

# 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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(Clean Air Technology)**

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## **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**

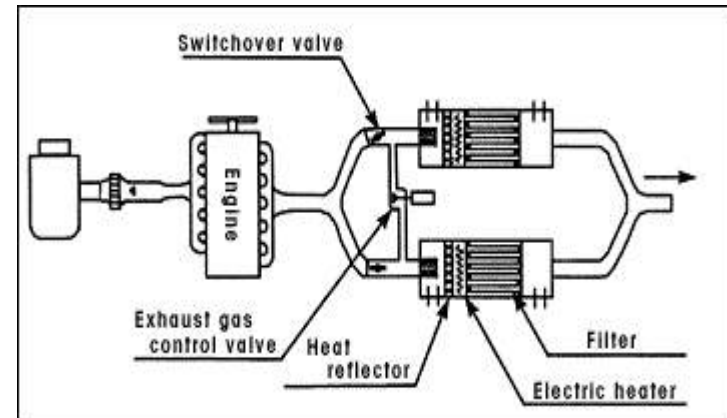
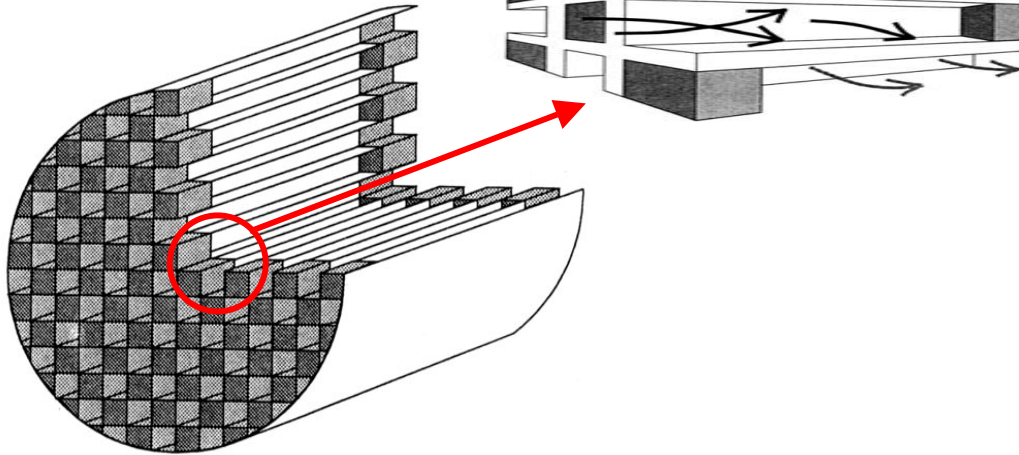
## **Main Product / Technology**

**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)**

<b>Performance</b>	<ul style="list-style-type: none"> <li>▶ High reduction efficiency with ~100 % for soot and 80~ 95% for PM</li> </ul>
<b>Durability Problem</b>	<ul style="list-style-type: none"> <li>▶ Thermal stress and crack propagation during regeneration process due to non-homogeneous filtration and heating</li> <li>▶ Special regeneration algorithm, essential for active DPF system (longer and slow regeneration)</li> <li>▶ Surface filtration method, results in rapid pressure increase</li> </ul>
<b>Price and maintenance</b>	<ul style="list-style-type: none"> <li>▶ High price (with catalyst)</li> <li>▶ Periodic cleaning and replacement of filter due to ash accumulation</li> </ul>

