Future Perspectives
of Flexfuel Vehicles in Brazil

ANFAVEA
Brazilian Automobile Manufacturers Association
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The Flexfuel Vehicles

- The Flexfuel Vehicles were introduced in 2003 at the Brazilian market and 4 car manufacturers (at least, by now) are locally producing them;
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The Flexfuel Vehicles are designed to be indistinctly fueled with gasoline, ethylic alcohol or any blend of these two fuels:
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*Through some special electronic sensors, the on-board computer recognizes the fuel kind and properly adjust the engine combustion parameters to that fuel, without any necessity of interference from the driver.*
The meaning of the Flexfuel Vehicles for the customers is the possibility of choosing the fuel they want, according to the price, quality, performance characteristics or even availability, at each refueling;
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These vehicles are the technical evolution of ethanol fueled models, sold at the Brazilian market since 1979, due to the PROALCOHOL.
The Brazilian Ethanol Fuel Program:

Adopted in 1975 by Brazilian government, due to the international oil crisis, aiming two applications:

1) to introduce the blend of gasoline with ethanol (gasohol) in the market;

2) to incentive the development of pure ethanol fueled vehicles.

Why Ethanol?

– Brazil is a great sugar and ethanol producer since Century XVI;
– In the time of World War II ethanol was used as vehicular fuel in Brazil, blended with gasoline, with good results.
In order to support the alcohol program, in 1976 the vehicle manufacturers and the Brazilian Government have signed an “Memorandum of Understanding” to produce ethanol fueled cars;

Once, at that time, there was not enough international experience available on ethanol fuel, the manufacturers have decided to develop this model in Brazil;

The first alcohol car prototype was run in 1977;

In 1979 the first alcohol model vehicle was sold.
The Governmental policy to PROALCOHOL

In 1978, the Brazilian Government adopted some financial measures to incentive the use of ethanol fuel, by the customers:

- Guarantee for ethanol fuel price ($\leq 65\%$ of gasoline price);
  
  (both prices were controlled by the government)

- Tax reduction (- 5%) for alcohol fueled vehicles;

- Subsided loans for ethanol producers to improve capacity;

- Obligatoriness for fuel stations to sell ethanol fuel (all over the country);

- Maintenance of ethanol fuel stocks to guarantee the supply and price.
Light Vehicles in the Brazilian Market

1979 to 1990

Source: ANFAVEA
At the end of 80’s:

- Due to economical difficulties, the government started to remove the ethanol fuel subsides and the price became closer of gasoline price;
- The official loans to producers were drastically reduced;
- The international sugar price increased and many alcohol producers decided to make sugar instead of ethanol, causing an alcohol supply shortage;
- The ethanol reserves were quickly drained off;
- The sales of new alcohol fueled vehicles fall and the retail value of the used alcohol cars became null and void.
Light Vehicles in the Brazilian Market

1979 to 2002

Units (x 1,000)

Source: ANFAVEA
Light Vehicles in the Brazilian Market

1979 to 2002

Subsides reduction; Alcohol price rising; Alcohol shortage.

Units (x 1,000)

Source: ANFAVEA
Light Vehicles in the Brazilian Market

- From 1979 to 1990:
  - Sales: 8,263,450 units
    - Alcohol: 4,606,728 units (55.8%)
    - Gasoline: 3,656,722 units (44.2%)

- From 1991 to 2002:
  - Sales: 13,547,318 units
    - Alcohol: 898,486 units (6.6%)
    - Gasoline: 12,648,832 units (93.4%)

- From 1979 to 2002:
  - Sales: 21,810,768 units
    - Alcohol: 5,505,214 units (25.2%)
    - Gasoline: 16,305,554 units (74.8%)
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The Alcohol return

From the 2nd half of 90’s on:

- The ethanol supply became normalized;
- The ethanol price have stabilized at low levels (½ of gasoline price);
- The Brazilian automobile industry continued to offer alcohol cars;
- The international press started to valorize the renewable fuels;
- The clime changes became a matter of big concern;
- The Kyoto Protocol was issued;
- Many papers brought out the environmental advantages of ethanol.
Alcohol Vehicles in the Brazilian Market

