History of Fuel Tank Development

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MIZ

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1. Production of Motor Vehicles

**World Motor Production in 2014** [92,348,192 vehicles including Passenger car, Bus and Truck]

- **China**, 23,722,890, 26%
- **USA**, 11,660,699, 13%
- **Japan**, 9,774,665, 10%
- **Germany**, 5,907,548, 6%
- **South Korea**, 4,524,932, 5%
- **India**, 3,840,160, 4%
- **Mexico**, 3,365,306, 4%
- **Brazil**, 3,146,118, 3%
- **Spain**, 2,402,718, 3%
- **Branch**, 1,146,118, 3%
- **Canada**, 1,910,586, 2%
- **Germany**, 1,631,548, 1%
- **South Korea**, 1,524,392, 1%
- **Brazil**, 1,397,665, 1%
- **Canada**, 1,397,665, 1%
- **Others**, 21,609,006, 23%


1. Production of Motor Vehicles

**Ratio of Plastic Fuel Tank in total production**

- **Europe**: 95%+<sup>1)</sup>
- **US**: 90%<sup>1)</sup>
- **Asia**: 60%+<sup>1)</sup>
  - **China**: 67% in 2013, 80%+ by 2017<sup>2)</sup>
  - **Japan**: about 60%

1. Production of Motor Vehicles
Why Plastic Fuel Tank?

**Light weight**

“Average plastic tank weighs two-thirds less than an average steel tank”

1996 GMT600 passenger van,

**Steel**: 21.92 kg → **Plastic**: 14.07 kg

Environmental Protection Agency (EPA) comparison test


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**Corrosion Resistance**

Fuel tanks are regularly exposed to the corrosive action of their contents (fuel) and of other elements such as road chemicals, salt, mud, gravels, etc.

HDPE is highly resistant to corrosion.

1. Production of Motor Vehicles
Why Plastic Fuel Tank?

Design Freedom

It is possible to design fuel tanks that occupy all the space available around them increasing the fuel storage capacity of the car and allowing more space for the passenger compartment.


1. Production of Motor Vehicles
Why Plastic Fuel Tank?

Safety

Fuel tanks can bend and flatten rather than tear, rupture.

When a plastic fuel tank is exposed to fire, it is more likely to melt or decompose and allow the contents to flow out and add fuel to the fire. That reduces the risk of explosion and enhances the safety of the car.

2. Fuel Tank! Where are you?

Civic Hybrid underfloor


Here, I am!

2. Fuel Tank! Where are you?

Jeep Grand Cherokee and Jeep Liberty underfloor  Chevy Blazer, Chevy Tahoe and Ford Explorer underfloor

3. History

1960s  Ford: First prototype made of polyamide (PA)
1970s  VW Passat: First in serial production made of HDPE (monolayer fluorine treatment)
1980s  Multilayer (3 kinds 5 layer) made of HDPE+PA
1993   Toyota Supra: “Sellar” HDPE+PA in monolayer
1990s- Multilayer (4 kinds 6 layer) made of HDPE+EVOH


4. Technology development

Gasoline permeation prevention - Material

<table>
<thead>
<tr>
<th>O₂ Transmission Rates</th>
<th>[cc·20μ/m²·day·atm] @20°C Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVOH</td>
<td>0.1</td>
</tr>
<tr>
<td>PA6</td>
<td>76</td>
</tr>
<tr>
<td>HDPE</td>
<td>3,600</td>
</tr>
</tbody>
</table>

Gasoline permeation prevention performance of EVOH is more than 4,000 times of that of HDPE.

Source: 1) The Nippon Synthetic Chemical Industry Co., Ltd [link], 2) Kuraray Co. Ltd [link].
4. Technology development
Gasoline permeation prevention - Structure

Monolayer

- Inner surface treatment (Fluorination) after molding
- PA blend “Selar” by DuPont


4. Technology development
Gasoline permeation prevention - Structure

Multilayer

- 3 kinds 5 layer
- 4 kinds 6 layer

### 4. Technology development

#### Gasoline permeation prevention - Regulation

**Europe**

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Year</th>
<th>Level</th>
<th>Fuel</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>EURO 1</td>
<td>1993</td>
<td>20.0g/24hr</td>
<td>E0</td>
<td>Tank</td>
</tr>
<tr>
<td>EURO 2</td>
<td>1996</td>
<td>2.0g/1hr</td>
<td>E0</td>
<td>Vehicle</td>
</tr>
<tr>
<td>EURO 3</td>
<td>2000</td>
<td>2.0g/24hr</td>
<td>E0</td>
<td>Vehicle</td>
</tr>
<tr>
<td>EURO 4</td>
<td>2007</td>
<td>2.0g/24hr</td>
<td>E0</td>
<td>Vehicle</td>
</tr>
<tr>
<td>EURO 5</td>
<td>2009</td>
<td>2.0g/24hr</td>
<td>E5</td>
<td>Vehicle</td>
</tr>
</tbody>
</table>

*<Note> Fuel E0: No ethanol mixed  Fuel E5: 5vol% ethanol mixed*

**US**

**CARB: California Air Resources Board**

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Year</th>
<th>Level</th>
<th>Fuel</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEV 1</td>
<td>1994</td>
<td>2.0g/hr</td>
<td>E0</td>
<td>Vehicle</td>
</tr>
<tr>
<td>LEV 2</td>
<td>2004</td>
<td>0.5g/hr</td>
<td>E0</td>
<td>Vehicle</td>
</tr>
<tr>
<td>P-ZEV</td>
<td>2005</td>
<td>0.054g/24hr</td>
<td>E0</td>
<td>Fuel System</td>
</tr>
</tbody>
</table>

*<Note> LEV: Low Emission Vehicle,  P-ZEV: Partial Zero Emission Vehicle*
4. Technology development
Operation - Material

**Suitable Operation Temperature [°C]**

- **EVOH**
  - 200 - 235

- **PA6**
  - 230 - 240

- **HDPE**
  - 190 - 230

Combination of HDPE and PA needs compromise.

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4. Technology development
Product design

1. **Development of Resin Materials**
   - Improve permeation suppressing performance by reducing the amount of EVOH ethylene served as a barrier layer and increasing the ratio of vinyl alcohol.

2. **Development of Component Parts**
   - Realize low permeation by forming component parts welded to tanks with a low permeation material and a denatured HDPE material.

3. **Development of Sealing Structure**
   - Improve sealing performance and low permeability by changing the materials of packing and locknut.

4. **Optimization of Pinch-off Shape in Blow Molding**
   - Replace permeation from the pinch part by improving the same part.

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4. Technology development
Process – Monolayer

- Blow molding machine
- Extruder
- Grinder
- HDPE
- PA
- CB

(Incase of “Selar”)

Followed by fluorination incase of simple monolayer

4. Technology development
Process – Multilayer 3 kinds 5 layer

- Blow molding machine
- Extruder
- Crusher
- Pelletizer
- Pelletized flash
- Denatured PE
- PA
- HDPE

Followed by fluorination incase of simple multilayer
4. Technology development
Process – Multilayer 4 kinds 6 layer

5. Supply chain
Car manufacturer

Source: FTS CO.,LTD. http://www.fts-com.co.jp/g/flow.php
Summary

Development of Plastic Fuel Tank stands on the technology to control the gasoline permeation complying with the regulations.