**Efficiency Account of the Installation of GBU for Motor Transport**

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**Abstract.** This article presents vehicle parameters that need to be adjusted to meet environmental standards using accessible and economically feasible means and methods. Calculations are made for a specific vehicle used for urban passenger transportation based on data relevant and applicable to this vehicle. An environmental analysis and economic impact are presented based on the values ​​obtained after switching to gaseous fuel.

**INTRODUCTION**

In general, there is a great deal of information of a different nature to bring in different kinds of calculations and calculations on this matter of the payment calculation. Technical data of all GBU systems installed in cars:

1. The system is installed in 4 generation of GBU.

2. The gas leakage from the system is zero, provided that the GBU is installed at a certified station.

Feasibility of installing GBU on ISUZU SAZ LE60.

The bus fully meets the requirements for vehicles and is intended for the transportation of passengers.

**TABLE** 1. Technical descriptions of the bus.

|  |  |
| --- | --- |
| Isuzu SAZ LE60 urban cycle passer bus | |
| Engine | Isuzu 4HK1, diesel, 4-stroke |
| Capacity | 190 h.p. |
| Extensions Box | Allison 2100 Automatic, 5-Stroke. |
| Number of passenger seats (total capacity) | 25 (56) |
| Length / width / height | 8065 / 2470 / 2750 |
| Maximum speed | 80 km/h |
| Fuel consumption | 27 l / 100 km |
| Fuel Tank Volume | 140 l |

**EXPERIMENTAL RESEARCH**

When calculating the efficiency of the application of the GBU (methane) system, the example of a bus characterizing in one direction is considered. The bus gets a range of 320 km per day.

Login Details:

1. The price of 1 liter of diesel fuel is 12,250 soums;

2. The price of 1 m3 of compressed gas (methane) is 5,000 soums;

3. The car travels 300 km per day:

*Qh=0.01⋅Hs⋅S⋅(1+0.01⋅D)*  (1)

where Qh is the standard fuel consumption;

Hs - fuel consumption for the movement of the vehicle, l / 100 km (Taking into account the normalized passenger load for the class and purpose of the vehicle);

S - the distance of travel of the bus;

D - Adjustment coefficient (total relative increase or decrease), %;

*Qh = 0.01⋅27⋅300⋅(1+0.01⋅30)* (2)

We've got the credentials, let's move on to the calculations.

To cover a distance of 100 kilometers, the bus will need 27 liters of diesel fuel, and the bus will also need 11% more fuel to cover the same distance on compressed gas. From this it follows:

*27 liters + 11% = 29.97 m3 of compressed gas* (3)

From this it follows that 89,9 m3 of compressed gas will be needed to cover the same 300 kilometers. Calculation of the number of gas cylinders required for 89.9 m3.

STG size is measured in cubic meters (m³). It is possible to calculate the bubble volume by knowing the pressure in the cylinder indicated by the standard pressure gauge, as well as the ambient temperature.

The capacity of any other methane cylinder can be determined by using the formula:

*V/k=STG volume (m³)*  (4)

Here, V is the size of the cylinder, k is the coefficient, determined from the table.

If 200 bars of gas are poured into the cylinder, the temperature is determined by + 40 ° C. We look at the table at the intersection of this data and find the number 11,63.

k = 50 l / 11.63 = 4.3 is the required coefficient.