# 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



**New DPF System**

# 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.)**

**Excellent Korean Technology**

# S-Cube : Leading Edge Technology in DPF

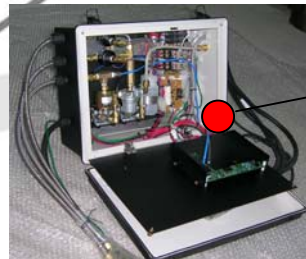
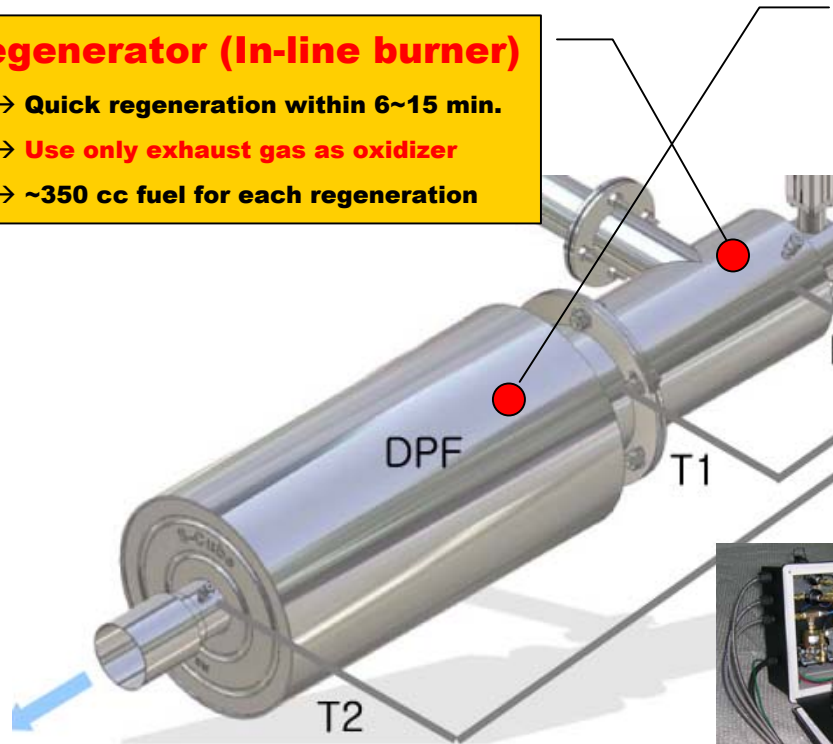
## Volumetric filtration of Diesel PM by MLF (Multi-Layered Filter) of Ceramic Granular Chip and its Integration into Active DPF system

### 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 driving
- No limitations on fuel, exhaust temperature and PM loading
- Muffler function

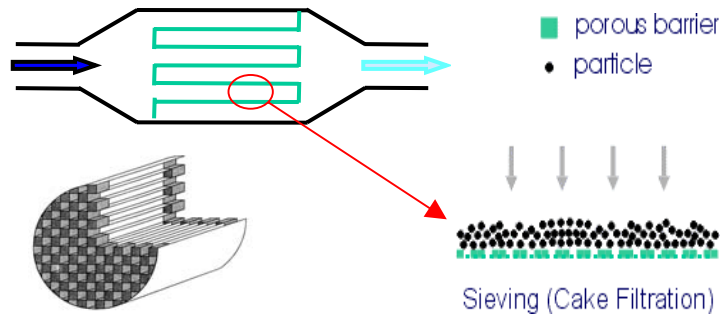


### ECU & Actuators

- Independent system
- Optimized software

# MLF - Filtration Mechanism

**Back pressure increase  $\propto$  due to filter structure + due to PM filtration**

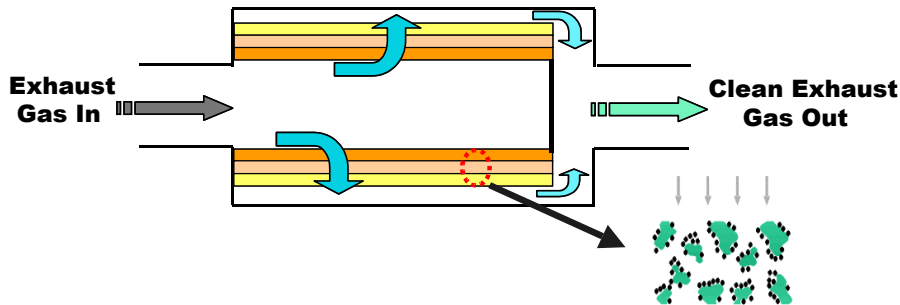


**< Surface filtration by other structured filters >**

## Ceramic filter (Surface filter)

- mean pore size:  $\sim 12.5 \mu\text{m}$
- filter thickness :  $\sim 0.7 \text{ mm}$

