octo-Square design*
2003	Start of other OEM application (C-DPF)

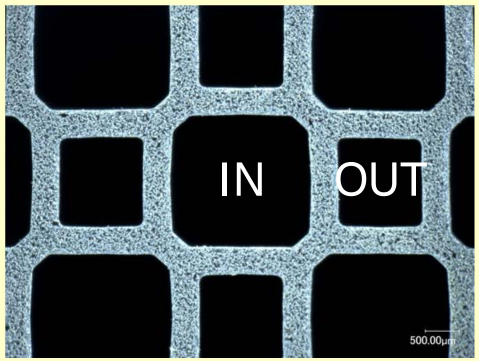


*Cell design

Square



Octo-Square



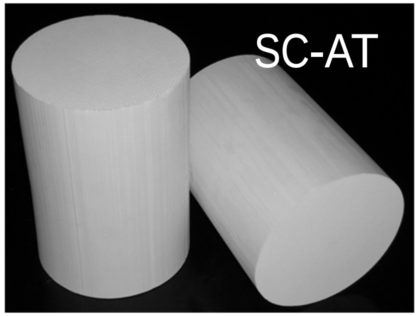
2. DPF Market Requirements

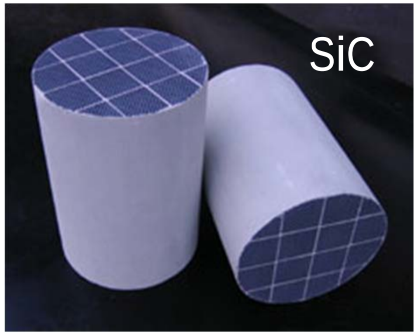
Requirements	SC-AT	SiC	Cordierite
Cost	+++	+	+++
Material	Mid	High	Low
DPF Structure	Monolith	Segmented	Monolith
Performance	+++	++	+
Filtration efficiency	Good	Good	Good
Pressure drop	Very low	Medium	Medium
Ash capacity	High	High	Medium
Soot mass limit	High	High	Low

3. Features of “SC-AT”

3-1. Process Comparison

SC-AT	SiC	
1.Mixing	1.Mixing	7.Segment Inspection
2. Kneading	2. Kneading	8.Assembling
3. Extruding	3. Extruding	9.Grinding
4.Plugging	4.Plugging	10.Skinning
5.Sintering	5.Debindering	11.Calcination
6.Inspection	6.Sintering	12.Final Inspection





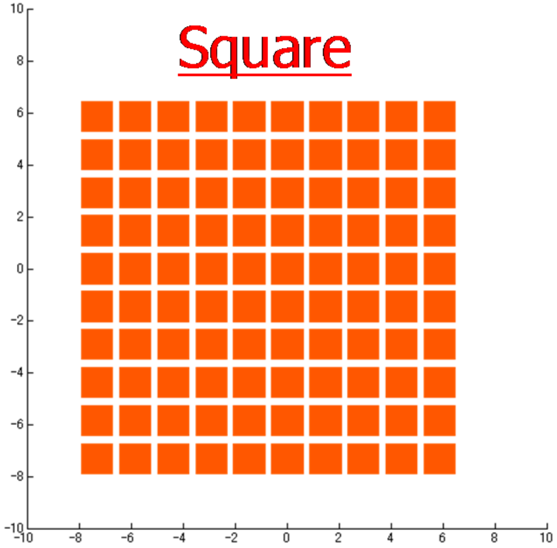
Simple Process, High Yield, High Productivity

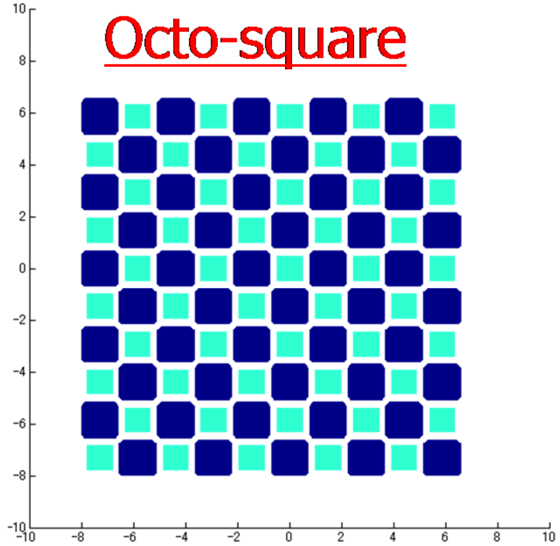
3. Features of “SC-AT”
3-2. Material Comparison

