MULTIFUEL ENGINE PERFORMANCE, EMISSIONS AND COMBUSTION USING ANHYDROUS AND HYDROUS ETHANOL

2012-36-0475

Authors:
Antonio Villela
Guilherme Machado
PETROBRAS/CENPES

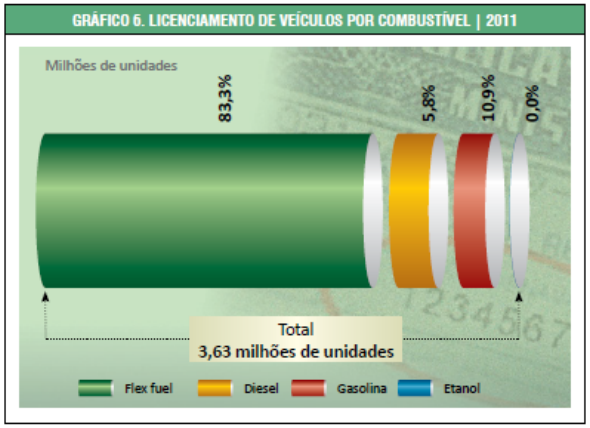
PETROBRAS

SUMMARY

INTRODUCTION

Brazilian light-duty automotive fleet

→ **multifuel engines efficiency**



Ethanol production plants

→ **product availability**

Ethanol specification

→ **water content: Anhydrous x Hydrous**

Combustion studies

→ **knowledge on fuel performance in engines**

FUELS

Anhydrous Ethanol – E100

→ blended to gasoline type C between 18%v and 25%v

→ up to 0,5%m water content

Hydrous ethanol – H100

→ available at service stations

→ up to 7%m water content

Parameter	Unit	E100	H100
RON*	-	106	110
MON*	-	89	92
Net heating Value	MJ/kg	26.2	24.9
Density 20°C	kg/m³	791.5	808.4
Ethanol content 20°C	°INPM	99.3	93.5
Stoichmetric A/F ratio*	-	8.918	8.702

*typical values

EXPERIMENTAL APPARATUS

FIAT 1.4L Tetrafuel engine at automated test bench

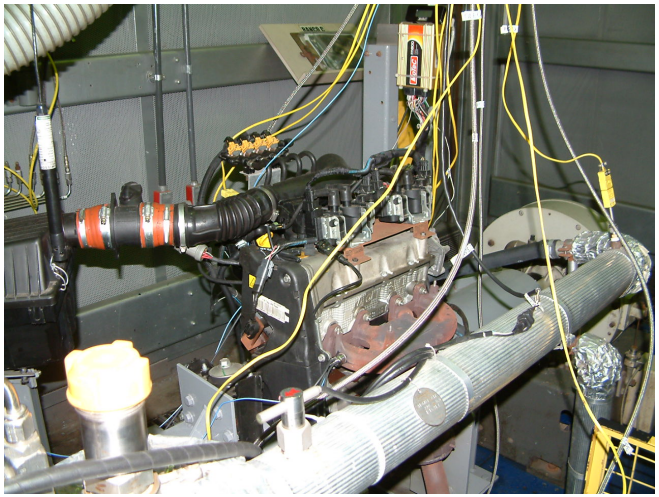
Programmable electronic central unit (PECU)