1.224

10.947

10.292

18.335

55.961

Source: ANFAVEA
Necessary Engine & Vehicle Modifications due to the Ethanol Fuel Application
Main Concerns Related to Ethanol Fuel

- Corrosion of metallic materials
- Chemical attack to the plastic materials
- Low molecular energy content
- Different air / fuel ratio for combustion
- Low vapor pressure
For 20 ~ 25% blend
For 20 ~ 25% blend

**Carburetor**
The material of the carburetor body or carburetor cover cannot be aluminum or exposed Zamak; if it is, must be substituted, protect with surface treatment or anodize; Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

**Electronic Fuel Injection**
Substitution of fuel injector material by stainless steel; New fuel injector design to improve the “fuel spray”; New calibration of air-fuel ratio control and new Lambda Sensor working range; Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

**Fuel Pump**
The internal surface of pump body and winding must be protected and the connectors sealed; Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

**Fuel Pressure Device**
The internal surface of the fuel pressure device must be protected; Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

**Fuel Filter**
The internal surface of the filter must be protected; The adhesive of the filter element must be appropriated.

**Fuel Tank**
If the vehicle fuel tank is metallic, the internal surface of tank must be protected (coated); Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

**Catalytic Converter**
It is possible to change the kind and amount of noble metal present in the loading and wash coating.

**Ignition System**
New calibration of ignition advance control.

**Evaporative Emission System**
The purge airflow of canister (activate charcoal filter) must be higher.
### For 100% Ethanol Fuel

**Carburetor**
- The material of the carburetor body or carburetor cover cannot be aluminum or exposed Zamak; if it is, must be substituted, protect with surface treatment or anodize;
- Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected;
- The material of buoy, nozzle, metering jet, floating axle, seals, gaskets and o-rings must be appropriated.

**Electronic Fuel Injection**
- Substitution of fuel injector material by stainless steel;
- New fuel injector design to improve the “fuel spray”;
- New calibration of air-fuel ratio control and new Lambda Sensor working range;
- Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected.

**Fuel Pump**
- The internal surface of pump body and winding must be protected and the connectors sealed;
- Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected;
- The pump working pressure must be increased.

**Fuel Pressure Device**
- The internal surface of the fuel pressure device must be protected;
- Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected;
- The fuel pressure must be increased.

**Fuel Filter**
- The internal surface of the filter must be protected;
- The adhesive of the filter element must be appropriated;
- The filter element porosity must be adjusted.

**Engine**
- The engine compression ratio should be higher;
- Camshaft with new cam profile and new phase;
- New surface material of valves (intake and exhaust) and valve seats.

**Intake Manifold**
- With new profile and less internal rugosity, to increase the air flow;
- Must provide higher intake air temperature.

**Fuel Tank**
- If the vehicle fuel tank is metallic, the internal surface of tank must be protected (coated);
- Any component in polyamide 6.6 (Nylon) that has contact with the fuel must be substituted by other material or protected;
- Higher fuel tank capacity, due to the higher fuel consumption.

**Catalytic Converter**
- It is possible to change the kind and amount of noble metal present in the loading and wash-coating of catalyst converter;
- The catalyst converter must be placed closer to the exhaust manifold, in order to speed up the working temperature achievement (light-off).

**Exhaust Pipe**
- The internal surface of pipe must be protected (coated);
- The exhaust design must be compatible with higher amount vapor.

**Suspension**
- Adjusted to the higher vehicle weight.

**Motor Oil**
- New additive package.

**Cold Start System**
- Auxiliary gasoline assisted start system, with temperature sensor, gasoline reservoir, extra fuel injector and fuel pump;
- The vehicle battery must have higher capacity.
Ethanol Engine: Relative Performance

- Power
- Torque
- Max Speed
- Acc Time (0~100 km/h)
- Consumption (L/100km)

**Options:**
- Gasoline 0%
- Gasohol 22%
- Ethanol 100%
Ethanol Engine: Relative Performance

- Power: 103.3% Gasoline 0%, 110.0% Gasohol 22%, 103.2% Ethanol 100%
- Torque: 102.1% Gasoline 0%, 106.4% Gasohol 22%, 105.3% Ethanol 100%
- Max Speed: 103.2% Gasoline 0%, 105.3% Gasohol 22%, 103.2% Ethanol 100%
- Acc Time (0~100 km/h): Gasoline 0%, Gasohol 22%, Ethanol 100%
- Consumption (L/100km): Gasoline 0%, Gasohol 22%, Ethanol 100%
Ethanol Engine: Relative Performance