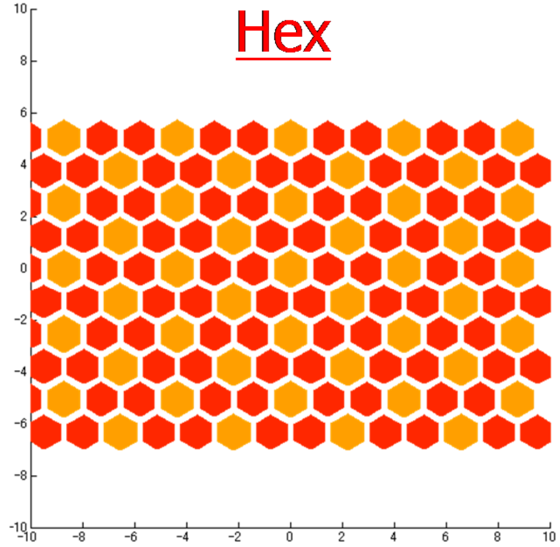
Substrate	AT	SiC	Cordierite	Effect on SML
Supplier	Sumitomo Corning	Ibiden,NGK	NGK,Corning	
Theoretical density [g･cm^{-3}]	3.7	3.2	2.6	High
Heat Capacity [J/ L･K]	2000	1900	1300	High
Thermal Conductivity [W/m･K]	2	50	2	Low
CTE / *10^{-6} [1/K]	1	4	<1	High

3. Features of “SC-AT”

3-3. Cell Design Advantage



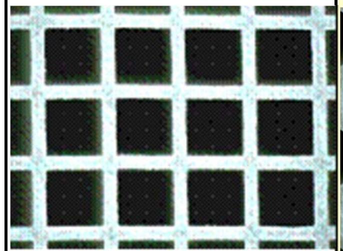
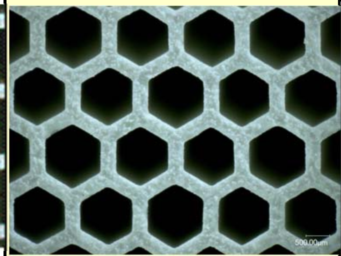
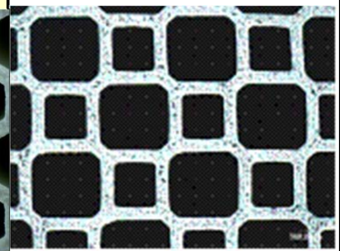




Cell design	Square	Octo-square	Hexagonal “Hex”
Ash capacity	Low	High	High
dp initial	Low	High	Low
dp w soot	High	Medium	Very low