- $\rightarrow \Delta P \propto$  mainly due to PM filtration
- $\rightarrow$  Steep increase with high PM filtration



**< MLF filtration - unstructured filter >**

## CATech MLF filter (Volumetric filtration)

- mean pore size :  $100 \sim 1,000 \mu\text{m}$
- filter thickness :  $> 20 \text{ mm}$
- different chip size and thickness for layers

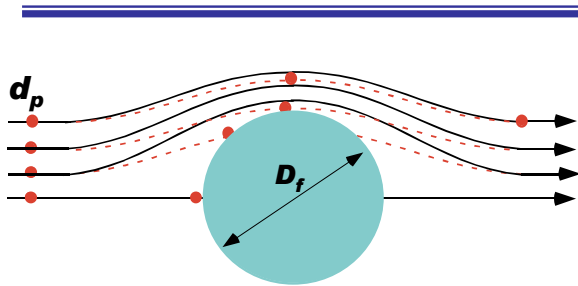
- $\rightarrow \Delta P \propto$  mainly due to filter structure
- $\rightarrow$  Slow increase even with high PM filtration

# MLF - Filtration Efficiency

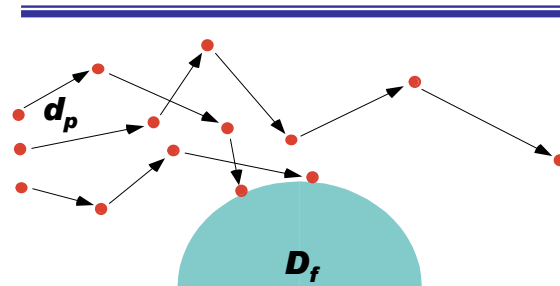
Overall Filter Efficiency  $\sim \frac{\text{Layer Thickness}(L)}{\text{Pore Size}(D_f)}$

$\sim$  Filtration by Interception + Filtration by Diffusion

Interception  $\sim$  Particle Size ( $d_p$ )



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



Surface filtration  $\leftarrow$  Mainly filtration by interception

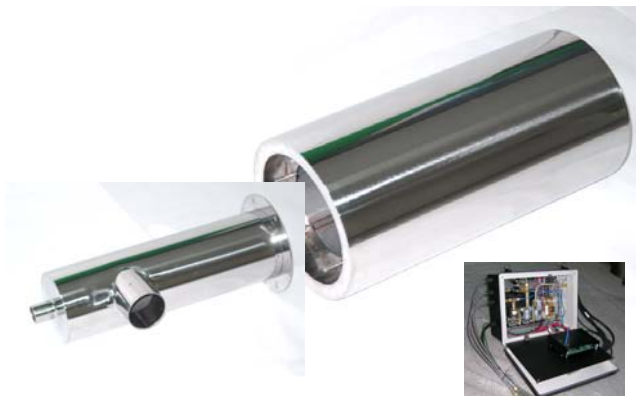
MLF filtration  $\leftarrow$  Filtration by both interception and diffusion

