Prospects to Development of Green Technologies for Alternative Motor Fuel's Production

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Abstract: Negative processes in ecosystems accompanying the rapid development of engineering and technologies during the transition to the fourth industrial revolution necessitate a change in the economic paradigm - the transition to a circular economy. Ecosystem degradation is taking place when accelerating urbanization and motorization. The search for global solutions to ensure comfortable living conditions on the planet is implemented by minimizing the negative impact of solid industrial and domestic waste on the environment. Consequently, on the one hand, it is necessary to solve the problem of reducing resource consumption, while reducing industrial and household waste, on the other. "Greening" of transport reduces the negative load on the environment and can be associated both with the search and use of alternative fuels, and with the reduction of emissions due to new technical solutions. The article presents a new technology to improve energy efficiency and environmental friendliness of road transport by processing wood and polyethylene waste as raw materials for alternative fuels. The offered solution will reduce the content of harmful substances in the exhaust gases of internal combustion engines and the negative load on the environment from vehicles.

1 INTRODUCTION

In the message of the President of Russia to the Federal Assembly of 2019, it was determined that solving problems in the field of ecology is both the primary task of industry and science and the responsibility of each citizen. One of the main directions for solving the problem is the formation of "nature-like" technologies (meeting the requirements of the Fourth Industrial Revolution). The set task is to form a civilized and safe waste processing system by 2024, as well as reclamation of all problem landfills in the country. At the same time, waste processing should be increased from the current 6-7 percent to 60 percent, and housing and communal services, energy, transport enterprises should be switched to cleaner environmental solutions. Businesses should participate more actively, including in projects for the development of the gas-motor market, invest in the creation of a network of refueling stations and fuel systems that use, in particular, liquefied natural gas (LNG) (On the State…, 2007).

The necessity to develop this direction is due to environmental problems, by increasing energy needs of mankind, depletion of reserves of non-renewable fossil fuels and, as a consequence, their rise in price. The development of technologies for obtaining energy from local renewable sources is a topical direction for the Russian Federation, which has reserves of biofuel from waste products of the woodworking and forestry industries, as well as plant biomass. At the same time, the main efforts are aimed at creating and improving gas generating plants for internal combustion engines and transport vehicles operating in remote regions of the country (Bozhko, 2003).

Obtaining energy from secondary raw materials, we simultaneously solve the problem of waste reclamation, receiving cheap, one might say, almost free gas fuel that can be used in transport while simultaneously reducing the negative load on the environment in places where this waste is accumulated through their utilization. The problem of providing alternative fuel is especially acute in the event of man-made disasters (natural disasters, military conflicts), when there is no or difficult access to power sources for transport (Automotive, 2019). The aim of the work is to substantiate the improvement of environmental friendliness and resource-saving work due to the use of generator gas obtained in processing solid household waste in a gas generator.

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2 STATE OF THE PROBLEM: ALTERNATIVE FUELS FOR ROAD TRANSPORT

In Japan, two oil crises in the 1970s triggered the introduction of "next generation vehicles." Examples include battery electric vehicles (BEVs), compressed natural gas vehicles (CNGVs), and hydrogen fuel cell electric vehicles (FCEVs). The study (Kimura, 2016) looks at the next-generation fuel supply infrastructure, in particular, its technical objectives, challenges and risks, as well as reviews of Japan's past approaches and efforts, as well as future prospects. Objective prerequisites for the growth of interest in the use of gas as a motor fuel in recent years are higher energy and environmental performance compared to oil fuel. Natural gas provides the safest exhaust emissions of all commonly used motor fuels and technologies, and has a noticeable effect on lubricating oils (30-40%). In addition, the gas does not contain the main gasoline pollutant - sulfur, so even the most refined «Euro-5» gasoline cannot be compared with gas fuel in clean combustion. Thus, according to the authors of the article (Khan,2016), among all alternative fuels, compressed natural gas (CNG) is considered one of the best solutions for replacing fossil fuels due to its availability throughout the world, clean combustion, economy and adaptability to gasoline and diesel engines.

Compressed natural gas is widely used as a vehicle fuel in countries with their own natural gas reserves. CNG vehicles are already in use all over the world, and the technology for its producing, storing and using has already been developed. Due to that these fuels have a high-octane number, and also a small amount of carbon dioxide is emitted during combustion. In recent years, China has made significant strides in promoting natural gas vehicles (NGV). The article (Hao, 2016) discusses the development of natural gas vehicles in China based on a technical and economic framework with a triple perspective (fuel-vehicle-infrastructure). The authors of the article believe that local governments should develop a strategy to support the further deployment of the CNG / LNG refueling infrastructure. The document (Wang, 2015) analyzes the favorable factors and barriers for the development of NGV in China. The following strategies are proposed for the further development of NGV in China: (1) to improve the infrastructure for the delivery of natural gas throughout the country; (2) of a reasonable reduction in the relative price of natural gas versus gasoline; (3) preference to small and medium-sized cities where gas refueling stations are easier to locate;(4) promoting the use of NGV in the private sector. In some countries, researchers (Mehra, 2017) are trying to reduce pollution by using medium and heavy vehicles powered by hydrogen-rich compressed natural gas (HCNG). Under certain parameters, the thermal efficiency of the HCNG engine is much better than the CNG engines, while the emissions are relatively low. The document (Khan, 2015) presents the global prerequisites, prospects and problems of using natural gas as a vehicle motor fuel, as well as the environmental and economic aspects of such a transformation. The main indicators chosen for the comparative assessment of natural gas as a vehicle fuel are: economic indicators, emission efficiency and safety. Of particular relevance is the use of transport vehicles running on natural gas in Latin America and Asia, where a significant part of megacities is located. Article (Ogunlowo, 2015) examines the approaches to the problem of converting vehicles to natural gas in seven countries with different backgrounds. It is required to gain an understanding of the barriers to the development of the NGV market in Nigeria.