**TABLE 2.** Сalculation of STG volumes in one cylinder with a volume of 50 liters, m³

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CNG pressure in cylinder, MPa (kg/cm²) | Ambient temperature, °C | | | | | | | |
| -30 | -20 | -10 | 0 | +10 | +20 | +30 | +40 |
| 10 | 0.55 | 0.55 | 0.54 | 0.53 | 0.53 | 0.53 | 0.52 | 0.52 |
| 20 | 1.15 | 1.12 | 1.16 | 1.1 | 1.09 | 1.07 | 1.06 | 1.04 |
| 30 | 1.79 | 1.7 | 1.7 | 1.69 | 1.65 | 1.63 | 1.61 | 1.57 |
| 40 | 2.41 | 2.33 | 2.3 | 2.27 | 2.22 | 2.17 | 2.15 | 2.13 |
| 50 | 3.2 | 3.05 | 2.98 | 2.94 | 2.84 | 2.81 | 2.75 | 2.72 |
| 60 | 4.05 | 3.76 | 3.66 | 3.57 | 3.53 | 3.45 | 3.41 | 3.27 |
| 70 | 5 | 4.61 | 4.43 | 4.32 | 4.17 | 4.07 | 4.02 | 3.89 |
| 80 | 6.45 | 5.71 | 5.33 | 5.2 | 4.88 | 4.76 | 4.65 | 4.55 |
| 90 | 7.63 | 6.72 | 6.25 | 5.92 | 5.63 | 5.49 | 5.29 | 5.17 |
| 100 | 8.77 | 7.69 | 7.24 | 6.76 | 6.49 | 6.25 | 5.95 | 5.81 |
| 110 | 9.82 | 8.59 | 7.97 | 7.53 | 7.24 | 6.96 | 6.63 | 6.47 |
| 120 | 10.91 | 9.38 | 8.95 | 8.45 | 8 | 7.79 | 7.32 | 7.14 |
| 130 | 12.04 | 10.16 | 9.85 | 9.29 | 8.78 | 8.33 | 8.02 | 7.83 |
| 140 | 12.18 | 11.11 | 10.77 | 10.14 | 9.59 | 9.09 | 8.75 | 8.54 |
| 150 | 13.16 | 11.9 | 11.36 | 10.87 | 10.27 | 9.74 | 9.38 | 9.15 |
| 160 | 13.79 | 12.5 | 12.12 | 11.43 | 11.11 | 10.39 | 10.13 | 9.76 |
| 170 | 13.93 | 13.28 | 12.69 | 11.81 | 11.49 | 10.9 | 10.63 | 10.37 |
| 180 | 14.29 | 13.64 | 13.24 | 12.5 | 12 | 11.54 | 11.25 | 10.98 |
| 190 | 14.62 | 14.18 | 13.57 | 12.84 | 12.5 | 12.03 | 11.59 | 11.18 |
| 200 | 14.93 | 14.29 | 13.81 | 12.99 | 12.66 | 12.5 | 12.19 | 11.63 |

*V/K = 150 l / 4.3 = 34.9 m3.*  (5)

Thus, the capacity of a 150 l cylinder at t=40°C is 34.9 m3 of methane. It turns out that for a daily flow of 300 km, you need 3 cylinders with a capacity of 150 l.

Next, we calculate the difference it takes to purchase diesel fuel and compressed gas:

The cost of buying fuel for 300 km.

*81 liters of diesel fuel ⋅ 12 250 soums = 992 250 soums* (6)

*89.9 m3 of compressed gas ⋅ 5 000 soums = 449 500 soums*  (7)

Difference in fuel expenditure per 300 km:

*992 250 – 449 500 = 542 750 soums*  (8)

Savings - 542 750 soums.

So we got numbers that speak for themselves in dry mathematical language. Calculate the GBU pays for the distance traveled by the car. Savings per kilometer:

*542 750 UZS/300 km=1809,16 UZS/km*  (9)

We calculate the number of kilometers traveled to pay for the installation of the GBU system, the cost of GBU after its installation is 35,000,000 soums.

*GBU price - 35,000,000 soums / 1809,16 soums / km = 19 345,99 km*  (10)

We calculate the number of days required to cover the GBU equipment:

*19 345,99 km/300 km = 64.4 days*  (11)

From the result obtained in the formula (8) above, it is shown the amount that one bus can save per day (640,467 soums). Toshshaharpasstrans has purchased 200 units of these buses. If 150 units of these buses are traveled daily, the following economic indicator will be obtained.

*542 750 soums ⋅ 150 = 81 412 500 soums*  (12)

This value is a one-day economic indicator.

The cost for the conversion of 200 buses to the gas cylinder system is as follows:

*200 ⋅ 35,000,000 = 7,000,000,000 UZS*  (13)

The period of time that goes to cover these expenses is as follows:

*7,000,000,000 UZS / 81 412 500 UZS = 85,9 days*  (14)

**Environmental efficiency of internal combustion engines running on gas fuel.** The main criteria for evaluating the efficiency of the use of various fuels in engines are: the level of harmful emissions, the price of fuel, the fuel infrastructure, and the cost of the engine. These criteria are chosen as the most important for the following reasons. Currently, the emission standards allowed by the car are constantly being tightened, forcing constructors to look for new solutions that meet these standards. It is important to note that we strongly support our dedicated team partners and support our customers.

