IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 16, Issue 4 Ser. IV (Jul. - Aug. 2019), PP 17-20
www.iosrjournals.org

Analysis of the Impact on Petrol ECU Adaptation Parameters in a CNG Powered Vehicle on the Level of Exhaust Emissions.

Marcin Dziewiątkowski
(Technical Manager of Research and Development Center , AC SA, Poland)
Corresponding Author: Marcin Dziewiątkowski

Abstract: *Currently, in many countries, where the conversion of combustion vehicles into alternative gas fuel is economically justified, the dominance is the installation of CNG fuel supply systems. Today, according to official data, around 20 million vehicles fueled with this fuel travel on roads around the world, according to figures. This number has doubled in the last 10 years[1]. In the light of the upward trend in conversions, more attention should be paid to the level of exhaust emissions of these vehicles. In the case of conversion of vehicles with a gasoline engine controlled sequentially by the engine computer, it is possible to adapt the parameters of this computer in various driving cycles, affecting the changes in vehicle emissions from the initial settings of this system. The analysis carried out in these tests indicates that with the passage of time of adaptation of engine control parameters, the level of exhaust emissions of the tested vehicle also changes. The article also suggests counteracting this process by reducing the process of adapting the petrol controller parameters by emulating the lambda probe signal and performing a series of exhaust gas repeatability tests, demonstrating the legitimacy of using this solution*

Date of Submission: 16-08-2019 Date of Acceptance: 31-08-2019

I. Introduction

As part of the work carried out on the development of the installation controller for the conversion of internal combustion engines, I observed the phenomenon of unstable vehicle emissions. Based on the fuel dose adjustment data received from the vehicle manufacturer, I concluded that the gasoline controller while driving made changes in the adaptation of parameters related to correction, derived from the analysis of the voltage course of the lambda probe s2 located behind the exhaust gas catalyst. In each subsequent emission measurement cycle, the fuel dose correction parameter increased its value, influencing the extension of the injection time in certain areas of the fuel map, resulting in enrichment of the mixture. This enrichment process directly influenced the signal path of the s1 (control) lambda probe located in front of the catalyst, which triggered the integrator of the first lambda probe to lean the mixture. This process in transient states of the exhaust emission measurement cycle causes changes in the exhaust emission level affecting the final emission result by increasing the content of nitrogen oxides and hydrocarbon compounds by up to 100% compared to the initial controller settings. In order to avoid this phenomenon, the lambda probe signal was emulated, the phenomenon of negative adaptation of the petrol controller was eliminated by selecting the appropriate signal emulation values.

II. Material And Methods

The research process was carried out on the basis of the Hyundai model i20 vehicle manufactured in May 2018, I have a combustion engine with a capacity of 1248 cc, with a maximum power of 86 HP at 6000 rpm and a maximum torque of 122 Nm achieved at 4000 rpm. According to the manufacturer's data, the vehicle is classified in the Euro 6 emissions standard. By default, the engine is powered by RON 95 unleaded petrol and is equipped with a 5-speed mechanical gearbox. The subject of the research was converted into an alternative fuel supply in the form of compressed natural gas (CNG). The vehicle mileage on the test day was 1080km.

Components used for conversion :
1. GAS ECU brand: STAG , model QNEXT PLUS
2. GAS injectors brand: Matrix , model HD344
3. Pressure reducer brand: STAG , model R14
4. Cylindrical tank brand: Elpigas

The measuring devices used in the study are:

a) MAHA exhaust mission tester, model MET 6.3

Date of certified calibration of the measuring device: 04-02-2019

device parameters:

- gas analyzer and opacimeter / particle measurement device in a high-quality synthetic casing - Steel mesh emission probe, 600 mm, 2000 mm probe tubing in LAN interface with LAN cable (RJ 45) in Power supply unit 110V - 230V, 50 / 60Hz at Transparent drain hose for condensed water with collecting tank at Main filter,

-zero filter and condensate filter at Electrochemical O2 sensor at Trigger tongs for MET for inductive RPM measurement at ignition cables at 2 replacement filters,

-2 replacement seals at Measurement software for continuous measurement and control of MET without country-specific test proceed

The tester gives the opportunity to measure the exhaust emissions of vehicles with gasoline and gas fuel both LPG and CNG.