3. Features of "SC-AT"

3-4. Filter specification

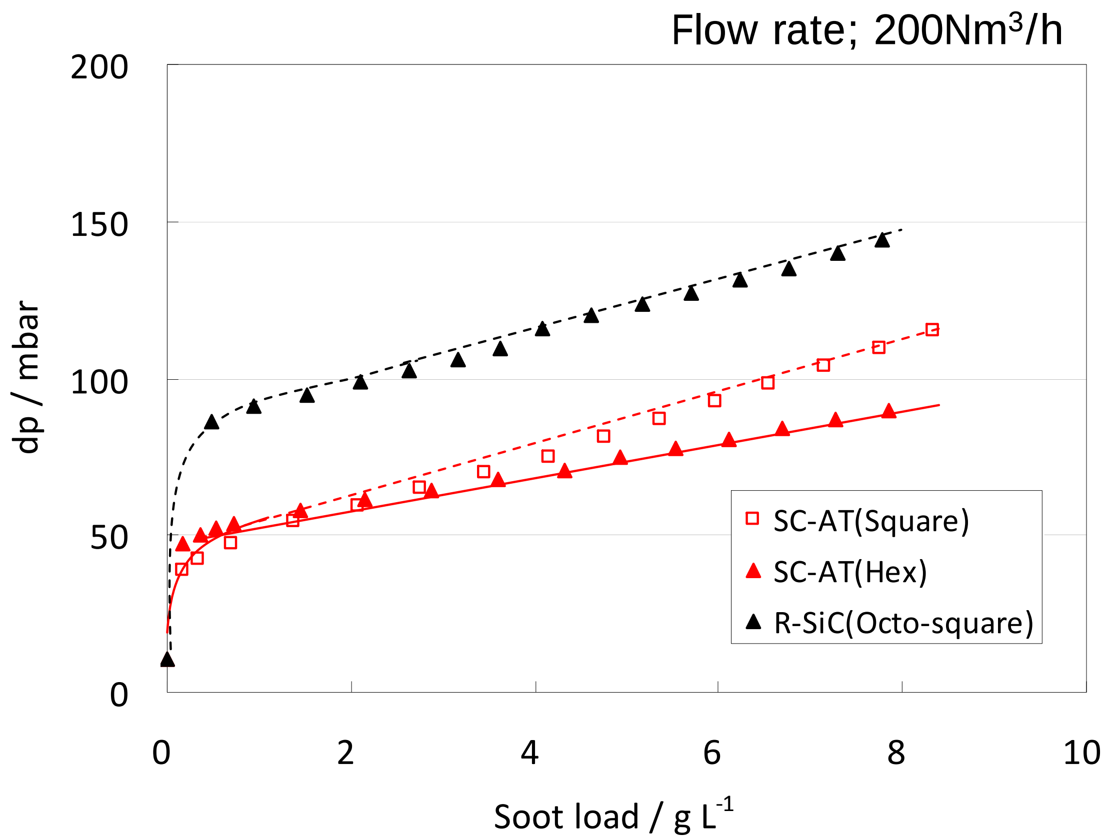
DPF	SC-AT		SiC
Cell design	Square 	Hex 	Octo-square 
Weight [g L^{-1}] as of size 5.66"D / 6"L	800	770	720
dh*_in/out [mm]	1.2/1.2	1.1/1.2	1.5/0.9
Cell density [cpsi]	290	350	280
Wall thickness [mil]	12	11	11
Segment binding area [%]	-	-	5.1
Open frontal area [%]	33	41	44**
Filtration area [m^2 L^{-1}]	1.0	1.3	1.0**

** Including frontal area loss by segment binding layer.

3. Features of "SC-AT"

3-5. Pressure drop (dp) at cold flow bench

dp under soot-loading

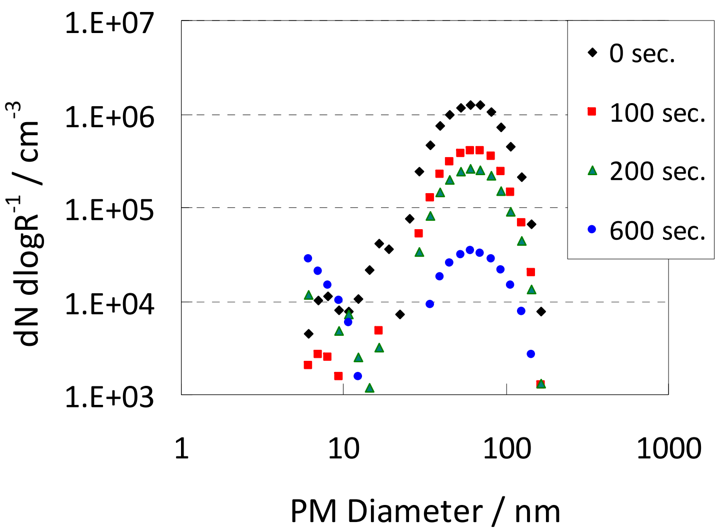


Hex design shows the lowest dP with soot.

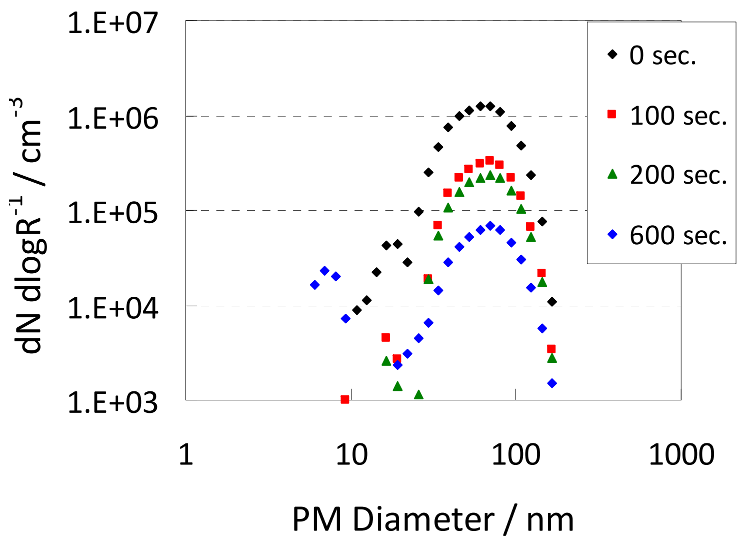
3. Features of "SC-AT"