Intake air conditioning device

Fuel temperature conditioning and fuel flow measurement device

In-cylinder pressure measurement and combustion analysis

Adapted vehicle on-board emissions measurement system



TEST METHODOLOGY

Test point

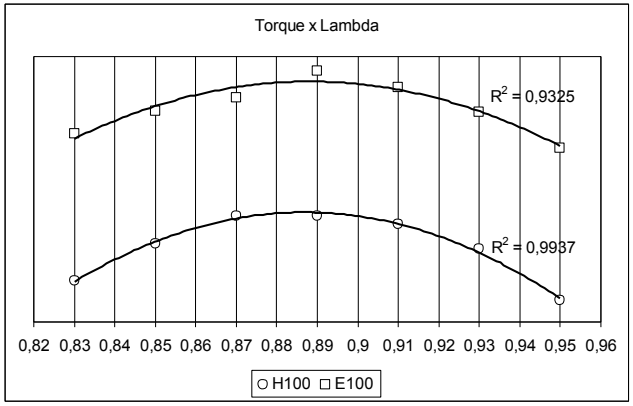
→ **max power: 5500rpm, 100% load.**

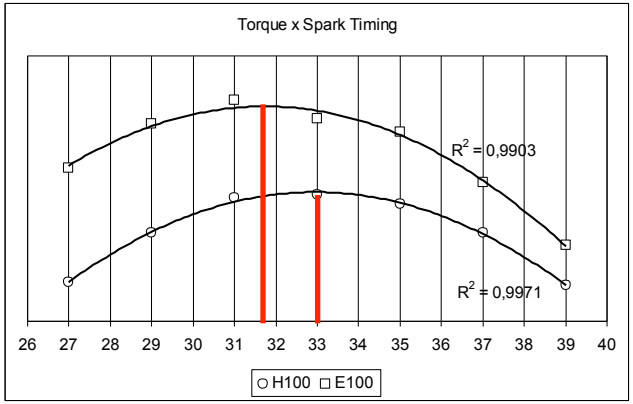
Lambda and spark timing optimized, through PECU

→ **MBT- Minimum spark timing for best torque**

Measurements

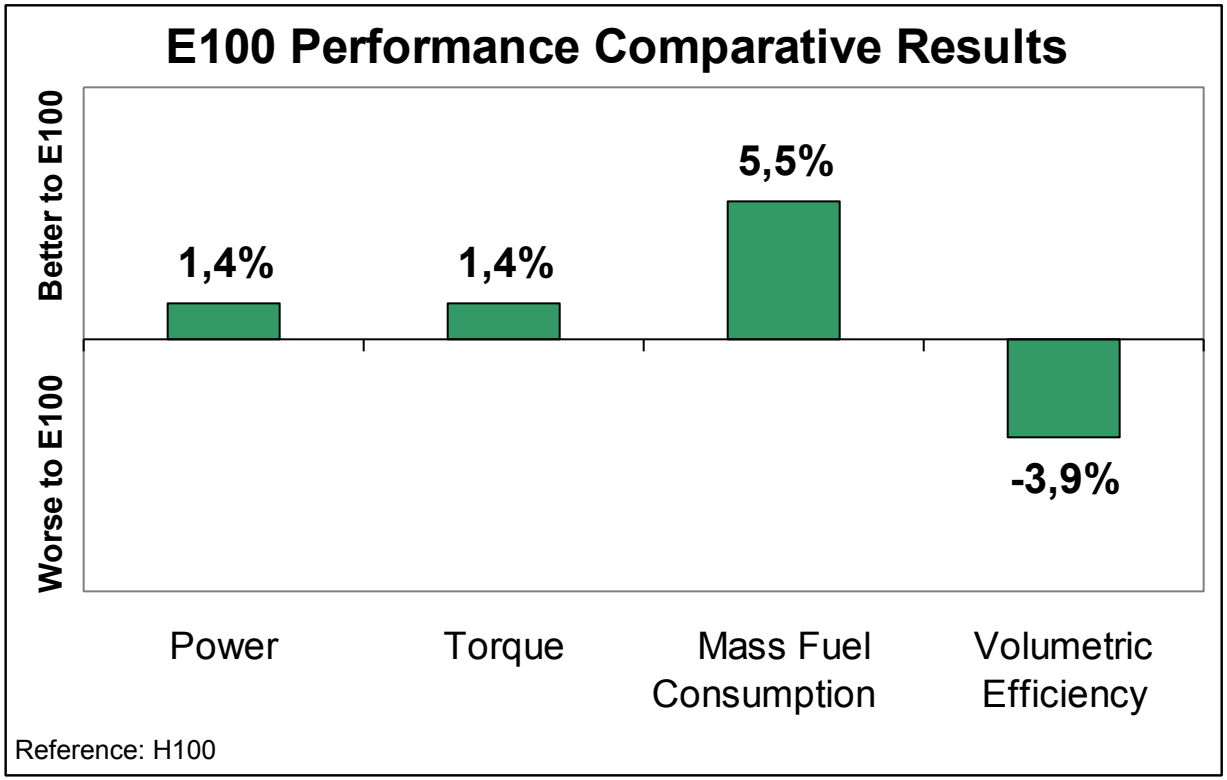
→ **torque**
→ **power**
→ **fuel consumption**
→ **Emissions (THC, CO, NOx and CO_2)**
→ **In-cylinder pressure**