The second evaluation criterion – fuel and infrastructure costs – allows for an assessment of the costs of production, delivery, fuel distribution and vehicle operation. When running on alternative fuels, the fuel consumption per unit of work performed by the car can vary significantly.

The third criterion - the cost of the engine - describes the cost of converting an engine to run on alternative fuels. Depending on the type of fuel used, a variety of changes may be required in the design of the engine and its systems, ranging from very simple (setting up fuel equipment) to significant changes in engine design (installing throttle equipment). As such, the complexity of upgrading an engine has a significant impact on its price.

So far, there is no unified concept for the transition to the production and use of alternative motor fuels. Therefore, the first step in addressing this problem is to consider all types of alternative motor fuels and analyze the prospects for their use. The table provides an estimate of the relative efficiency of using different alternative fuels in vehicles.

Government agencies will play a key role in the development and widespread use of alternative fuels with improved environmental characteristics.

Alternative Petroleum Fuel Substitutes. The challenge of expanding engine fuel resources through the use of alternative fuels is facing the construction of a modern engine. First of all, we pay attention to sufficient reserves of raw materials (natural gas, hydrogen, methanol, etc.) and fuels other than oil with optimal environmental characteristics.

When choosing an alternative energy source, one should take into account the feasibility of using it as motor fuel in each individual case. Preliminary assessment can be made on the basis of a comparative analysis of the physicochemical and chemical properties of individual energy carriers (see Table 3).

**TABLE 3**. Physical and chemical properties of various energy carriers

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Property | Diesel fuel | Methanol | Ethanol | Methane | DME |
| Chemical composition | - | СН3-ОН | СН3-СН2-ОН | СН4 | СН3-О-СН3 |
| Density, *g/cm3* | 0,84 | 0,79 | 0,81 | - | 0,66 |
| Setang Number | 40...55 | 5 | 8 | - | 55 |
| Self-ignition charity, °C | 250 | 450 | 420 | 650 | 235 |
| Octane number | - | 111 | 108 | 130 | - |
| Boiling point, °C | 180...370 | 65 | 78 | -162 | -25 |
| Evaporative heat, *kDj/kg* | 250 | 1110 | 904 | - | 410 |
| Explosion limit (% of airborne fuel vapors) | 0,6...6,5 | 5,5...26 | 3,5...15 | 5...15 | 3,4...18 |

Disambiguation pages with short descriptions

According to the production method, gaseous fuels are obtained from natural (natural gas), extraction from gas fields and reservoirs (combined petroleum gases), and artificial, oil refining or gasification of solid fuels.

The decisive impact of transport on the state of the environment requires special attention to the use of new environmentally friendly fuels. These include, primarily, compressed or liquefied gas.

In world practice, the most commonly used as an engine fuel is compressed natural gas with at least 85% methane in its composition. To a lesser extent, the use of joint petroleum gas is widespread; It is basically a mixture of propane and butane. This mixture can be in a liquid state at normal temperature under pressure of up to 1.6 MPa. To replace 1 liter of gasoline, 1.3 liters of liquefied gas are needed, and its cost-effectiveness is 1,7 times lower than compressed gas in terms of equivalent fuel costs. It is important to note that natural gas, unlike petroleum gas, is not toxic.

The analysis shows that the use of gas reduces toxic emissions: carbon monoxide - 3-4 times; nitrous oxide - 1.5-2 times; hydrocarbons (except methane) - 3-5 times; lead particles and sulfur dioxide (smoke) of diesel engines - 4-6 times. When running on natural gas with a surplus coefficient of air α = 1.1, the PAU emissions generated by the engine during the combustion of fuel and lubricating oil (including benzo(a)pyrene) is 10% of the emissions when running on gasoline. Natural gas-powered engines now meet all modern standards for exhaust gases and solid components.

