Automotive Emission Control

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CONTENTS

♦ Background of Automotive Emission
♦ Typical Properties
♦ Canning
♦ Advantage of Advanced Ceramic Substrate
  • Effect of Substrate GSA
  • Effect of Substrate Bulk Density
♦ Conclusions
♦ Other Recent Application
Background of Automotive Emission

History of Emission Regulation
- 1970 US (Muskie Act)
- 1973 Japan
- 1984 Europe (Euro 0)

Aftertreatment System required (TWC)

Ceramic Substrate required for Catalytic Support

Typical Efficiency of a Three-way Catalyst

Typical Catalytic Reaction

\[
\begin{align*}
2\text{CO} + \text{O}_2 & \rightarrow \text{CO}_2 \\
2\text{C}_2\text{H}_6 + 7\text{O}_2 & \rightarrow \text{CO}_2 + 6\text{H}_2\text{O} \\
2\text{NO} + 2\text{CO} & \rightarrow \text{N}_2 + 2\text{CO}_2
\end{align*}
\]
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Material Properties of Ceramic Substrate

♦ Material : Cordierite

♦ Low Thermal Expansion : < 1.0 x 10^{-6}/deg.C *
  (Good Thermal Shock Resistance)

♦ Softening Temperature : > 1400 deg. C

♦ Porosity (Water Adsorption) : 35% (Typical)
  (Good Coat-ability)

*(40-800 deg. C)
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Typical Canning Method

Clam-Shell

Stuffing

Tourniquet
Canning

- Properties of the Mounting Materials -

![Graph showing properties of mounting materials at different mat temperatures.](image-url)
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Typical Effect of Substrate GSA

- Test Condition -

<Test Configuration>
- ULEV certified 2.3L gasoline engine
- Cold-Transient (Bag-1)
- Stabilized (Bag-2)
- Soak
- Hot-Transient (Bag-3)

@Test Mode>
- FTP-75 (US)

<table>
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<th>Speed (mile/hour)</th>
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<tr>
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<td>80</td>
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<table>
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<td>1500</td>
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<tr>
<td>2000</td>
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<tr>
<td>2500</td>
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Pd/Pt/Rh Catalyst
1.0 liter 106Dia.x114Lmm

O₂ Sensor

1100mm
Effect of Substrate GSA

Aging: max. 850 deg. C x 50hrs

TOTAL NMHC-Emissions, g/mile

TOTAL NOx Emissions, g/mile

GSA of Substrate, cm²/cm³

5/300 (Prototype)

6.5/400

3.5/600

4.3/600

5/300 (Prototype)

6.5/400

4.3/400

4.3/600

3.5/600
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<Test Configuration>
Secondary Air Injection

Close-Coupled Converter (0.69 liter)
- 6.5/400, 4.3/400, 4.3/600, 3.5/600
- Pd only Catalyst

Under-floor Converter (1.6 liter)
- 6/400

<Test Mode>
FTP-75 (US)

Graph showing speed vs. time for different test modes:
- Cold-Transient (Bag-1)
- Stabilized (Bag-2)
- Soak
- Hot-Transient (Bag-3)
**Effect of Substrate Bulk Density**

- **HC-Emissions (g/mile)**
  - **Total**
  - **Cold Start (Bag-1A)**

- **Bulk Density of C.C.Substrate (g/cm³)**
  - 0.2
  - 0.3
  - 0.4
  - 0.5

- **Concentration Levels**
  - 3/600
  - 4/400
  - 6/400

Graph showing the relationship between bulk density and HC-emissions.
**Emission Performance in MVEG-B**

*Test Condition*

Vehicle V8 Engine
Converter Configuration : Close Coupled + Underfloor
Cell structure : 6.5/400, 4.3/400 or 3.5/600 (CC)+ 4.3/400 (UF)
Aging : max. 930 deg.C

![Emission graph]

(SAE Paper # 1999-01-0272)
Influence of Catalyst Volume
- Test Condition -

<Test Configuration>
Secondary Air Injection

Close-Coupled Converter
(0.3-1.0 liter)
6.5/400, 4.3/600, 3.5/600

Under-floor Converter (1.7 liter)
6/400

<Test Mode>
FTP-75 (US)
Influence of Catalyst Volume

Total HC-Emissions (g/mile)

Volume of C.C Substrate (liters)

6.5/400
4.3/600
3.5/600

3.5/600 (0.59)
4.3/600 (0.7)
6.5/400 (1.0)
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Conclusions

♦ Thin wall and high cell density substrates, 4.3mil/400cpsi, 4.3mil/600cpsi, and 3.5mil/600cpsi, shows catalytic performance improvement.

♦ The effect of thin wall and high cell density is confirmed in not only FTP(US) but MVEG-B(EU).

♦ It is demonstrated the bulk density and geometric surface area are the significant factors for reduction of HC and NOx emissions.
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Effect of Hex. Cell on NOx Trap Catalyst

- Uniform thickness to improve Sulfur Desorption properties

NOx storage amount (mmol/cm³)

<table>
<thead>
<tr>
<th></th>
<th>Square</th>
<th>Hexagonal</th>
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</thead>
<tbody>
<tr>
<td>NOx storage performance after durability test</td>
<td></td>
<td></td>
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</tbody>
</table>

(SAE Paper 1999-01-1279)
Effect of Hexagonal Cell on TWC

- Relative Emissions Amount, %
  - THC
  - NOx

Emissions Amount

- Square
- Hexagonal

Test Mode: FTP-75

- ULEV certified
- 2.3Liter L-4 gasoline engine
- 1.0 liter 106Dia.x114Lmm

AECG 2004
Ceramic Substrate for Diesel-powered Vehicle

Oxidation Catalyst can convert SOF as particulate matter

Standard Cell Structure:
6mil/400cpsi, 8mil/300cpsi, 12mil/200cpsi
Porosity : 35%
Thank you for your Attention.