Fuel	Operating Point	ST (°BTDC)	Lambda
E100	Max Power	31,7	0,89
H100	Max Power	33	0,89

RESULTS - Performance

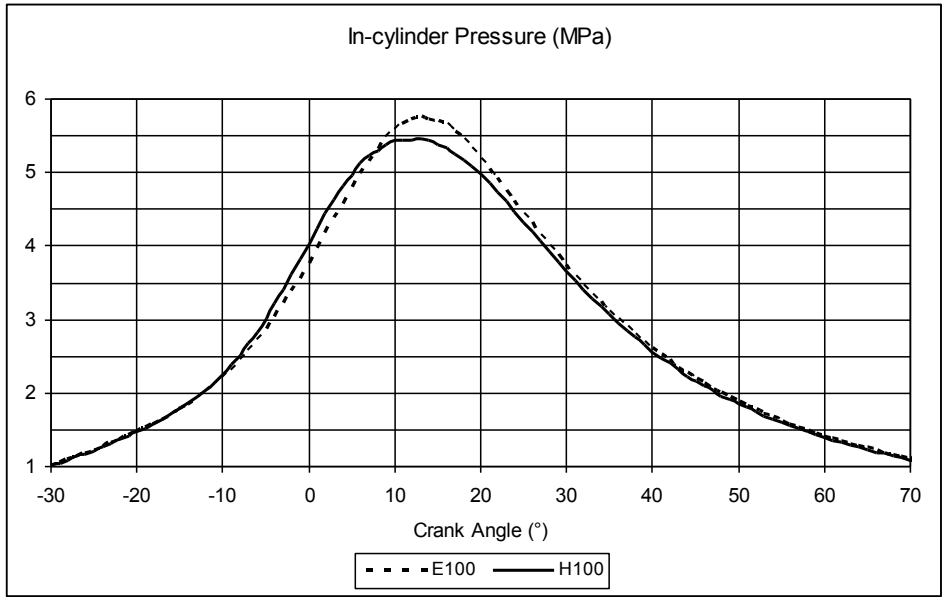


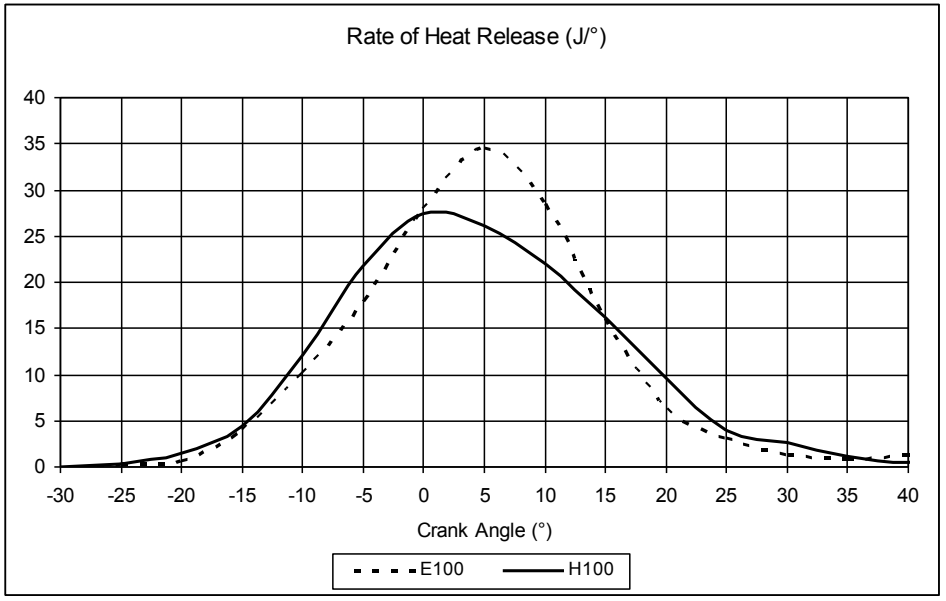
Fuel	E100	H100
Power (kW)	52,9	52,2
Torque (Nm)	91,9	90,6
Mass Fuel Consumption (kg/h)	25,2	26,7
Volumetric Efficiency	74,00	77,00