3-6. Filtration efficiency at cold flow bench

SC-AT(Hex)



R-SiC(Octo-Square)



DPF	Filtration Efficiency** (%)
SC-AT (Hex)	**96**
R-SiC (Octo-square)	**94**

**After 10 min. soot generation

Filtration efficiency ; SC-AT is comparable w/ R-SiC.

3. Features of "SC-AT"

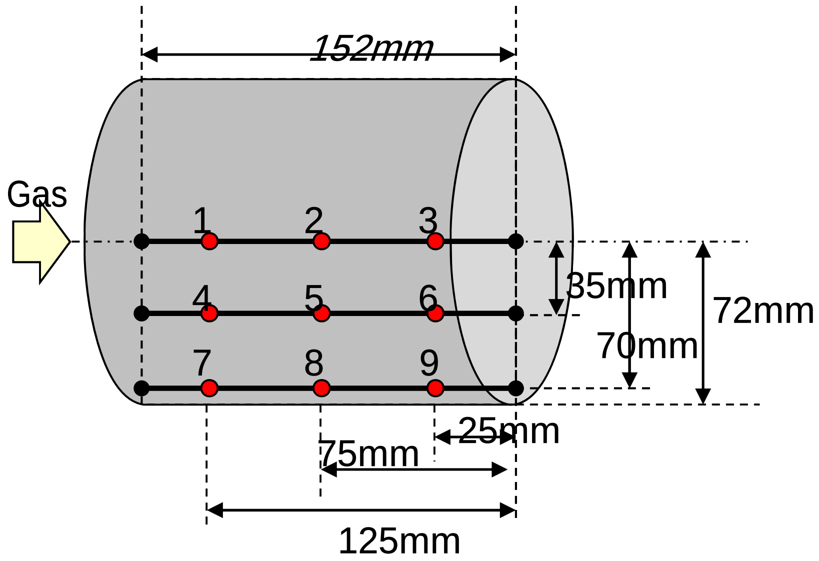
3-7. SML test at engine bench

Test procedure

Post injection

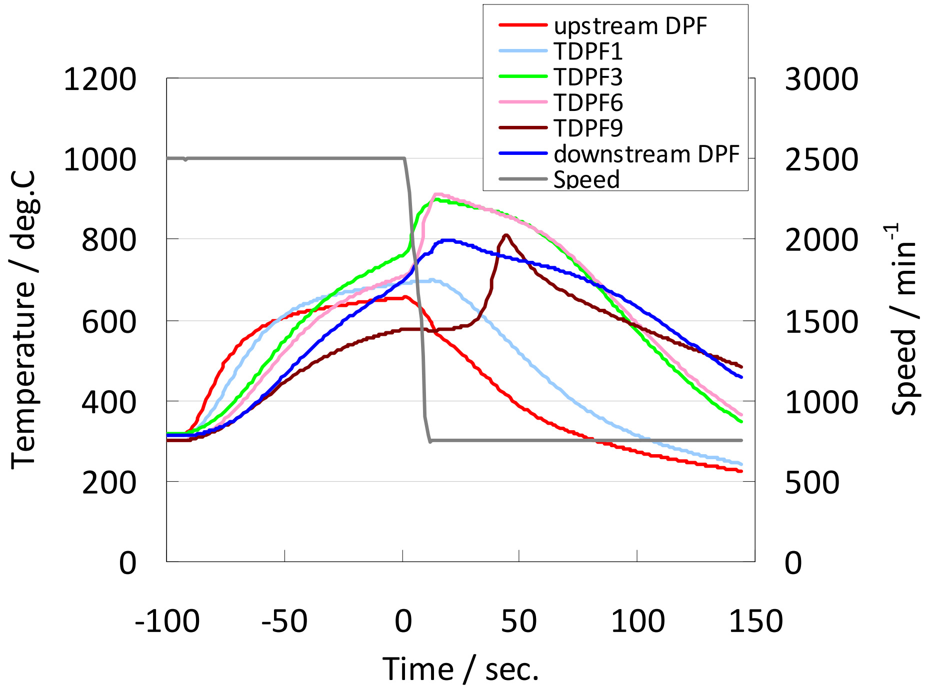
Soot load → Drop to Idle → Blow-off test