■ 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)**

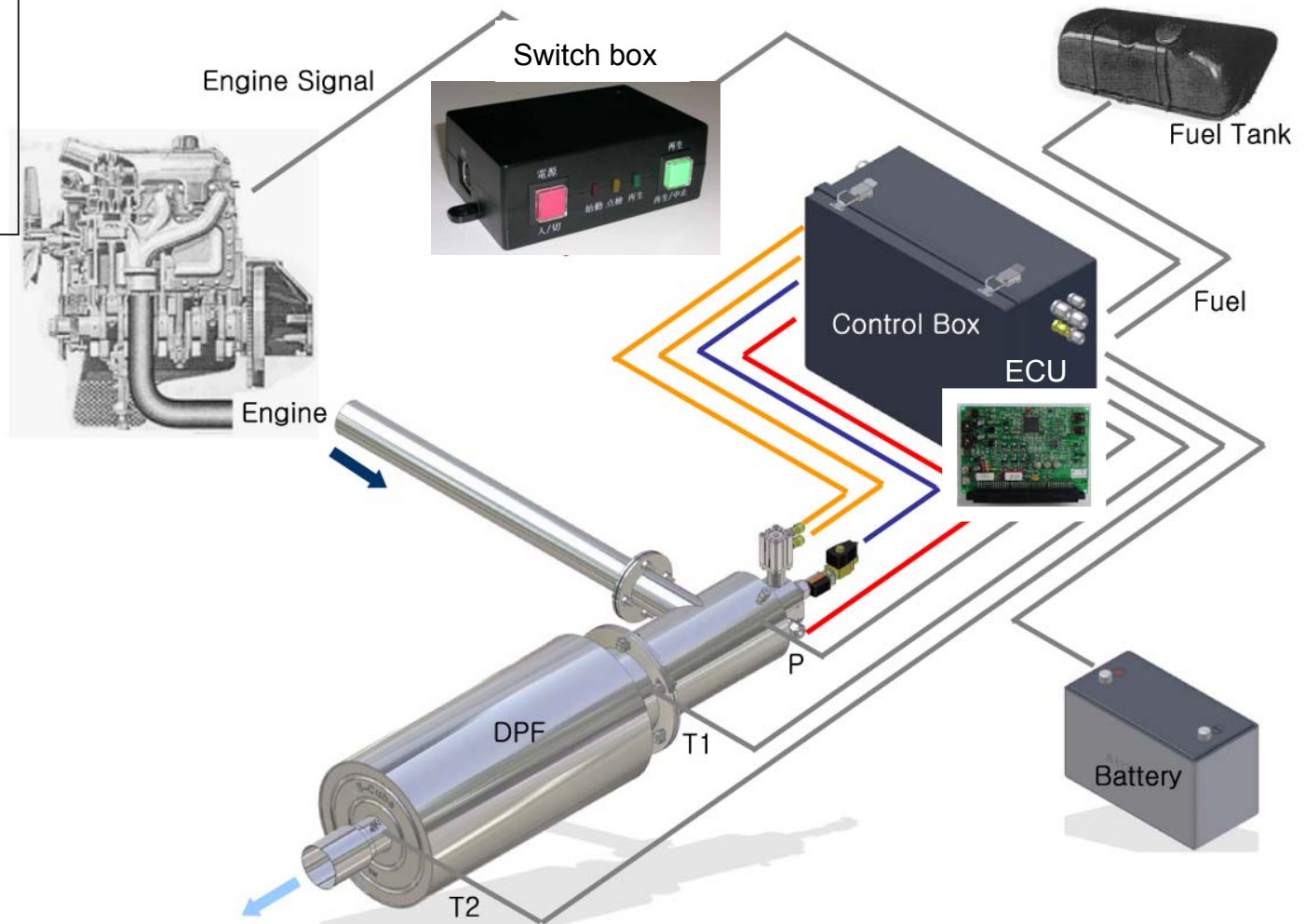
- D = 26cm, L=45cm, 32Kg
- Annular type cylinders
- PM capacity : ~40 g/Reg.