The final results obtained after the end of the test are presented in units of g / km of individual measured exhaust gases. For the tests, the possibility of measuring the level of HC, CO and NOx gas

b) ETAS software, model INCA 7.0

It is software that enables the reading of internal parameters of a petrol controller and the analysis of these parameters based on their course in real time as well as their recording and subsequent analysis as recorded data.

For the described tests, we use the program function described by the manufacturer as:

Measurement data acquisition, acquisition and online display of measurement values, calibration parameters (scalars, characteristic curves / diagrams), numerous trigger options, online calculation and representation of derived signals, ECU storage dump in hex and physical representation

c) Interpid brand communication interface, ValuCAN3 model.

It is a digital module that enables communication via a USB protocol of a PC with vehicles equipped with OBDI / OBDII and a diagnostic socket.

For the Hyundai i20 tested, we use CAN-XCP communication.

d) Chassis dynamometer by Maha, model LPS-3000.

To measure exhaust emissions, a dynamometer function was used, called by the manufacturer driving simulation. Driving simulation is also called road simulation and is used to map the conditions existing on the road at the bench (also flat sections and no wind). All draft force components such as rolling resistance, air resistance, climb resistance and measuring components are included here. Regulation and automatic loss compensation are available here from 0 km / h up to rated speed. The test in Driving Simulation mode is carried out motorically and generically. Using the Maha software, a set of vehicle parameters such as vehicle mass, air resistance coefficient, rolling resistance coefficient, step resistance coefficient was introduced to the dynamometer controller. The dynamometer has an additional NEDC driving cycle that has been used to measure exhaust emissions.

The measurement process carried out in the tests was in accordance with the Euro 6 regulation, the measurement conditions were carried out at an ambient temperature between 20-23`C (the regulation is 25`C +/- 5`C). Each emission measurement was performed after at least 6 hours of conditioning the vehicle. During each emission measurement, a PC with INCA 7.0 software was connected to the petrol controller using the Valuecan module to record the internal parameters of the petrol controller. The key parameter that was observed as the one affecting the fuel dose correction was DLAHI. This is the fuel dose correction factor due to the diagnostic signal of the lambda probe [4] it is designed to affect the fuel dose in the situation when the signal of the second lambda probe indicates that the effective catalyst operation is starting too slowly after exiting the transient states of engine operation. Its changes directly affect the change of fuel injection time. The principle of the gas controller is based on the measurement of gasoline injection time, then multiplying this injection time by a number of coefficients contained in the internal gas controller algorithm and sending the calculated injection time to the gas injector. In the process of initial calibration of the gas controller, the internal algorithm of the controller calculates a number of factors, among others, such as correction of gas temperature, correction of gas pressure, correction of vacuum of the engine intake manifold, etc. In order to verify the operation of the change in the fuel dose correction factor, first the exhaust gas emission was measured with gasoline observation, observing the engine operating parameters such as STFT, LTFT, DLAHI, then the same measurements were made with the CNG fuel supply. In subsequent measurements, lambda probe signal emulation was used to limit the adaptation of petrol controller parameters. In the obtained measurement data we observe how the correction factor changes and how it affects the change in fuel dose and the level of exhaust gas emissions.

III. Result

Table 1 Measurements on petrol mode.

Measurment On petrol	STFT before test (max/min) %	STFT after test (max/min) %	LTFT before test (max/min) %	LTFT after test (max/min) %	DLAHI before test	DLAHI after test	CO (g/km)	HC (g/km)	NOx (g/km)
1	5/-6	4/-5	3/3	4/4	0,000121	0,000136	0,533	0,035	0,022
2	5/-6	4/-5	3/3	4/3	0,000136	0,000136	0,488	0,050	0,022
3	5/-6	7/-5	3/3	4/4	0,000136	0,000140	0,511	0,045	0,022
4	5/-6	4/-5	3/3	4/4	0,000140	0,000142	0,608	0,070	0,011
5	5/-6	4/-5	2/2	4/4	0,000142	0,000136	0,522	0,033	0,040
6	4/-6	4/-5	4/4	4/4	0,000136	0,000136	0,530	0,035	0,022
7	4/-6	3/-5	3/4	3/4	0,000136	0,000140	0,605	0,060	0,018
8	5/-6	4/-5	3/3	3/3	0,000140	0,000121	0,531	0,035	0,022
9	5/-6	6/-5	3/2	4/3	0,000121	0,000136	0,498	0,035	0,022
10	3/-5	5/-5	3/3	3/3	0,000136	0,000136	0,602	0,055	0,013

Table 2 Measurements on CNG mode .

