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METHODS OF IMPROVING THE ENVIRONMENTAL SAFETY AND OPERATIONAL INDICATORS OF CNG VEHICLES DURING THEIR MOVEMENT

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Abstract

In this article, optimal selection of their standard settings, taking into account the ambient temperature, gives effective results in improving the operational efficiency of GCA and increasing its environmental safety. From the results of the experiment above, we can know that when the ambient temperature is between 18°C-22°C, when GCE's diagnostic software changes the temperature indicator in the default setting from 40°C to 36°C, petrol to CNG made it possible to reduce the fuel transition period to almost 1.5 minutes. This leads to a further decrease in petrol consumption and fuel costs, as well as a decrease in harmful gases.

Keywords: automobile, fuel economy, environmental safety, gas cylinder equipment, petrol, gas cylinder automobiles, CNG, petrol-gas mode, diagnostic programs, temperature, Chevrolet Cobalt, Gas controller settings.

1.1. Introduction

Effective organization of vehicle operation and environmental safety is beneficial and economically important for all industries. The rapid development of production processes primarily depends on the timely delivery of raw materials, as well as the delivery of manufactured goods and services on time. Among the types of transport that provide transportation services around the world, automobile transport is distinguished from other types of transport by its mobility, ease of loading and unloading, and this transport provides the opportunity to transport cargo and passengers to designated stops or loading points.

The largest share of transportation services in transportation is cargo and passenger transportation services [2]. Compared to other types of transportation, this type of transportation is in high demand due to its flexibility and the relatively cheapness of the services provided. For

information, the total share of passenger transportation services in the Republic of Uzbekistan in January-February 2022 reached 63.8% [2].

According to the data of 2022, the automobile transport in the world exceeds 1.45 billion [3], the movement of these automobiles requires a certain amount of energy, and the majority of current automobile s use petrol and diesel fuels, which are extracted from oil. These fuel-powered automobiles have been improving for almost a century, but the use of conventional fuels has led to rising fuel costs and global environmental problems. at the same time, limited oil reserves require the use of alternative types of fuel for these automobiles.

Improving fuel economy and environmental safety among the performance indicators of automobiles is an necessary issue. Economy of fuel costs determines the economic efficiency of this transport. The lower the cost of fuel, the cheaper the transportation service. Today, automobile s use petrol, diesel and gas fuels. Among automobile fuels, gas fuel is cheap, safe for fire (when it comes out of the fuel tank, it spreads upwards due to its lightness from the air) and sufficient reserve source compared to petrol and diesel fuels is one of the advantages of fuel.

First of all, automobiles are re-equipped and additional equipment is installed to use gas fuels. They are generally gas cylinder equipment (GCE) and automobiles equipped with GCE are called gas cylinder automobiles (GCA).

In the decision of the President of the Republic of Uzbekistan dated December 2, 2022 PQ-436 " On measures to increase the effectiveness of reforms aimed at the transition of the Republic of Uzbekistan to a “green” economy until 2030" in the operation of automobiles, in particular, the main measures for the use of natural gas-powered buses and electric buses for public transport are defined. Also, priorities for the promotion of energy-efficient and environmentally friendly vehicles were determined.

Today, GBA is widely popular in our country due to its environmental friendliness and low price. In accordance with the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan dated November 11, 2015 No. 326 "General Technical Regulation on safety of motor vehicles utilizing CNG (compressed natural gas), LPG (liquefied petroleum gas) and hybrid diesel and gaseous fuel", installation requirements are listed in our republic gas equipment for automobiles. The number of GCAs increased rapidly due to these requirements.

By 2022, out of 3.6 million vehicles on the roads of our republic, more than 1.570 million will run on methane gas, and more than 200,000 vehicles will run on liquefied gas fuel, appropriate gas cylinders will be installed [4,5].

Increasing their operational performance and environmental safety by standardizing the optimal operation process of GCA, which is the main part of the automobilefleet, while using the available opportunities, is one of the urgent problems today.