Theromocouple position



Regeneration profile

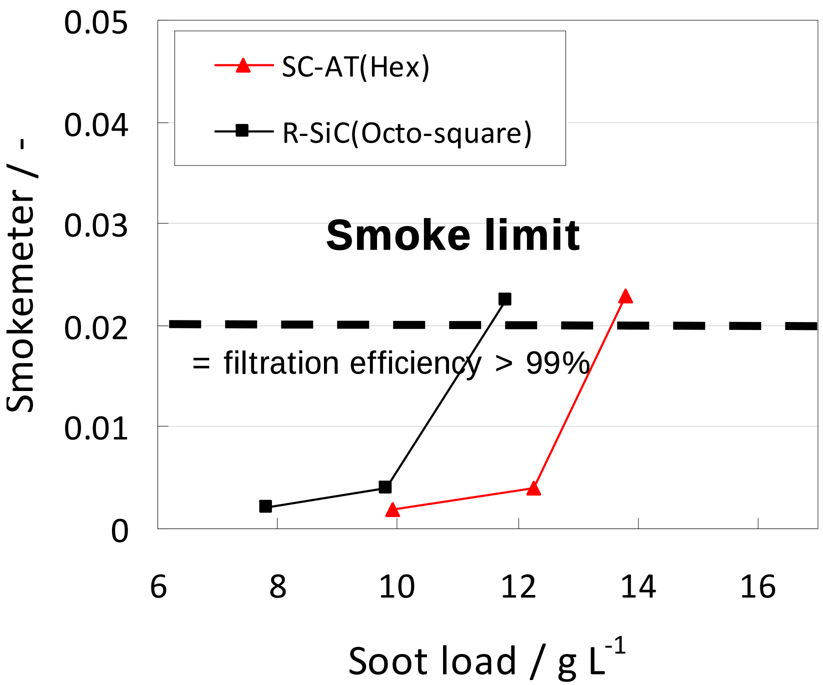
-SC-AT(Hex) w/ 10gL^{-1} soot -



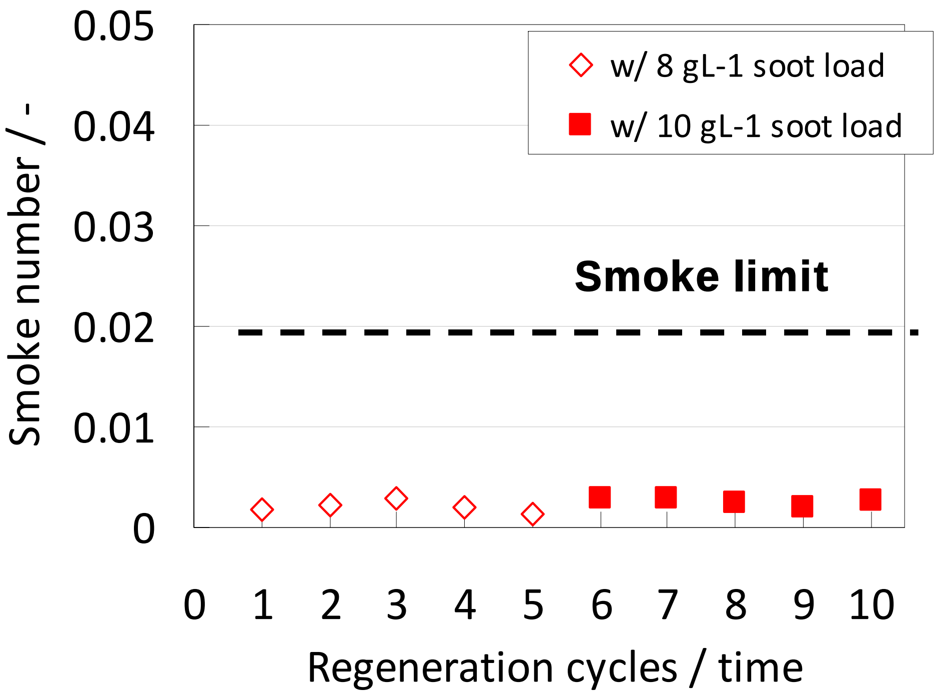
3. Features of “SC-AT”

