DPF System S-Cube (S^3 : Soot Solving System

- MLF Volumetric Filtration and Active Regeneration

New Generation in Diesel Particulate Filter

Japan Certification (2004. 1.)

KT Mark Award (2004. 6.)

2004. 8.

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KOREA

Object

Introduction

- CATech Inc.
- DPF system S-Cube

Profile of CATech Inc.

"Clean Air for our Descendants"

Company Vision

Leading Company with Innovative Technologies

in Energy / Environmental Application for Clean Air

Main Product / Technology

Diesel Particulate Filter System (DPF)

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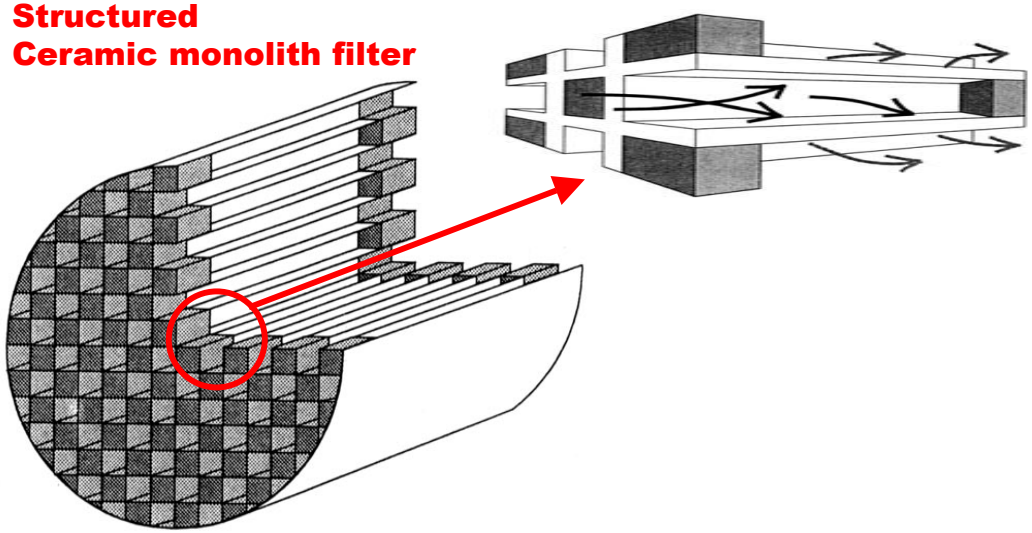
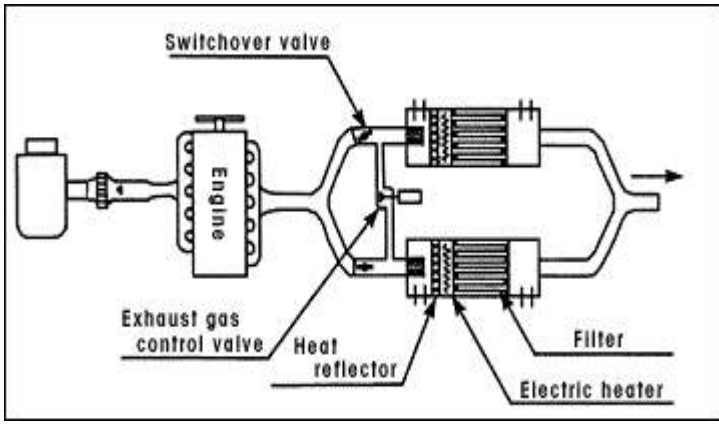
Facts on structured ceramic monolith filters

Structured
Ceramic monolith filter





Typical Active DPF system
(Fig. from DieselNet)

Performance	▸ High reduction efficiency with ~100 % for soot and 80~ 95% for PM
Durability Problem	▸ Thermal stress and crack propagation during regeneration process due to non-homogeneous filtration and heating ▸ Special regeneration algorithm, essential for active DPF system (longer and slow regeneration) ▸ Surface filtration method, results in rapid pressure increase
Price and maintenance	▸ High price (with catalyst) ▸ Periodic cleaning and replacement of filter due to ash accumulation

DPF system with catalyst

■ General consent

→ Durability problem, related to structured monolith filters, is occurred by *periodic regeneration process in active DPF system*, even with specially prepared regeneration algorithm and flow control valves.

→ Thus *passive DPF system, such as continuous regeneration system by catalyst,* may be the solution.

Passive DPF system with catalyst

(CRT / DPX etc.)

