amap University of Sunderland
automotive & manufacturing advanced practice

HyTrEc
Hydrogen Transport Economy for the North Sea Region

HyTrEc Mixed Fuel Demonstrator Report

European Union The European Regional Development Fund

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region

AMAP, University of Sunderland & Gateshead College 18th May 2015

Background

As part of the HyTrEc project it was agreed to develop a demonstration vehicle that would highlight the advantages of mixing hydrogen into the fuel stream of a petrol engined vehicle. A few years previously AMAP had developed a low cost dual fuel vehicle that allowed a petrol ICE powered vehicle to run on either petrol or hydrogen. This work would take this knowledge and develop a truly mixed fuel solution that was anticipated would reduce emissions considerably and take advantage of the considerable development history and investment made in internal combustion engine technology. In addition the team aimed to develop a low cost adaptation that would allow all types of hydrogen regardless of purity to be used in transport applications without increasing emissions.

The Vehicle

The vehicle chosen was a Nissan Qashqai, LHD 2011 Model year, 1.6 petrol with 5 speed Manual Transmission. It produces 115 BHP and has a quoted average fuel consumption of 42 mpg from a 65 litre tank.

The conversion

An off the shelf CNG conversion kit was adapted to operate with hydrogen. This was chosen due to the similarities between CNG and Hydrogen (as opposed to LNG) and to keep costs as low as possible. This was coupled to a Dynetek DyneCell Cylinder, Model: V074H350X8N 74L (1.79 kg (@ 350bar) 350Bar (5075 PSI) Hydrogen storage tank and a Dynetek BV351 Hydrogen solenoid valve. Some issues regarding the voltage of the new injectors were overcome by using a separate supply for the additional injectors.

Standard safety features are implemented in the valve such as thermal and PRD. In addition the permanent live which powers the tank and the CNG kit is taken from the fuel pump line ensuring shut-down in case of an accident.

A relay controlled by a hydrogen sensor (HydroKnowz sensor) is placed in line with the ECU signal: warning with sound and light if a gas leak is detected and interrupts the permanent live closing the valve.

The power for the hydrogen sensor comes from the permanent live. The ECU will take 30 seconds to start before it will switch the tank valve. During this period the H2 sensor can start up and prevent valve operation in case of a leak. The sensors relay is normally open, which means that as long as it is not active yet the valve will not receive a switch signal.

An excess flow valve is installed in the output from the tank, which closes if an open tube occurs (and the flow increases above a certain value).

Filling is achieved via a WEH TN1 receptacle coupled to a TK16 H2 (350bar) Filling nozzle with hose set which connected up to a L800 – 172 Bar regulator connected directly to a K cylinder or Manifold Cylinder Pack (MCP).

Testing

The vehicle was set up and calibrated prior to being tested on the Gateshead College Performance Test Track. This allowed the team to evaluate different hydrogen mixes and select the most suitable ones for emissions testing. During these tests the vehicle was subjected to hill starts, high speed running and even a bird strike!

Once the road evaluation was completed the vehicle was transported to Gateshead College's Automotive Centre of Excellence where it was placed on a rolling road for emissions testing using a standard MOT exhaust analyser. Prior to the test work an oil

sample was taken an this was compared with a sample taken after approx 200 miles of running.