- Power: Gasoline 103.3%, Gasohol 102.1%, Ethanol 103.2%
- Torque: Gasoline 110.0%, Gasohol 106.4%, Ethanol 105.3%
- Max Speed: Gasoline 95.5%, Gasohol 89.3%
- Acc Time (0~100 km/h): Gasoline 100%, Gasohol 98.2%, Ethanol 96.2%
- Consumption (L/100km): Gasoline 89.3%, Gasohol 83.5%, Ethanol 79.2%
Comparative Exhaust Emission

Before Catalyst Converter

- CO
- HC
- NOx

- Gasoline 0%
- Gasohol 22%
- Ethanol 100%
Comparative Exhaust Emission

Before Catalyst Converter

After Catalyst Converter

- CO
- HC
- NOx

Gasoline 0%
Gasohol 22%
Ethanol 100%

0%
22%
100%
Comparative HC Emission Profile

Ozone Formation Reactivity Increasing
(according to: D.J. Patterson & N.A. Henein)
CO_{2} Emission (Greenhouse Effect)

FOSSIL FUELS
CO$_2$ Emission (Greenhouse Effect)

FOSSIL FUELS
CO₂ Emission (Greenhouse Effect)

FOSSIL FUELS
CO₂ Emission (Greenhouse Effect)

FOSSIL FUELS

CO₂
CO$_2$ Emission (Greenhouse Effect)

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CO$_2$ Emissions (Greenhouse Effect)

RENEWABLE FUELS
CO₂ Emission (Greenhouse Effect)

RENEWABLE FUELS

CO₂
CO$_2$ Emission (Greenhouse Effect)

RENEWABLE FUELS
CO$_2$ Emission (Greenhouse Effect)

RENEWABLE FUELS
Flexible Fuel Vehicles
March, 2003: Introducing of Flexible Fuel Vehicles

VW GOL Total Flex
Fuel Blend Recognition System

- Reservatório de gasolina para partidas a frio
- Canister
- Bomba elétrica de combustível
- Válvula solenoide
- Válvula de Fuga do canister
- Vela de ignição
- Bobina
- Sonda Lambda
- Pré-catalisador
- Sensor de fase
- Sensor de detonação
- Sensor de rotação
- Galeria de combustível / válvula de injeção
- Módulo de Bomba de combustível em tanque
- Sensor de pressão / temperatura do ar

Módulo de controle
Performance Comparison

![Performance Comparison Graph]

**Gasohol.**

**Ethanol.**

TORQUE [Nm]

POWER [kW]

1000 RPM
Sales: Alcohol x Flexfuel
Jan, 2003 to Aug, 2004

Jan/03 Feb/03 Mar/03 Apr/03 May/03 Jun/03 Jul/03 Aug/03
0  5,000  10,000  15,000  20,000  25,000  30,000  35,000  40,000

Alcohol
Flex Fuel
Sales: Alcohol x Flexfuel x Gasohol

Jan, 2003 to Aug, 2004
Other Vehicle Manufacturers

DAIMLERCHRYSLER

HONDA

NISSAN

TOYOTA

VOLVO

RENAULT

PSA PEUGEOT CITROËN

AUDI

MITSUBISHI MOTORS
Future Perspectives for the Flexfuel

Sectorial Chamber of Sugar & Alcohol:

- Agriculture & Breeding Ministry
- Energy Ministry
- Industry Development Ministry
- Economy Ministry
- Planning Ministry
- Automobile Manufacturers Association
- Auto part Manufacturers Association
- PETROBRAS
- Fuel Distributors Association
- Alcohol & Sugar Producers Association
Future Perspectives for the Flexfuel

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December 2003
Alcohol Demand Study
2004 ~ 2010
Brazilian Light Vehicles Fleet Forecast

- Gasohol
- Alcohol
- Flex Fuel
Thank you

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