■ Drawbacks

(a) ULSD

(b) Limitations

→ Exhaust temperature

→ PM emission level

→ Installation location

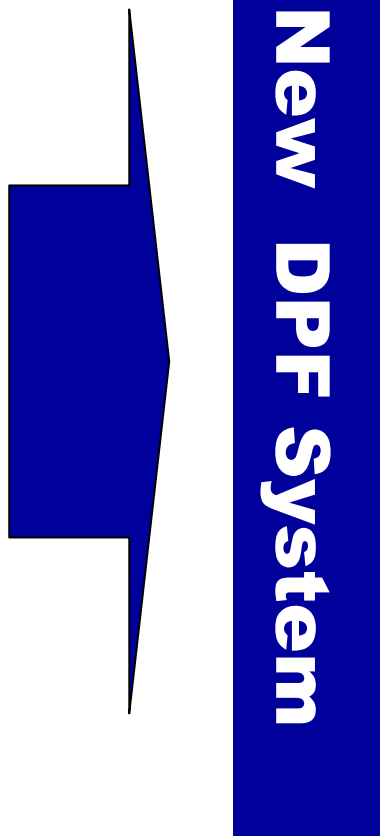
(c) High price

New DPF system is often sought.

Need for new DPF system with different concept

.... specially in Korea

- **Demonstration program in Korea**
  - → '97~'98 : 1,400 Garbage trucks in Seoul
  - → 4 DPF systems using structures filters
  - → Installed after severe certification processes
  - → Failed
- **15 years research experience**
  - → "Flame propagation within porous ceramic medium"
  - → Limit on durability with structured ceramics !!
- **System price in Korea**
  - → Feasible and economical price



Imagine

Sand, ... Sand layer .....

Can it be used as DPF filter ?

.... Small granular chip can be used as filtering material for Nano-size DPM ??

Let us change DPF filter concept ...

Introduction of S-Cube :

Active DPF system,
Newly Certified
and Commercialized

S^3 (S-Cube : Soot Solving System)

Japan Certified (2004. 1.)

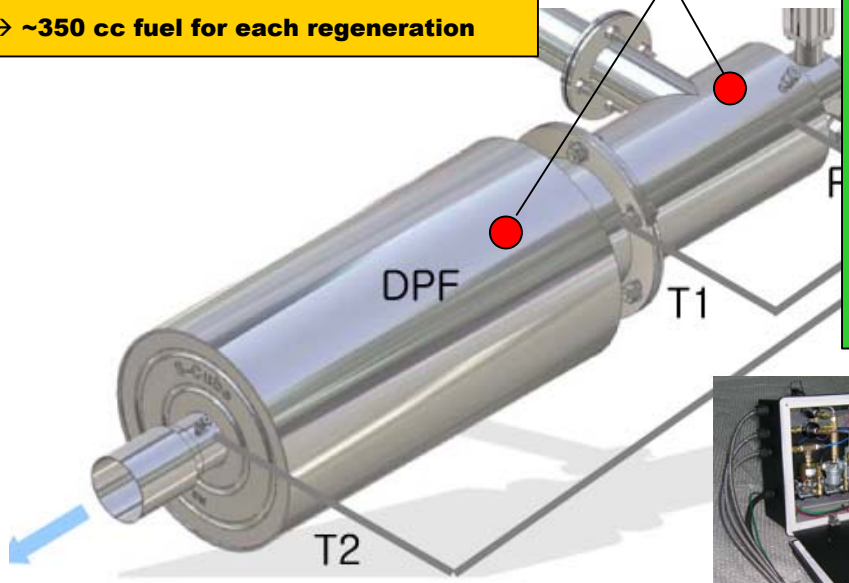
KT Mark Award (2004. 6.)

S-Cube : Leading Edge Technology in DPF

Volumetric filtration of Diesel PM by MLF (Multi-Layered Filter) of Ceramic Granular Chip and its Integration into Active DPF system

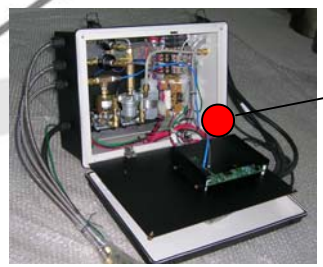
Regenerator (In-line burner)

- → Quick regeneration within 6~15 min.
- → Use only exhaust gas as oxidizer
- → ~350 cc fuel for each regeneration



MLF (Multi Layered Filter)

- → Innovative MLF design method and manufacturing
- → Reduction over 95~100% for soot and 70~99% for PM
- → High design flexibility on filter shape and efficiency
- → Unique solution for filter durability problem
- → Highly economical DPF system due to low filter cost
- → Favorable and slow pressure increase rate
- → Large loading capacity, regeneration at 300~700 Km drivin
- → No limitations on fuel, exhaust temperature and PM loadin
- → Muffler function