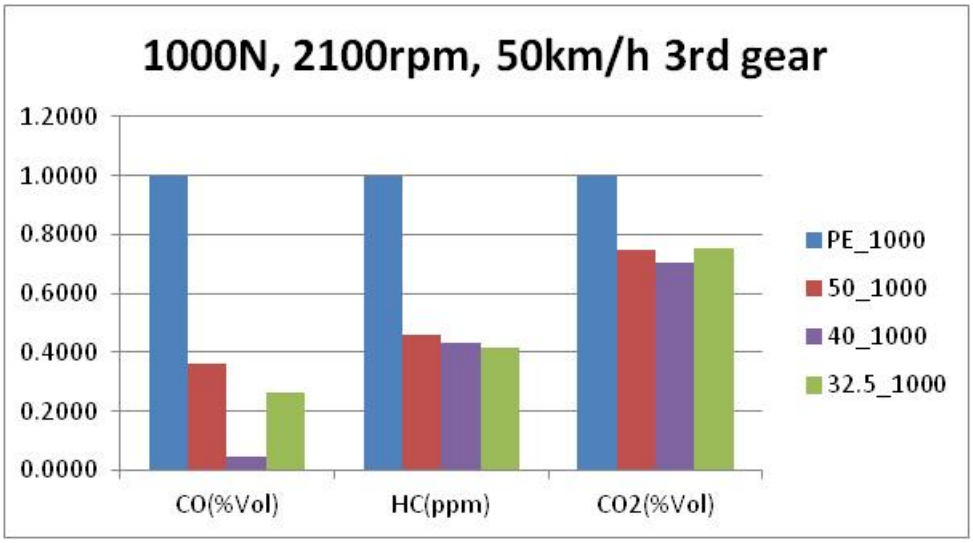

Figure 1: the results for different fuel mixes at 2100RPM indicates that a 40% hydrogen/petrol mix seems optimum.

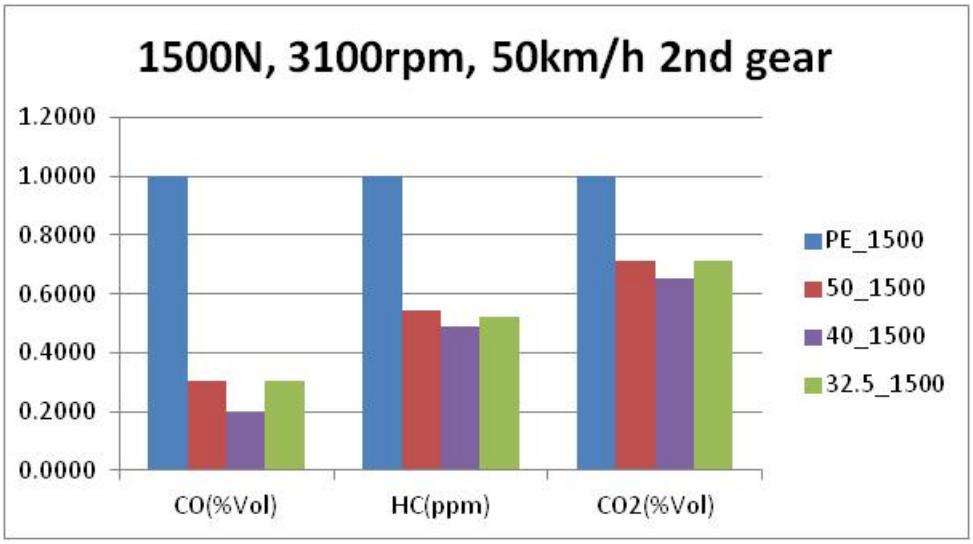

Figure 2: the results for 3100RPM appear to confirm that the optimum mix is 40% hydrogen.

As a result of the experimentation it is estimated that mixing hydrogen into a petrol fuel stream at percentages between 32% and 50% will reduce emissions by the following amounts on average:

- CO_2 29% by volume
- CO 75% by volume
- Hydrocarbons by 52% (ppm)

Additional improvements are estimated as follows:

- Fuel consumption improves from 42 MPG to 57MPG
    - Based on 208 miles from 16.25 litres (est)
    - Giving a range of 823 miles per tank of petrol
- Hydrogen tank range is estimated at 120 miles/Kg (at 50/50 mix) or
- 167 miles per 1.74 Kg tank
    - More than enough to carry out deliveries around a city during one day.
- No detectable change was found in the engine oil
    - Very low mileage has to be taken into account

Costs

Component	**Price GB£ excluding VAT**
Conversion (including labour)	2119
Tank + Valve	4200
Hydrogen Sensor	150
Electronics	100
Tubing and valves	561
Receptacle	180
Total	**7310**

Conclusions

Mixing hydrogen into the fuel stream dramatically improves emissions performance and range per tank of fuel. This is important not only for environmental reasons but because this element of the fuel stream is the most heavily taxed.

Adding more hydrogen into the fuel stream may not improve matters further and indeed the optimum may be around the 35% to 40% area. More testing will be required to establish this.

The cost of the conversion suggests that this may prove a suitable conversion for urban petrol powered delivery vehicles and may breathe new life into the ICE.