**TABLE 4.** Composition of toxic components in the exhaust gases of internal combustion engines, %

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Toxic content of waste gases | | | | |
| Type of fuel | СО | CnHm | NOx | Soot | Benzopyrene |
| Gasoline | 25-30 | 10 | 25 | 2 | 50 |
| Diesel fuel | 10 | 10 | 50-80 | 100 | 50 |
| Gas + diesel fuel | 8-10 | 8-10 | 50-70 | 20-40 | 30-40 |
| Compressed natural gas | 5-10 | 1-10 | 25-40 | 2 | 3-10 |
| Propane - butane | 10-20 | 50-70 | 30-80 | 2 | 3-10 |

**FIGURE 1**. Composition of toxic components in the exhaust gases of internal combustion engines, %

When using gaseous fuel, the technical characteristics of cars will be improved, including:

- the reliability and service life of engines is increased by 30-50%;

- the service life of engine oil increases by 2...3 times;

- the time between major repairs is 1.4... It increases by 1.5 times.

Power. There is a common belief that in methane, the engine loses up to 25% of power. This idea is true for two-fuel "gasoline-gas" engines and partly for atmospheric diesel engines. For modern turbocharger engines, this idea is wrong. The high-power runtime of the original diesel engine, designed to operate with a compression rate of 16-22 times and high-octane gas fuel numbers, allows the use of a compression ratio of 12-14 times. Such a high compression ratio allows for the same (and even more) specific strength to be obtained when operating in stoichiometric fuel mixtures. However, toxicity standards higher than Euro-3 cannot be met, and the thermal stresses of the converted engine also increase.

Modern turbocharger diesel engines (especially those with chilled air) allow you to run in significantly economical compounds while maintaining the power of the original diesel engine, keeping the thermal regime within the same limits and meeting Euro-4 toxicity standards.

For naturally aspirated diesel engines, we offer two alternative options: either reduce the operating power by 10-15%, or use an intake collector water intake system to maintain acceptable operating temperature and achieve Euro-4 emission standards.

A turning point. The maximum torque value does not change and may even increase slightly. However, the point of reaching maximum torque goes to higher speeds.

The radical solution to the problem of changing the moment peak for a gas engine is to replace the turbine with a special type of large turbine with a rotary electromagnetic valve at high speed. However, the high cost of such a solution does not allow you to use it for individual conversion.

Reliability. Engine resource increases significantly. Since the combustion of gas occurs more uniformly than that of diesel fuel, the compression of the gas engine is less than that of diesel fuel and the gas does not contain impurities unlike diesel fuel.

Oil. Gas engines are more demanding on the quality of the oil. We are strongly recommended to use all high-quality oils of SAE class 15W-40, 10W-40 and to change the oil at least 10,000km.

Due to the high-water content in the combustion products of gas-air mixtures in gas engines, problems with the water resistance of engine oils may arise, and gas engines are also susceptible to stale formation in the combustion chamber. For this reason, the sulphate ash content of oils for gas engines is limited to lower values, and the requirements for the hydrophobicity of oil are increased.

Noise. The gas engine is very low noise compared to the diesel engine. The noise level is reduced by 10-15 dB.

The distance traveled by a refueling station. Methane on board the vehicle is stored in special cylinders in a gaseous state at a high pressure of 200 atmospheres. The massive weight and dimensions of these cylinders are a significant negative factor limiting the use of methane as a gas engine fuel.

To store 1 Nm3 of methane, you need a hydraulic volume of 5 liters of cylinders, i.e. for example, a 100-liter cylinder will allow you to store about 20 Nm3 of methane. The weight of 1 liter of hydraulic case is about 0.85 kg, i.e., for 20 Nm3 of methane, the weight of the storage system will be about 100 kg (the weight of an 85 kg cylinder and the weight of 15 kg of actual methane).

**CONCLUSIONS**

5 ... A decrease of 8% and a significant increase in the labor efficiency of maintenance and repair by 3... An increase of 5% can be noted.

The main approximate characteristics of gaseous fuel:

Combustion temperature. For gases, these temperatures are relatively high (above 470°C), which requires the use of high-performance fireworks from an external source (electric spark or combustion diesel fuel).

1. Octane number. Describe its antidetonation properties. Gaseous fuels have an octane count of 90...125, i.e. higher than gasoline and ensure uniform engine performance.

2. The combustion heat of gas-air mixtures is slightly lower than that of gasoline-air mixtures, which reduces the energy performance of the engine (7... 12%).

3. The amount of moisture contained in the gas. This impairs the combustion process, causing corrosion of metal surfaces. Moisture vapor must be removed from the gaseous fuel.

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