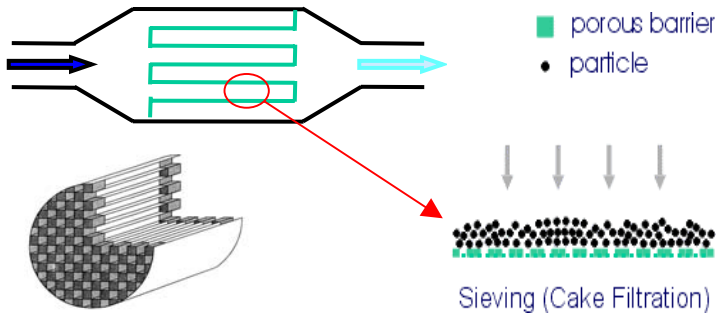


ECU & Actuators

- → Independent system
- → Optimized software

MLF - Filtration Mechanism

Back pressure increase ∝ due to filter structure + due to PM filtration



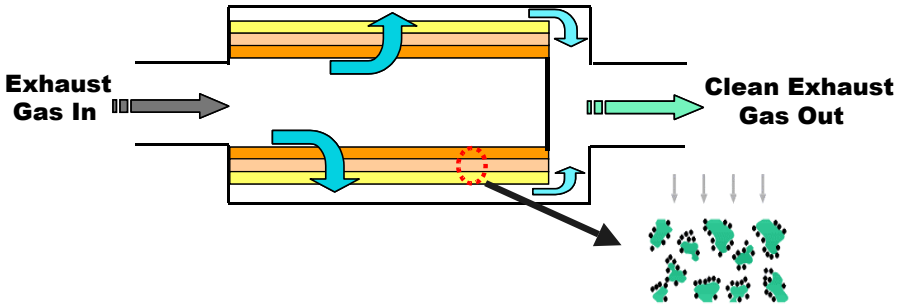
< Surface filtration by other structured filters >

Ceramic filter (Surface filter)

- **mean pore size: ~ 12.5 μm**
- **filter thickness : ~ 0.7 mm**

➔ **ΔP ∝ mainly due to PM filtration**

➔ **Steep increase with high PM filtration**



< MLF filtration - unstructured filter >

CATech MLF filter (Volumetric filtration)

- **mean pore size : 100 ~ 1,000 μm**
- **filter thickness : > 20 mm**
- **different chip size and thickness for layers**

➔ **ΔP ∝ mainly due to filter structure**

➔ **Slow increase even with high PM filtration**

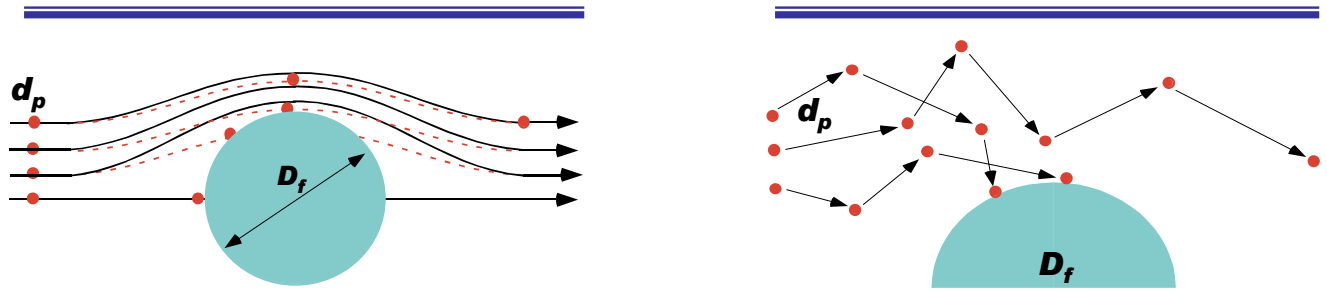
MLF - Filtration Efficiency

Overall Filter Efficiency ~ $\frac{\text{Layer Thickness}(L)}{\text{Pore Size}(D_f)}$

~ Filtration by Interception + Filtration by Diffusion

Interception ~ Particle Size (d_p)

Diffusion ~ $\frac{1}{\text{Particle Size}(d_p)}$

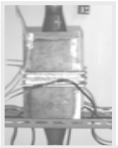


Surface filtration ← Mainly filtration by interception

MLF filtration ← Filtration by *both interception and diffusion*

- **As the size of PM is reduced, it can be guessed that**
  - → **Filtration by Diffusion will be enhanced even with present MLF filter.**
  - → **Thus it could be the solution for Nano-particle problem, which is difficult to expect from other structured (surface filtration type) filter systems.**