# 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 Regeneration***



**<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>**

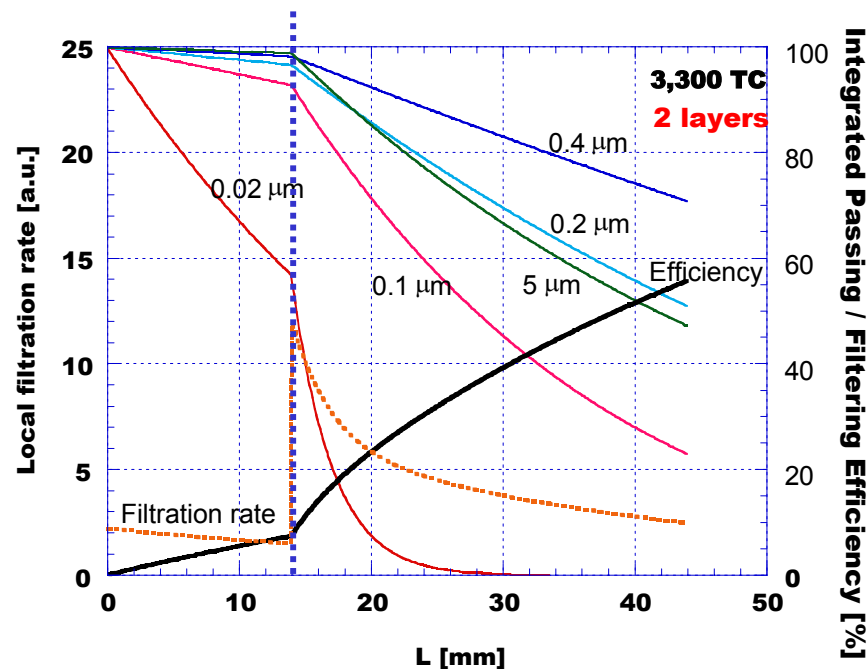
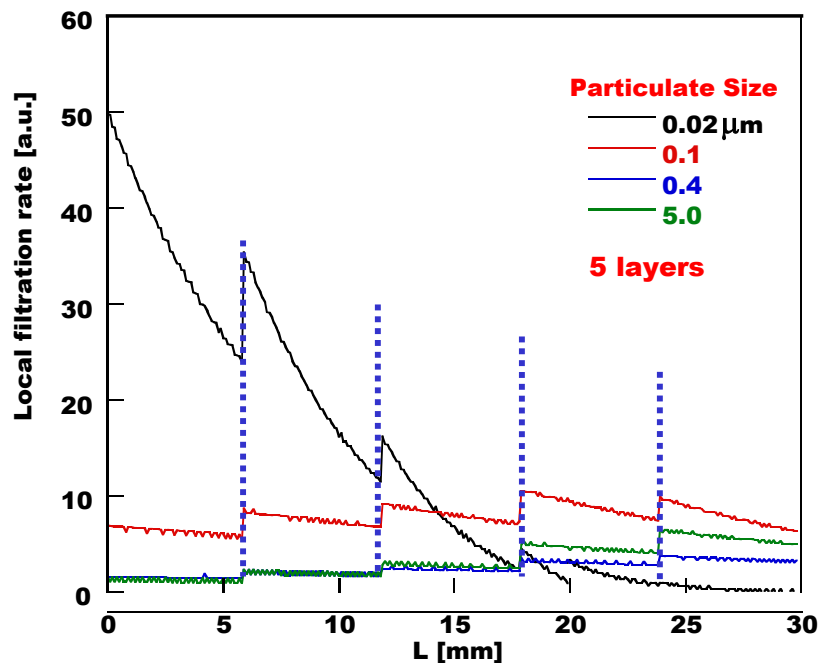
# MLF – Design Parameters

## A. Design aspects

- Chip Size Distribution,  $D_f$
- Layer Thickness,  $L$
- Filtration Area, (velocity  $u$ )