3-7. SML test at engine bench

Blow-off test after thermal shock



Blow off test after cyclic regeneration



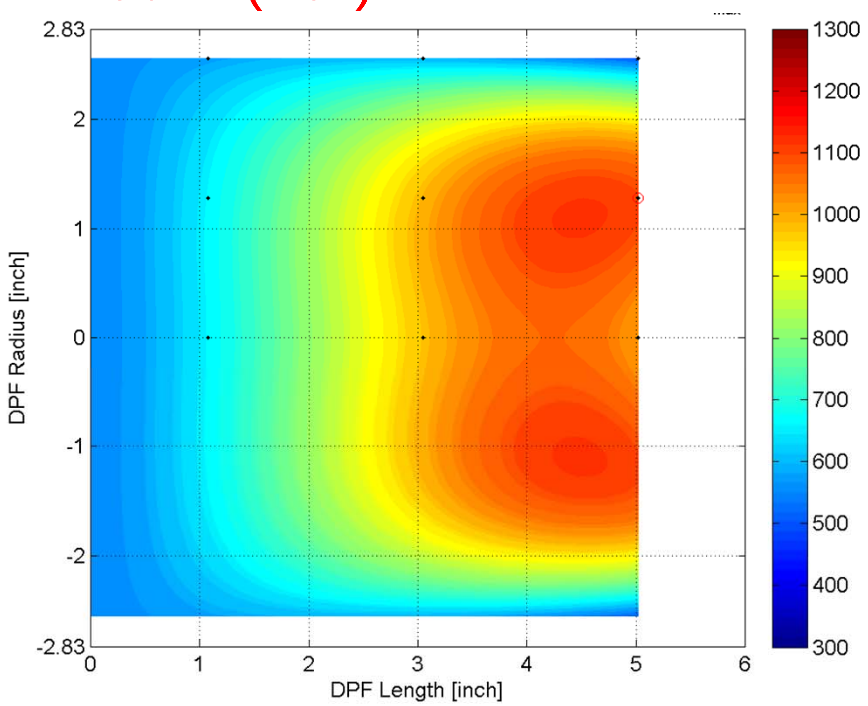
3. Features of “SC-AT”

3-7. SML test at engine bench

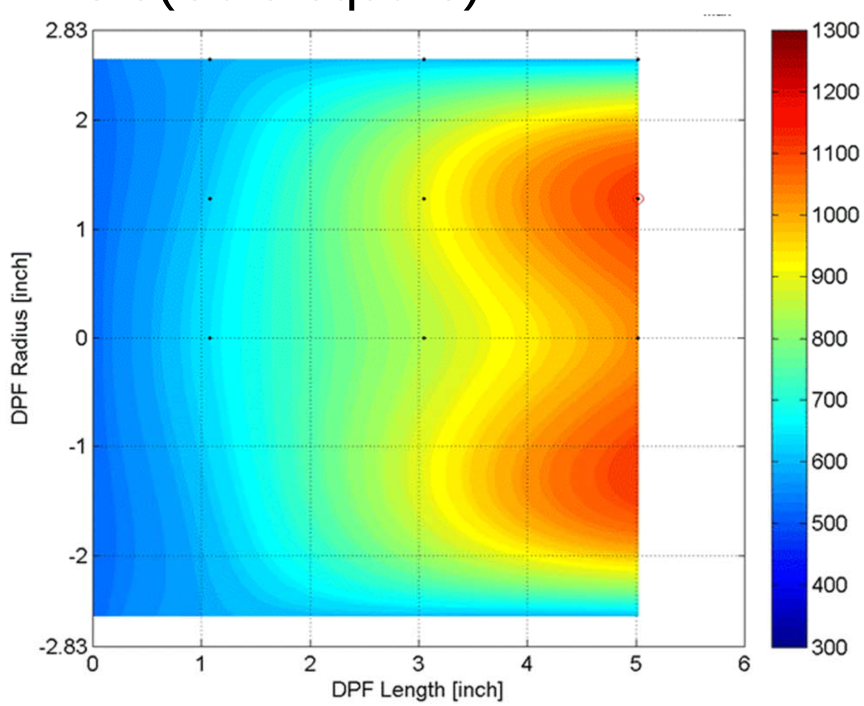
Distribution at Maximum temperature

(soot-load 12 g/L)