S-Cube : 4 years development

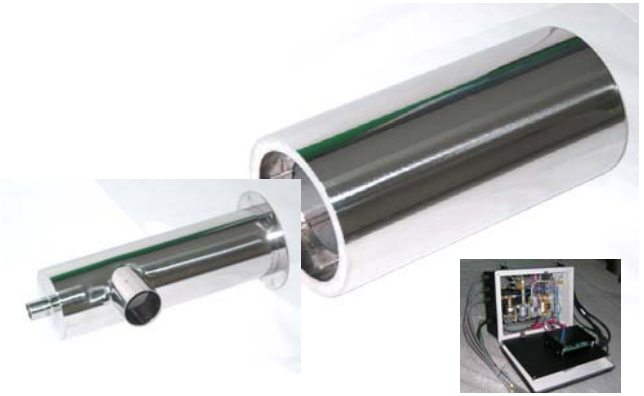













Filter with MLF type

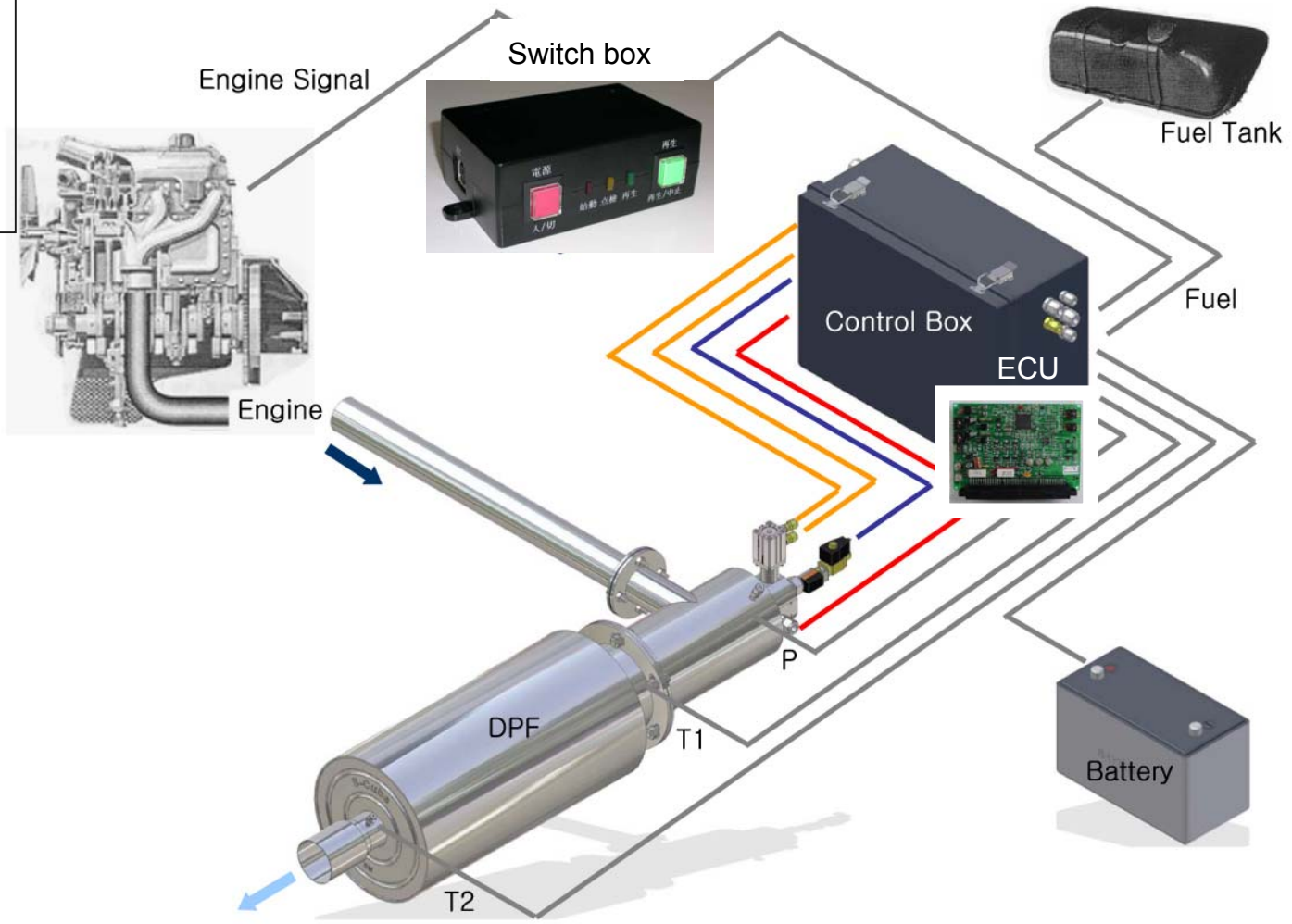
(SC-060MB, ~7L)