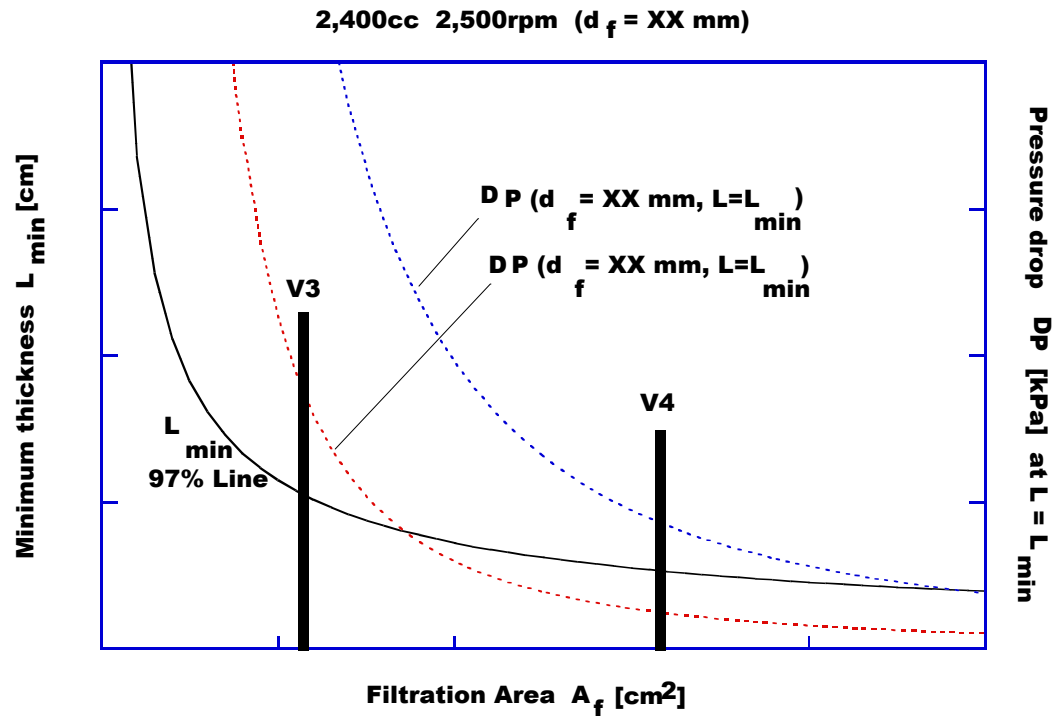
## B. Environmental aspects

- Particulate Size Distribution ( $d_p$ )
- 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.