Mean of at least 3 measurements

Percent differences are statistically significant

RESULTS – explaining….E100 better power



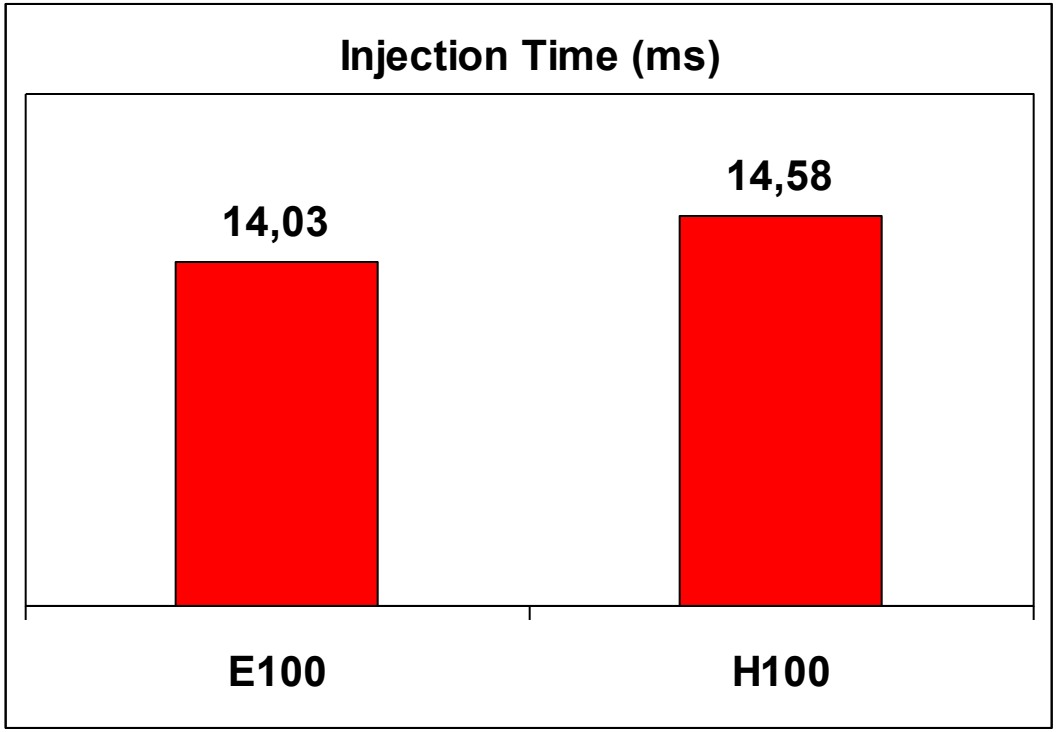


Fuel	E100	H100
Spark Timing (1)	-31,7°	-33,0°
10% MFB (2)	-5,4°	-7,9°
90% MFB (3)	21,8°	23,8°
Combustion Duration (3)-(2)	27,2°	31,7°

E100 burns faster → later spark timing and shorter combustion duration

E100 lower water content contributes to increase combustion efficiency

RESULTS – explaining…E100 better mass fuel consumption



To ensure the same lambda (0,89), engine injects less E100

→ E100 higher stoichmetric air-fuel ratio

RESULTS – explaining…H100 better volumetric efficiency

H100 higher water content.