- **D = 26cm, L=45cm, 32Kg**
- **Annular type cylinders**
- **PM capacity : ~40 g/Reg.**

S-Cube : DPF System – In-Line Burner Regeneration

Regeneration

- **Every 300~700Km**
- **at engine idling**
- **manually starting**
- **~6 min~15min.**
- **~350cc Diesel fuel**



S-Cube : DPF System – Electric Heater Regeneratio

<Control Box & Air Compressor>

<Switch Box>

<Signal gage>

<Signal lamp>

Regeneration

- at engine stop
- 220vAC External power
- ~6.0 Kwh (60 min.)

<Motor-car application>

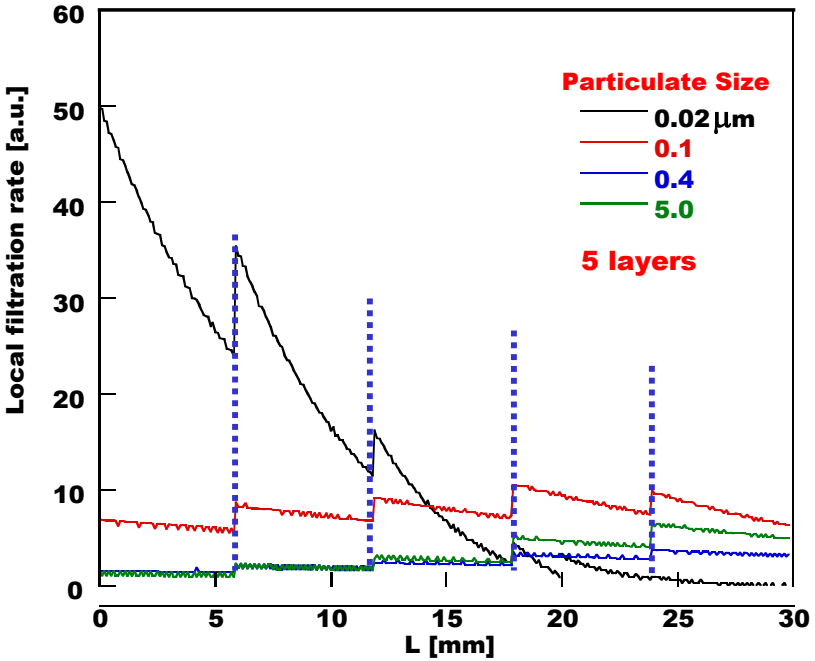
MLF – Design Parameters

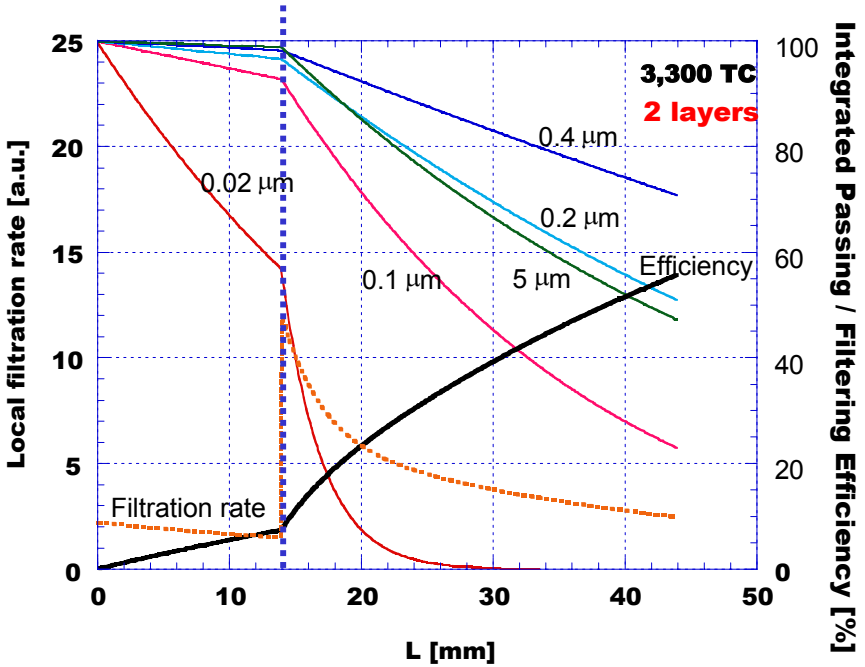
A. Design aspects

- -Chip Size Distribution, Df
- -Layer Thickness, L
- -Filtration Area, (velocity *u*)