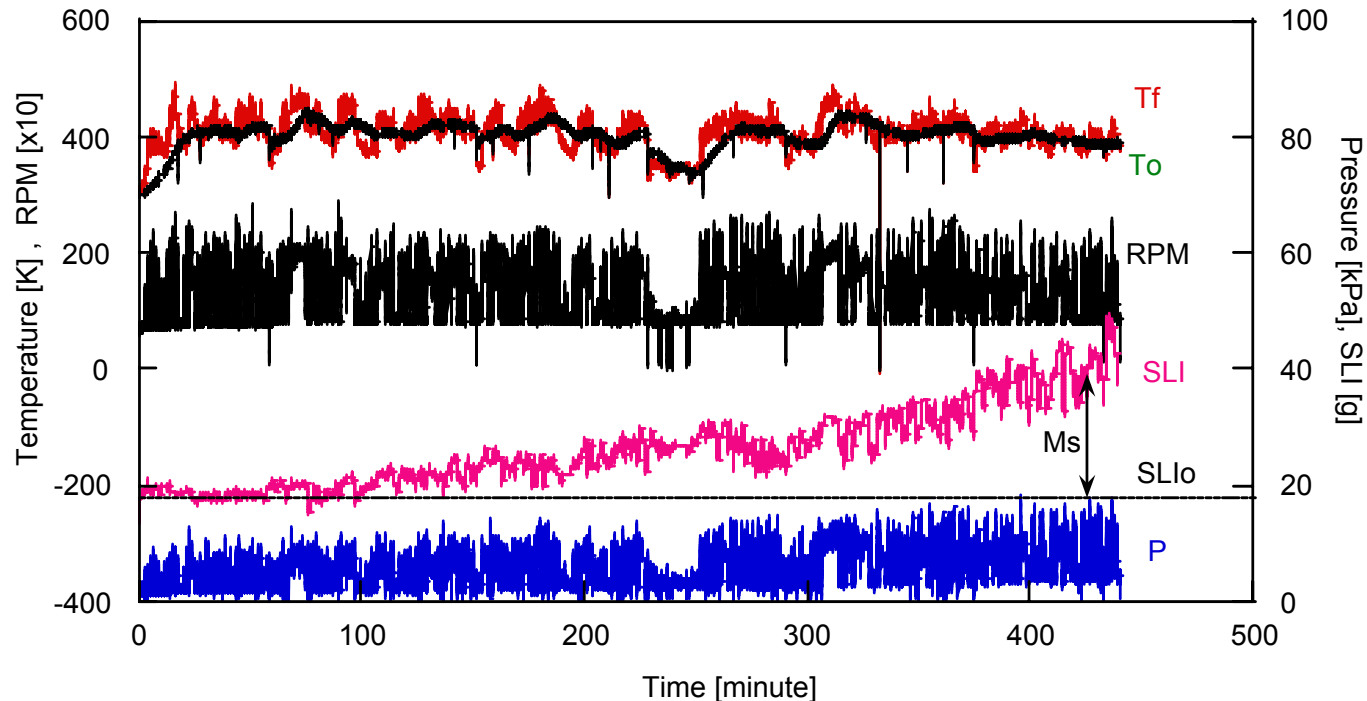
# MLF - Design



■ Design with Nano-size PM movement analysis

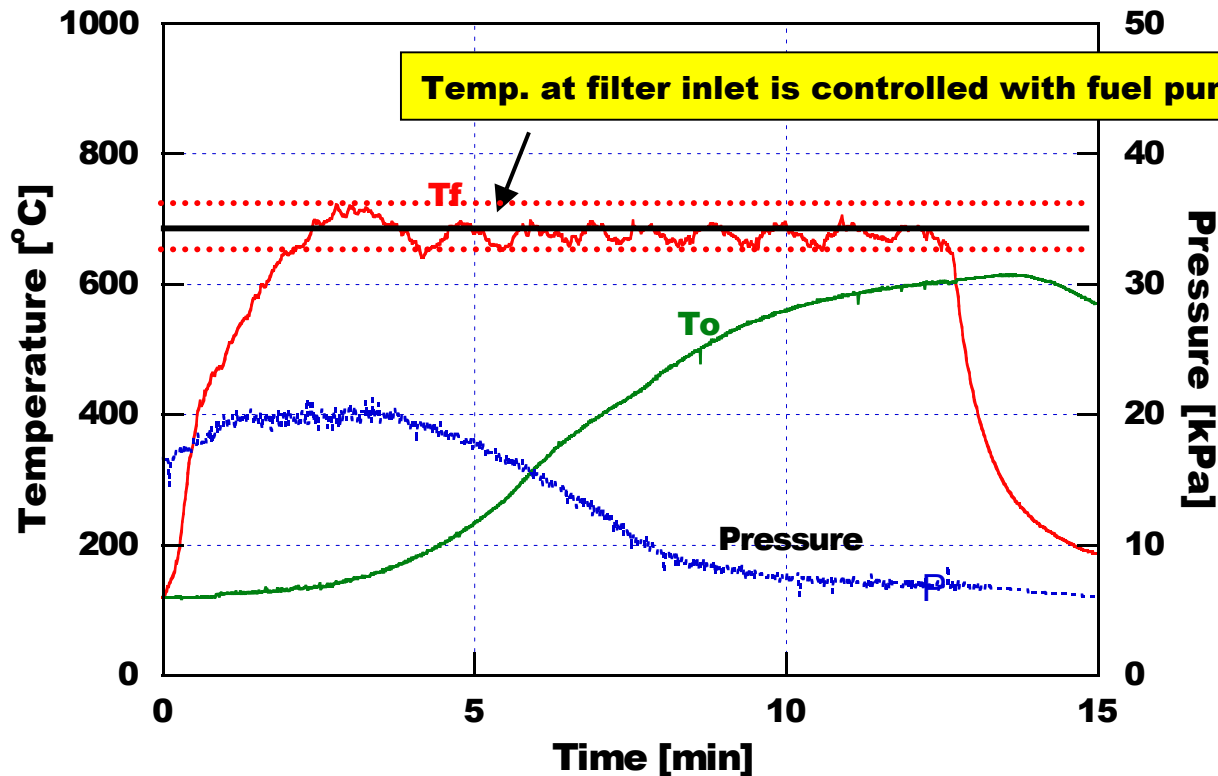
→ for filter surface area, thickness, pressure drop and efficiency.