Water

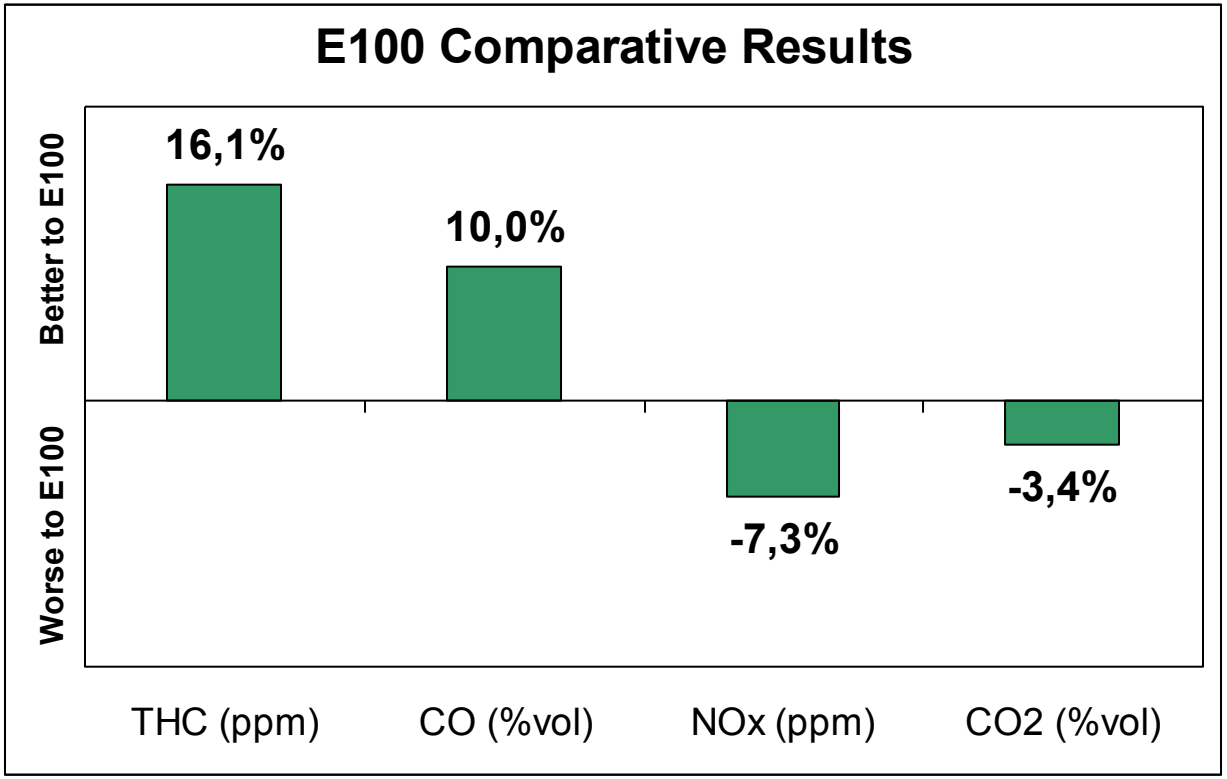
- → **Latent heat of vaporization higher than ethanol**
- → **Requires more energy to vaporize**
- → **Absorbs more heat from surroundings**
- → **Causes air-fuel mixture temperature reduction**

Air density increases

Greater air mass flows into the cylinder

It was not sufficient to obtain higher power

RESULTS- Emissions

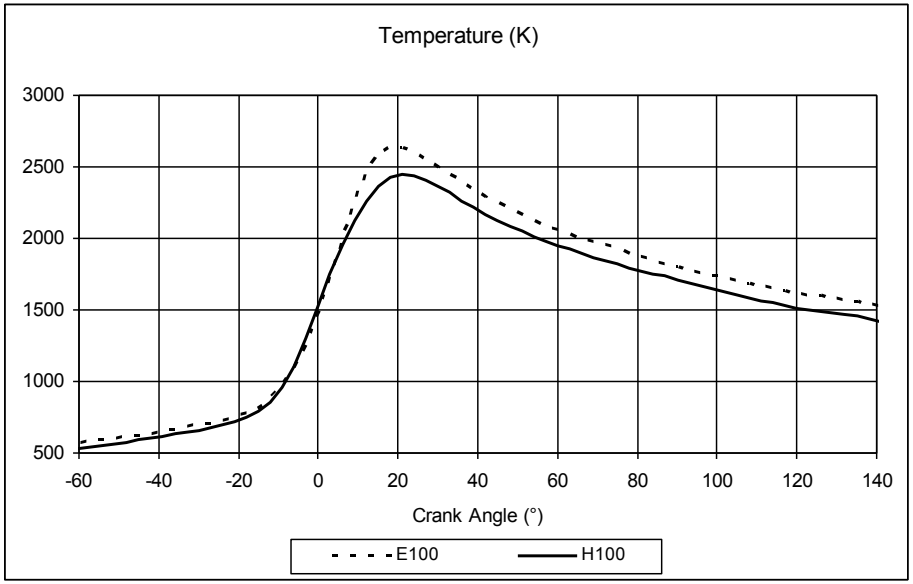


Fuel	E100	H100
THC/10 (ppm)	163,10	194,50
COx100 (%vol)	279,90	311,10
NOx/10 (ppm)	97,00	93,79
CO_2x10 (%vol)	100,00	93,20