B. Environmental aspects

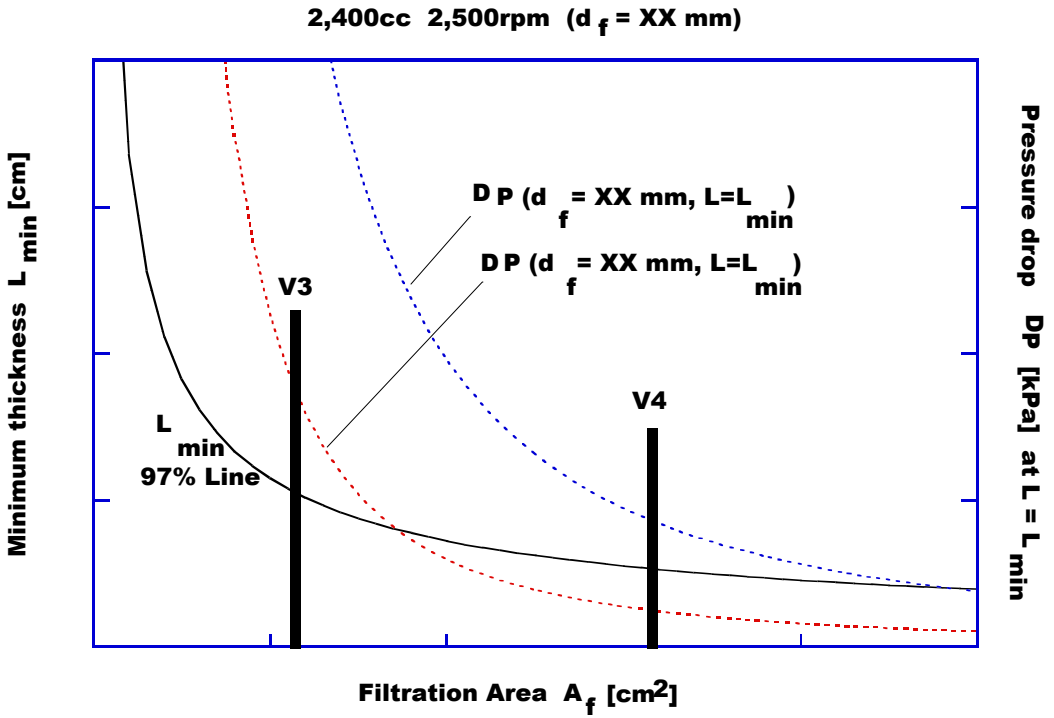
- -Particulate Size Distribution (dp)
- -Temperature
- -Engine displacement and RPM (velocity *u*)
- -Local/total filtered mass of particulates (porosity)





- Calculated local filtration rate for various sizes of particulate in layered clean filter at a typical flow condition.