# 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 <sub>x</sub> (g/kWh)	CO <sub>2</sub> (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)	NO <sub>x</sub> (g/km)	CO <sub>2</sub> (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***

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## **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)**

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## **Categorized by regeneration method**

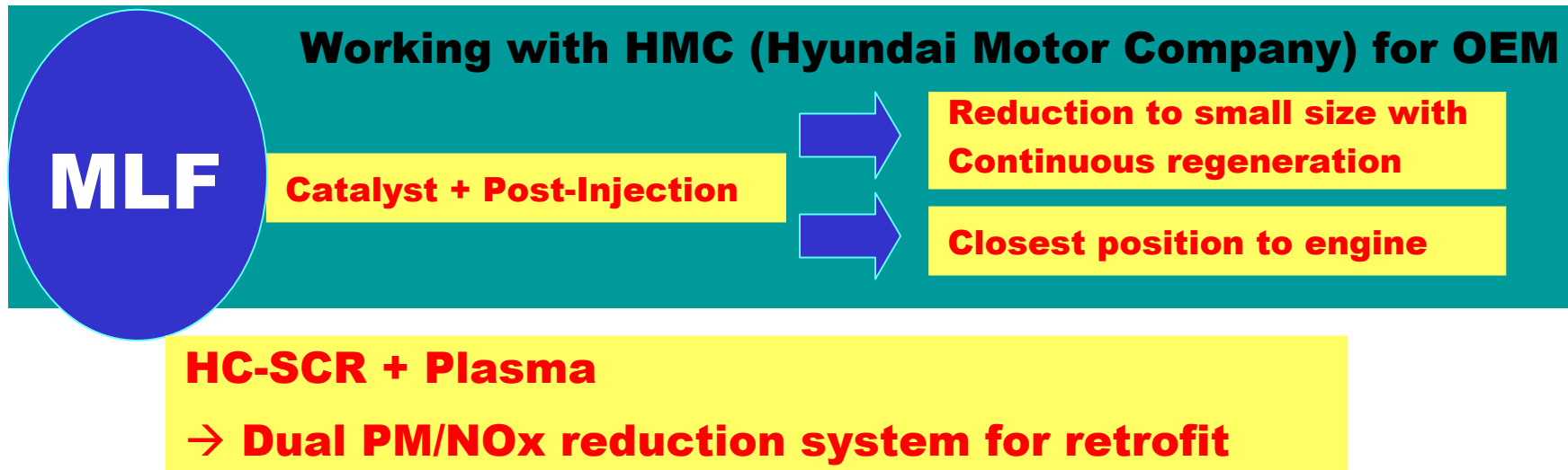
- DPF system **with In-line burner** – exported to Japan retrofit market
- DPF system **with electric heater regeneration** (external electric power)
- **DPF filter only on vehicle + external hot gas supplier (available in Dec. '04)**

## **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 heating**
- ❑ **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**



## ■ **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)**

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**Thank you very much !**

**CATech Inc. is looking for  
best partner  
for Europe DPF market,....**