Measurment On CNG	STFT before test (max/min) %	STFT after test (max/min) %	LTFT before test (max/min) %	LTFT after test (max/min) %	DLAHI before test	DLAHI after test	CO (g/km)	NMHC (g/km)	NOx (g/km)
1	6/-5	5/-5	4/3	5/4	0,000121	0,000136	0,655	0,057	0,011
2	7/-5	5/-5	5/3	5/3	0,000136	0,000160	0,702	0,065	0,017
3	5/-6	7/-5	5/3	4/5	0,000160	0,000240	0,802	0,080	0,044
4	8/-6	6/-5	3/3	4/4	0,000240	0,000320	0,850	0,080	0,011
5	6/-8	5/-5	2/3	4/4	0,000320	0,000360	0,870	0,095	0,008
6	5/-5	4/-5	4/5	4/3	0,000360	0,000380	0,350	0,040	0,101
7	3/-4	6/-5	3/4	3/4	0,000380	0,000420	0,480	0,060	0,033
8	5/-6	6/-5	3/3	3/5	0,000420	0,000560	0,780	0,070	0,010
9	3/-3	4/-5	3/2	4/4	0,000560	0,000780	0,950	0,088	0,008
10	2/-5	5/-5	3/4	3/4	0,000780	0,001250	0,980	0,120	0,005

Table 3 Measurements on CNG mode with lambda sensor emulation.

Measurment On CNG	STFT before test (max/min) %	STFT after test (max/min) %	LTFT before test (max/min) %	LTFT after test (max/min) %	DLAHI before test	DLAHI after test	CO (g/km)	NMHC (g/km)	NOx (g/km)
1	5/-6	4/-5	2/4	4/4	0,001250	0,000780	0,533	0,035	0,022
2	5/-5	4/-5	3/3	4/3	0,000780	0,000560	0,488	0,050	0,022
3	5/-6	4/-5	3/4	3/4	0,000560	0,000360	0,511	0,045	0,022
4	3/-4	4/-5	3/3	4/3	0,000360	0,000180	0,608	0,080	0,011
5	4/-3	4/-5	4/2	4/4	0,000180	0,000142	0,522	0,033	0,040
6	3/-4	4/-5	4/3	4/3	0,000142	0,000142	0,530	0,035	0,022
7	2/-5	3/-4	4/4	2/4	0,000142	0,000136	0,605	0,060	0,018
8	5/-5	4/-5	3/3	3/3	0,000136	0,000144	0,531	0,035	0,022
9	4/-5	4/-5	3/3	4/4	0,000144	0,000136	0,498	0,035	0,022
10	3/-4	5/-5	3/3	3/4	0,000136	0,000136	0,602	0,055	0,013

IV. Result Analyze

The first part of the measurements (Table 1) made on petrol supply illustrates how stable the emission of exhaust gases is in the tested vehicle and what is its level:

Average emission of CO: 0,542 g/km highest level 0,608 g/km limit for Euro 6 : 1.000 g/km it results 68%
Average emission of HC: 0,044 g/km highest level 0,070 g/km limit for Euro 6 : 0,100 g/km it results 70%
Average emission of NOx : 0,021g/km highest level 0,080 g/km limit for Euro 6 : 0,060 g/km it results 30%

The level of CO emissions does not exceed 68% of the norm, HC emissions of 80% and NOx 30% of the norm. During the measurements, we also observe the oscillation of the DLAHI coefficient at the level from 0.000121 to 0.000140, the oscillation only affects the maximum differentiation of exhaust emissions at the level of:

CO : 0,120 g/km
HC : 0,035 g/km
NOx. : 0,011g/km

In the next measuring session (Table 2), the vehicle is tested while running on CNG.