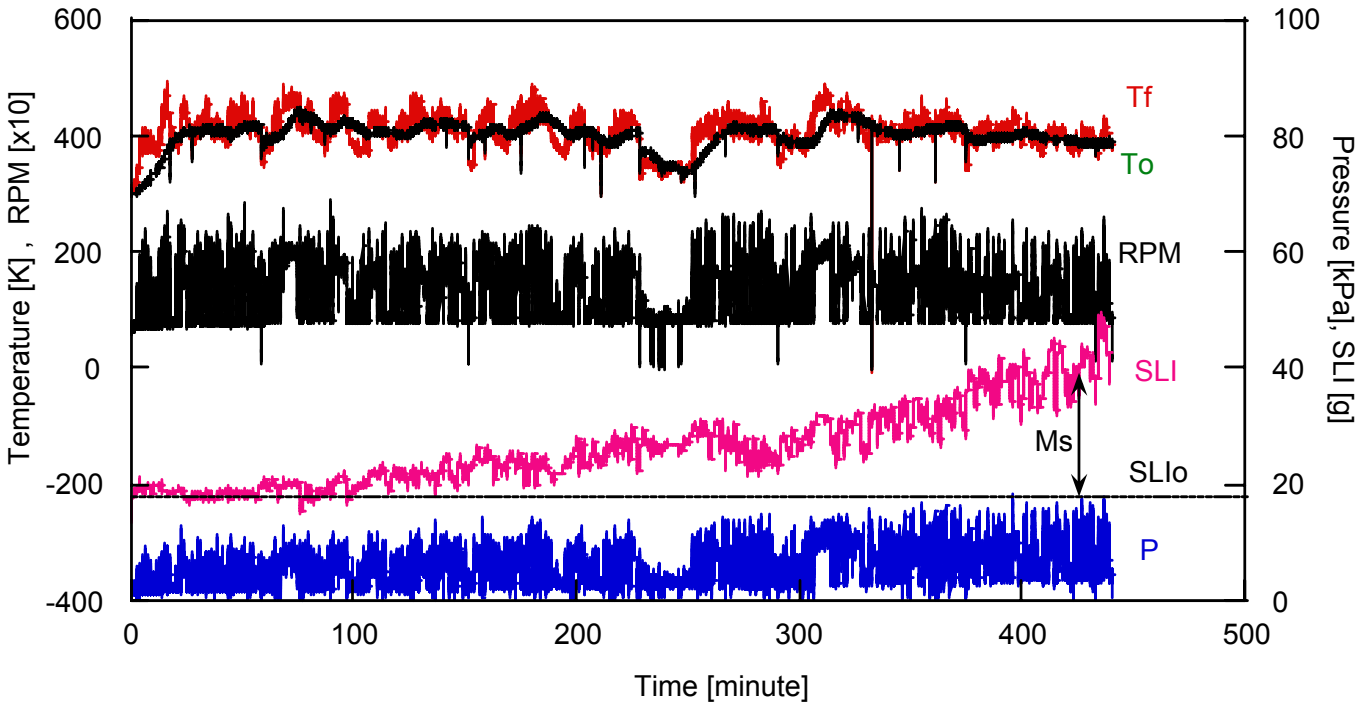
MLF - Design



■ **Design with Nano-size PM movement analysis**

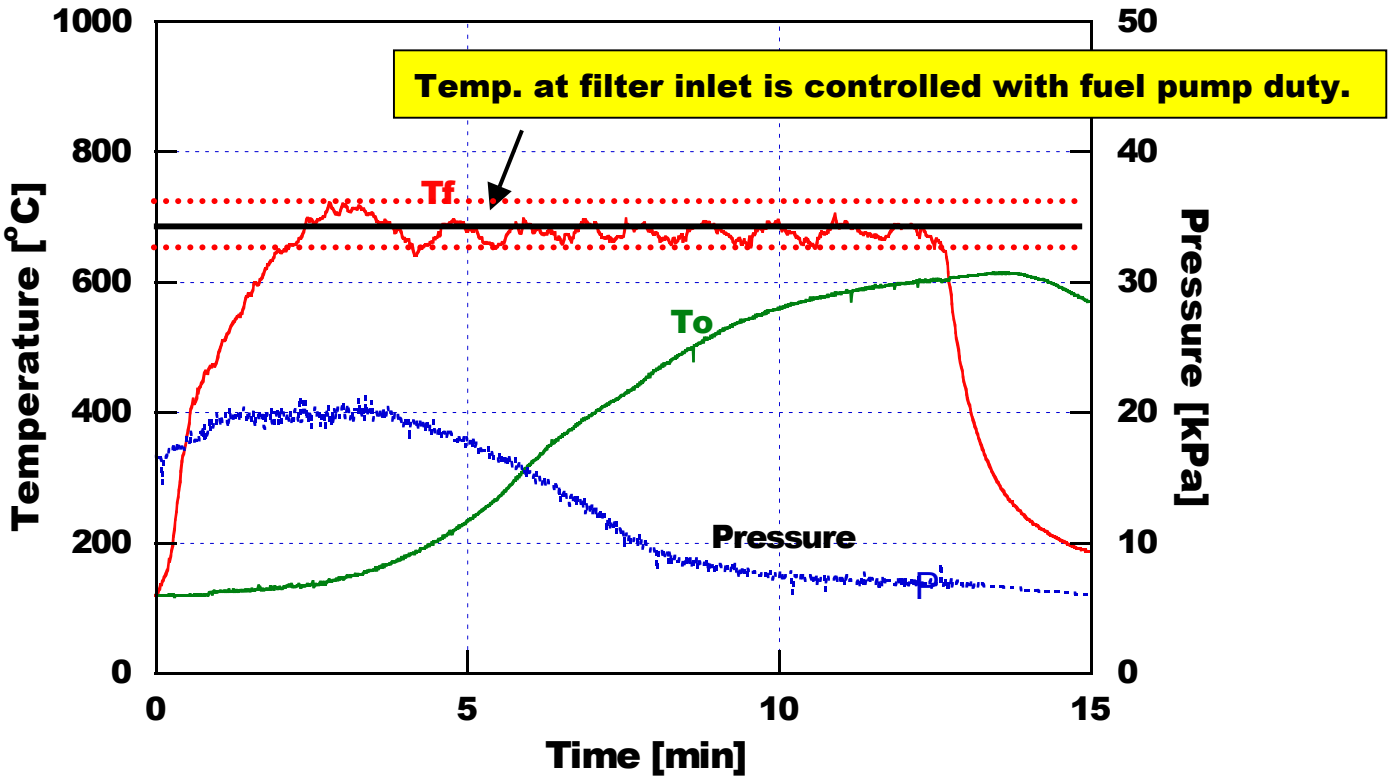
→ **for filter surface area, thickness, pressure drop and efficiency.**