1.2. Materials and Methods

The use of CNG as an automobile fuel was discovered in Italy in the early 1930s [6] and became popular worldwide from the 1970s, due to the scarcity of petroleum products that began at that time. After that, CNG started to emerge as an all-round promising alternative to automobile fuel. The sharp rise in oil prices in the late 1970s and early 1980s led to a further increase in the number and improvement of CNG vehicles.

CNG is obtained directly from gas fields and associated gases released during the refining of petroleum products. CNG mainly consists of methane (82...98%), and additionally contains ethane (up to 6%), propane (1.5%) and butane (up to 1%). CNG is transported through branched gas pipelines to gas collection compressor stations, and from there it is distributed as fuel to vehicles. Methane is a colorless and odorless gas, slightly soluble in water, lighter than air (specific gravity of 0.55) and belongs to the class of saturated hydraulic machines. Methane molecules consist only of carbon and hydrogen, so it does not emit a poisonous gas when burned.

The higher hydrogen content in LNG ensures more complete combustion of the fuel in the engine cylinders compared to liquefied natural gas or petrol.

The main characteristics of CNG and petrol fuel are presented in Table 2 [1]. Comparing these characteristics with each other, using CNG as fuel in an internal combustion engine gives 12 different performance indicators.

Table 2

The main characteristics of CNG and petrol fuels

Indicators	**CNG**	***Petrol***
1	2	3
Molecular mass	16,03	114,2
Elemental Composition, *%*: *H* C	 25,03 74,57	 15,0 85,0
H/C ratio	4,0	2,25
Gas constant: *kgsm/kg·K* *kkal/kg·^{0}C*	 52,81 0,124	 7,6 -
Density of the vapor state under standard conditions: *kg/m^3* when the fuel is liquid *kg/l*	 0,670 0,415	 - 0,626
Evaporation Temperature, *kkal/kg*	122,6	65
Relative density	0,554	3,18
Oxygen required from air for the complete combustion of fuel will be: *m^3/m^3* fuel *m^3/kg* fuel	 9,52 14.2	 - 12,35
The heat of combustion of a stoichiometric mixture under standard conditions; *kkal/m^3*	770	850
Boiling point, *^{0}C*	-161,6	99,2
Boiling Temperature, *^{0}C*	590…690	480-520
The ignition temperature of a stoichiometric mixture, *^{0}C*	2020	2100
Coefficient of molecular change when a stochnometric mixture burns	1,0	1,058
Octane rating	100…120	100
The maximum value of the normal speed of flame propagation, *m/s*	3,4…3.7	4,0-4,2
The coefficient of excess air at the same speed	0,95	0,89
The value of this coefficient at the lower concentration limit	2,0	1,76
Value at the limit of high concentration	0,65	0,3
Flammability limits in air,*g/m^3 %*	5...15; 16,66...102,6	1,5/6,0
The minimum energy of ignition, 10-3 J oil heat	0,23	0,28
Wobbe Index (or Wobbe Number): high value lower value	12300 11300	- -

Converting vehicles from petrol to gas can reduce harmful emissions by an average of five times, and the impact of noise by half [7]. According to a study by Kenedy Aliila Grayson and others [6], 280 barrels of petrol are saved per passenger automobileannually, and US$46,500 is saved by using CNG in vehicles. According to numerous studies, the amount of harmful gases and noise emitted by CNG vehicles is significantly reduced compared to petrol vehicles. By using this fuel, the service life of the engine lubrication system is extended and optimal oil viscosity is maintained for a long time.

CNG fuel is cheaper than petrol or diesel fuel (Using the example of fuel prices in the Republic of Uzbekistan, CNG fuel for vehicles is 3.18 times cheaper than petrol fuel and almost

4.54 times cheaper than diesel fuel) [8, 11]. It inherently has lower air pollution emissions. It has lower greenhouse gas emissions. Its use expands oil reserves, and there is a large amount of fuel available in the world [9]. The advantage of CNG is the higher thermal efficiency of brakes by an average of 1.1% and 1.6% than petrol [10].