SC-AT(Hex)



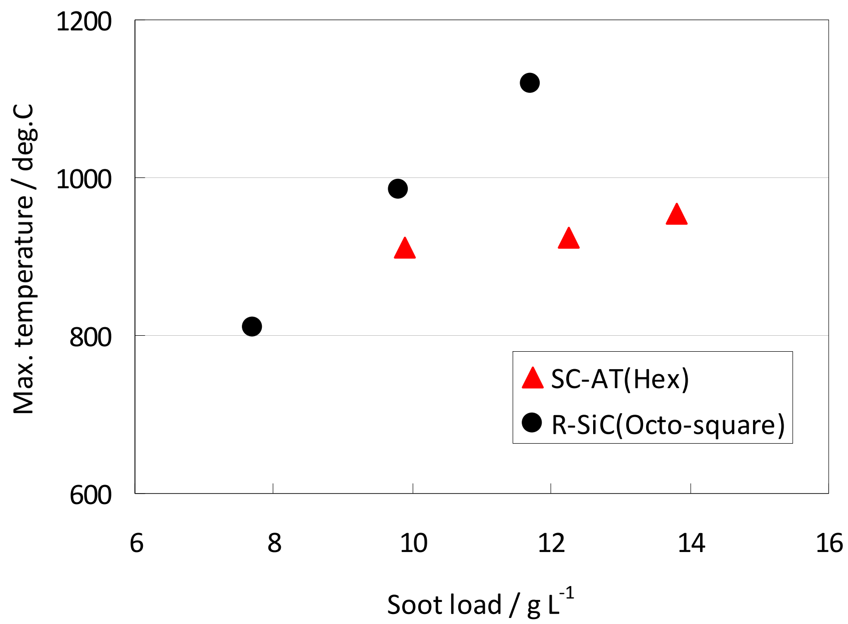
R-SiC(Octo-square)



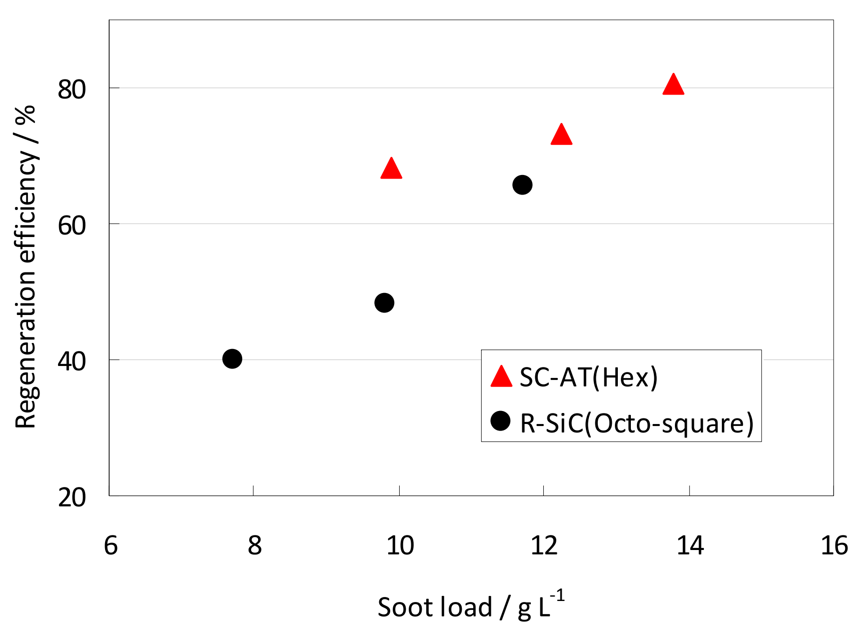
3. Features of "SC-AT"

3-7. SML test at engine bench

Maximum temperature



Regeneration efficiency



4. Conclusion

Feature of Sumitomo DPF “SC-AT”

- ✓ Highly cost competitive.
- ✓ High thermal shock resistance.
- ✓ High ash capacity.
- ✓ Higher SML.
- ✓ Remarkably lower pressure drop.
- ✓ Comparable Filtration efficiency.

Sumitomo DPF - Exhibition

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Thank you very much for your attention.