Driving with S-Cube DPF



- Pressure, P, increases with PM loading during real road driving.
- Mass of filtered PM, Ms, is calculated by pressure, RPM and temperatures.
- Tf and To represent temperatures before and after the filter, respectively.
- Vehicle : 4,330 cc NA ISUZU ELF truck - 0.5 g/kwh PM emission by Japan D-13 mode.
- Driving : In urban area of Tokyo.

Regeneration by In-line burner



Fuel penalty due to regeneration :

- ~ 350cc for each regeneration for SC-060MB DPF system (~7L Engine)
- If regeneration at every 350 Km with fuel mileage of 10Km/L vehicle → 1% fuel penalty.

S-Cube : Performance

* **Official performance test data from Japan and Korea test centers**

Test data at Tokyo Metropolitan Environment Research Institute

5 試験結果

(1) ディーゼル１３モード

	CO (g/kWh)	HC (g/kWh)	NO_x (g/kWh)	CO_2 (g/kWh)	PM (g/kWh)
装着前	3．33	0．21	4．21	1340	0．45
装着後	3．82	0．19	4．03	1360	0．04

Japan D-13 mode : (PM 91 % ↓)

(2) ディーゼル１０・１５モード及び粒子状物質測定

	CO (g/km)	HC (g/km)	NOx (g/km)	CO_2 (g/km)	燃料消費率 (km/L)	粒子状物質 (g/km)
装着前	0．61	0．12	0．90	258	10．1	0．05
装着後	0．68	0．13	0．88	266	9．80	0．01

Japan 10 • 15 mode : (PM 85 % ↓)

(3) 排気煙濃度試験

最高出力時回転数に対するエンジン回転数の割合	40%	60%	100%
装着前平均濃度 (%)	20	43	30
装着後平均濃度 (%)	0	0	0

Smoke test with load : (100 % ↓)

(4) スモークテスト

装着前平均濃度	18%
装着後平均濃度	0%

Smoke test by free acceleration : (100 % ↓)

測定結果等の詳細は、別添のとおり。 以下余白。

* **Power output reduction : less than 2% with D-13 mode test**

S-Cube : Strength - Economical DPF system without any limitations

1. Free of durability problem
2. No limitation on fuel, exhaust temp., PM level
3. Solution for Nano-PM problem
4. Quick and intensive regeneration
5. Economical active DPF system

S-Cube : Drawback

1. Heavy and large :

~ due to the reason that to make same pressure level with other structured filters.

2. High CO/HC emission at the moment of burner start-up

~ plan to apply “Clean-up catalyst” to one of filter layers.

Product portfolio (Aug. 2004)

Categorized by regeneration method

- DPF system with In-line burner – exported to Japan retrofit market
- DPF system with electric heater regeneration (external electric power)
- DPF filter only on vehicle + external hot gas supplier (available in Dec. '04)

Application

- Retrofit
- OEM
- Diesel generator
- Construction engines and vehicles
- Ship and locomotive engine

MLF - High Technology Potential

- Solution to Nano-particle PM reduction due to diffusion filtration mechanism
- Economical and durability free filter system, sustainable to rapid and intense heatin
- Various functional catalysts, applicable to each layer of MLF
- Design flexibility for various shape, efficiency and size
- Engineering potential for various applications such as locomotives and ship

MLF

Catalyst + Post-Injection

Working with HMC (Hyundai Motor Company) for OEM

- **Reduction to small size with Continuous regeneration**
- **Closest position to engine**

HC-SCR + Plasma

→ Dual PM/NOx reduction system for retrofit

■ DPF retrofit market in Korea

→ Starting on Jan. 2005

→ Market size for DPF/DOC : ~1,200 million(USD) till 2012 (50% from Gov.)

→ 150,000Km or 3 yr. Warranty

→ Bus and trucks with high PM and (or) low temperature (~Euro-II)

→ Expected DPF system price for 12L engine : ~about $6,500 (USD)

■ DPF Maker in Korea with products (2004. 8)

→ CATech Inc. (Active type DPF)

→ SK (CRT type DPF)

Thank you very much !

CATech Inc. is looking for

best partner

for Europe DPF market,....