1.3. Results

Modern CNG vehicles are equipped with 4th generation GCE, which are initially run on petrol fuel until the engine cooling system reaches a set temperature, and then switch to CNG fuel. The change temperature of petrol-gas modes can be corrected in special diagnostic programs (Fig. 1).

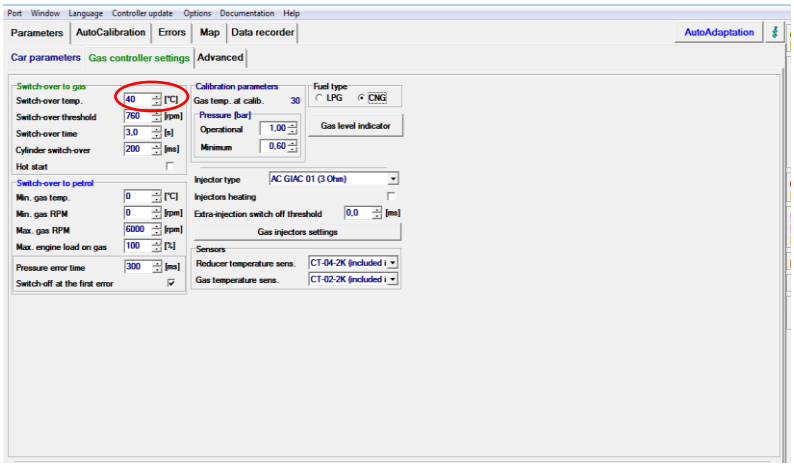

Figure 1. "Gas controller settings" section in the diagnostic program "ACGasSynchro 11.2.1.1" for CNG vehicles equipped with 4th generation GCE

As the specified temperature changes, the conversion time from petrol to CNG fuel also changes. In the standard settings of this program, the change of petrol -gas regimes is set at a temperature of 40 C. It is possible to switch from petrol to CNG fuel when the coolant temperature reaches this indicator. But by reducing the temperature indicator in standard settings, it is possible to save petrol consumption of GCA. At the same time, environmental safety can be ensured.

The "Transport energy equipment" department of Tashkent State Transport University conducted a practical experiment on Chevrolet Cobalt automobile running on CNG to improve fuel economy and environmental safety of GCA.

The main hypothesis of this experiment was to run 4th generation GCE vehicles on petrol and optimize the duration of the transition to CNG fuel, ensuring the operational efficiency and environmental safety of CNG vehicles.

Initially, the range of Chevrolet Cobalt petrol -gas mode change depends on the temperature change of the external environment, the indicator of the "Switch-over temperature" item in the "Gas controller settings" section of the "ACGasSynchro 11.2.1.1" program was set to the standard 40°C from 34°C to 34°C, and also changed the "Switch-over threshold" band indicator from 760 RPM to 960 revolutions per minute (RPM) (Figure 2). These changes were made when the outside temperature was 18°-22° C and the automobile engine was started.

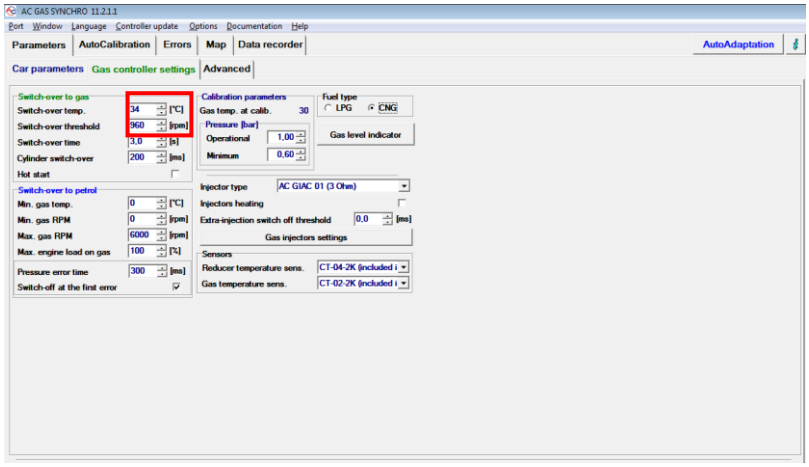

Figure 2. The temperature in the "Gas controller settings" section and the change status of the "Switch-over threshold" indicator

After the changes made, the automobile was started and the time to switch from petrol to gas fuel was measured. This test was repeated ten times, with the engine shut down until it reached ambient temperature and then restarted (Figure 3). The obtained results were compared with those before the change (Table 1).