Mean of at least 3 results

Percent differences are statistically significant

RESULTS- explaining…THC and CO reduction and NOx increase with E100



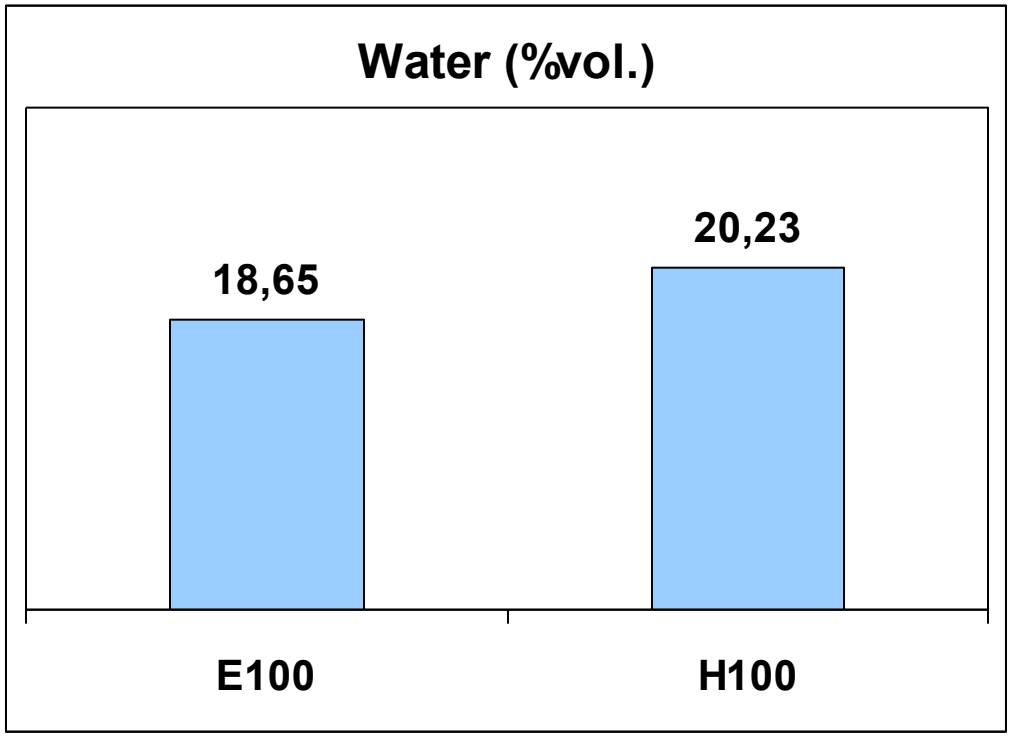
E100 lower water content

→Higher ROHR

→Higher combustion efficiency →diminishes THC and CO emissions

→Higher temperatures → favors NOx formation

RESULTS- explaining…CO_2 increase with E100



E100 lower water proportion (%v.) in exhaust gases

E100 slightly higher carbon fraction

E100 lower CO results

CONCLUSION – Summary of results

E100 higher in-cylinder pressure levels, shorter combustion duration and higher ROHR → slightly higher torque (1,4%)

E100 5,5% lower mass fuel consumption → higher stoichmetric air-fuel ratio

E100 3,9% lower volumetric efficiency → H100 higher latent heat of vaporization increased mass flow into the cylinder

THC and CO emissions decreased respectively 16,1% and 10% with E100, mainly due to higher combustion efficiency with this fuel

E100 higher temperature during combustion contributed for 7,3% lower NOx emissions

CO2 increase of 3,4% using E100 can be explained by its lower water content, slightly higher carbon fraction and higher CO level in exhaust gases

CONCLUSION

Combustion study was helpful in E100 x H100 performance, fuel consumption and emission analysis in engine

Results showed E100 better results with no operational problems to the engine

MULTIFUEL ENGINE PERFORMANCE, EMISSIONS AND COMBUSTION USING ANHYDROUS AND HYDROUS ETHANOL

THANK YOU!

Antonio Villela

antonio.villela@petrobras.com.br

PETROBRAS