Average emission of CO: 0,714 g/km highest level 0,980 g/km limit for Euro 6 : 1.000 g/km it results 98%

Average emission of HC: 0,075 g/km highest level 0,120 g/km limit for Euro 6 : 0,100 g/km it results 120%
Average emission of NOx: 0,026g/km highest level 0,101 g/km limit for Euro 6 : 0,060 g/km it results 101%

The level of exhaust emissions becomes much more unstable, the DLAHI coefficient increases steadily from 0.000121 to 0.001250 units, the dispersion of exhaust emissions results is respectively for:
CO : 0,630g/km
HC : 0,063 g/km
NOx. : 0,039/km

The direct impact of the result of the adaptation of the DLAHI factor on the increase of individual gas emissions and the destabilization of results is clearly visible. The phenomenon observed during these measurements is related to the difference in the signal path of the lambda probe in the case of supplying the engine with a different fuel that the gasoline controller was designed for. In the case of stoichiometric combustion of gasoline, the AFR coefficient is 14.7, the petrol controller is programmed for this proportion of the fuel mixture, in the case of CNG supply this coefficient for stoichiometric combustion is 17.2, one of the factors that affects the adaptation of controllers in transient states[2]. The second more significant are the physicochemical differences of fuels, chemical composition and thus the substrates of the combustion process in the engine cylinder are different, the exhaust gas contains a different oxygen content despite the correct preparation of the mixture ratio in the stoichiometric cycle. This phenomenon affects the fact that in engines where the gasoline controller controls the efficiency of the catalyst by precise control of the lambda probe voltage diagnostic signal, the fuel dose correction factor depending on the oxygen content in the exhaust gas after leaving the catalyst undergoes additional adjustment of its value. The level of this adaptation while working on CNG is several times higher than in the case of engine running on gasoline fuel, and in the studied case increased from 0.000121 units to 0.001250 (over 10 times) its increase translates into correction of the fuel dose. This correction causes unnecessary enrichment or reduction of the fuel dose, which is delayed by the petrol controller based on the signal analysis of the first lambda probe. In addition, we can observe that changes in the fuel dose correction parameter from the second lambda probe are not visible by reading the dose integrators available via global OBD, i.e. STFT and LTFT. In all tests, the values of these corrections remain in oscillation at a similar level both when running on gasoline as well as when running on CNG. As a result of the development of the gas controller in order to avoid this phenomenon, the company AC SA, the STAG brand manufacturer, in its controller used an additional solution consisting in the appropriate modification of the lambda probe. The results of this solution can be seen in Table 3, already in the first measurement we can observe a decrease in engine exhaust emissions, CO drops from 0.980 g / km to 0.533 g / km and HC from 0.120g / km to 0.035 g / km. In subsequent measurements, the DLAHI correction level stabilizes and assumes the same value as for gasoline measurements. A similar phenomenon is observed when it comes to the level of vehicle emissions. In the above description of the research, for reasons related to the technical secret of the STAG brand, it is impossible to describe the details regarding the lambda probe emulation solution. We can only conclude that it is effective and eliminates the problem associated with the adaptation of the gasoline controller.

V. Conclusion

As a result of the conducted data, data was obtained that allow a clear observation of the phenomenon of adaptation of gasoline controller parameters directly affecting the increase of harmful emissions of the combustion process in a vehicle equipped with a CNG installation. At the same time, it can be stated that without specialized measuring equipment enabling the analysis of the operation of the gasoline controller for hidden registration for universal OBD testers, it is not possible to verify the engine operation characteristics and its correct operation after conversion of the engine to CNG fuel supply, especially when we consider the correct emissions the vehicle. .

References

[1]. Report na CNG portal : NGV Global http://www.ngvglobal.com/blog/tag/alternative-fuels
[2]. E. Anderson, H. Wandrie, J. Celmins i inni: "The GMI Fuel Injected Propane Conversion Vehicle" GMI Engineering & Management Institute Aslam, M.U., Masjuki, H.H., Kalam, M.A., Abdesselam, H., Mahlia, T.M.I., Amalina, M.A., 2006. An experimental investigation of CNG as an alternative fuel for a retrofitted gasoline vehicle. Fuel 85, 717–724
[3]. Hyundai internal petrol ECU documentation

Marcin Dziewiątkowski. "Analysis of the Impact on Petrol ECU Adaptation Parameters in a CNG Powered Vehicle on the Level of Exhaust Emissions." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 16, no. 4, 2019, pp. 17-20