Figure 3. The process of connecting the computer to the engine gas electronic control unit and changing the petrol -gas mode indicators

Table 1

Comparative analysis of the times of switching from petrol to gas fuel in the Chevrolet Cobalt automobile engine equipped with 4th generation GCE

Experiments	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
The time to switch from petrol to gas before the change, min	4,2	3,58	3,48	3,37	4,54	3,23	4	3,14	4,19	3,57
The time of transition from petrol to gas after the change, min	2,46	3,02	2,54	2,46	2,38	2,58	3,09	2,51	2,38	2,42

It should be noted that the engine needs to be warmed up to optimum temperature and then it is good to run. But in GCA, the time to switch to CNG fuel after starting the engine on petrol will result in more petrol consumption than the default settings. This causes all sorts of negative consequences.

1.4. Discussion

As mentioned above, it is very important to improve operational efficiency and environmental safety of GCA. According to the results of the experiment, it is necessary to make

changes to the standard settings for reducing petrol fuel consumption. It is very important to improve the operating efficiency of the GCA by accurately selecting the optimal parameters of the temperature setting or the frequency of crankshaft rotations in accordance with the ambient temperature.

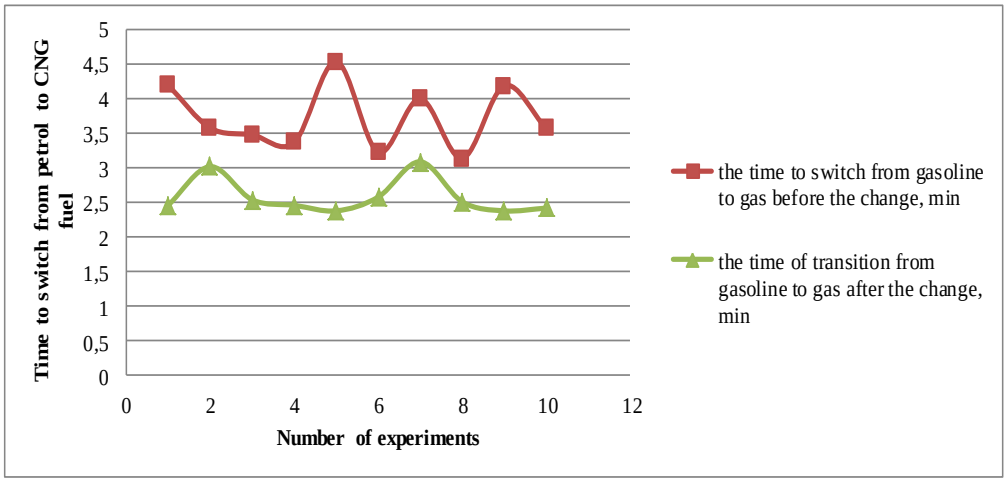

Figure 3. Comparative analysis of the times of switching from petrol to gas fuel in the Chevrolet Cobalt automobile engine equipped with 4th generation GCE

If we see the result of the experiment in the graph (Fig. 4), we can see that the consumption of petrol has decreased significantly. In this case, if the engine temperature is partially below the optimal temperature, heating on CNG fuel will be possible and petrol consumption will be reduced.

1.5. Conclusions

In conclusion, in improving the operational efficiency of GCA and increasing its environmental safety, the optimal selection of their standard settings, taking into account the ambient temperature, gives effective results. From the results of the experiment above, we can know that when the ambient temperature is between 18°-22° C, when GCE's diagnostic software changes the temperature indicator in the default setting from 40° C to 36° C, petrol to CNG made it possible to reduce the fuel transition period to almost 1.5 minutes. This leads to a further decrease in petrol consumption and fuel costs, as well as a decrease in harmful gases.

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