The authors of the article (Wang, 2015) believe that political support and special measures are needed in European countries to stimulate the use of natural gas as a fuel for vehicles. Looking at the UK LNG van market, the authors of (Kirk, 2014) identified a number of barriers, the most important of which is the lack of refueling facilities, but the authors also point to the opportunities, namely fuel costs and the potential for reducing pollution. The authors of the article (Rosenstiel, 2015) note that the measures being taken, the market share of gas transportation vehicles (NGV) in Germany lags far behind expectations and market trends in other countries. The authors conclude that lack of co-ordination, market monopoly and undeveloped infrastructure hinder the development of the NGV market. The authors of the article (Makarova, 2012) believe that the main weak point for LNG as a fuel in Italy is its distribution and, in particular, the supply process. It is important to solve this problem together with the problem of the lack of rules and standards on the places for the development of new alternative fuels and support for the introduction of LNG in the Italian market.

One of the main parts of the exhaust gases produced by internal combustion engines are solid particulate matter. CNG is a potentially profitable fuel as particulate matter emissions are significantly reduced by using natural gas fuels because natural gas does not contain aromatic and poly-aromatic compounds, and contains less dissolved sulfur compounds than oils fuel. The authors of the study (Goyal, 2003) compared the pollution levels in Delhi before and after the implementation of the project to convert public road transport in 2002 to compressed gas. A decrease in the number of suspended particles by 14%, CO by 10%, SO_2 by 22% and NO_x by 6% was found. In (Huang, 2016), the authors also conducted a study of CO, HC and NOx emissions from 9 vehicles under 8 operating conditions. Based on the data obtained, the influence of operating conditions and types of fuel on the level of pollution was analyzed. Thus, the contribution of CNG to smog generation may be less than that of vehicles with gasoline and diesel engines. But there are studies (Dondero, 2005) in which CNG results were unsatisfactory or even worse than gasoline vehicles due to inadequate maintenance of CNG vehicles. With the obvious advantages of NGV fuel, as we see, the problem of its implementation is the undeveloped infrastructure, in particular, deficiency of refueling stations and services. Therefore, in our opinion, a good alternative is the application of gas generating plants, which, in addition, contribute to the rational use of waste.

3 RESULTS AND DISCUSSION

The designs of the produced automobile gas generator units have not changed significantly since the middle of the last century. Specific requirements for transport gas generators (small dimensions, stability of the gasification process, variable mode and the necessity for more thorough purification and cooling of gas) require a comprehensive analysis of modern gas generator plants and further optimization of transport gas generators by improving their design (Makarova, 2019). It is known that one of the most successful technical solutions of the last century is a gas generator of the Imbert and Volkswagen Type 82. Such gas generators were produced by many automobile companies, including GM, Ford, Mercedes-Benz. Currently, the companies of France, VOLVO (Sweden), "Attik" Ukraine, "Nasha-Energiya" LLC, Ukraine, the "Adaptika" group of companies, Russia produce automobile gas generators that do not require any major vehicle alteration, which are installed: on a trailer; inside the body; between the body and the cab (Fig. 1). The use of synthetic combustible gas based on generator gas obtained from solid industrial and domestic wood waste, including with the addition of polyethylene-containing waste can be accepted as a promising direction as a motor fuel both on mobile and stationary plants. Fig. 2 presents a gas generator set (general view), which can be both stationary and mobile.

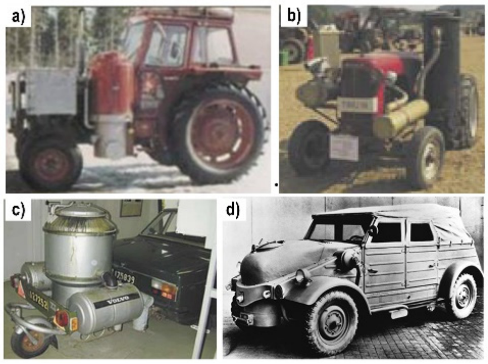

Figure 1: Layouts of gas generating plants: a, b - gas generator tractor with a gas generator set of the "Imbert" type (Sweden, 1976), (France, 2004); c - trailed gas generator set of the "Imbert" type of the VOLVO company (Sweden, 2002); d - gas generator vehicle Volkswagen Type 82 (Volkswagen AG, 1944).

The processes for producing generator gas from wood waste are represented by the suggested formulas for the composition of the gas generated from wood with an initial moisture content of 20% per 1 m^3 – (97 g of moisture); 3.5 g - dust; 0.5 g - resin:

$$0.054(C_6H_{10}O_5+2,2H_2O) + 0.097(O_2+4N_2)= \\ =0.161H_2+0.209CO+0.092CO_2+0.023CH_4+0.388N_2 \\ +0.009O_2+0.117\ H_2O+Q_3$$

where Q_3 is the heat released as a result of the reaction of obtaining generator gas from wood.

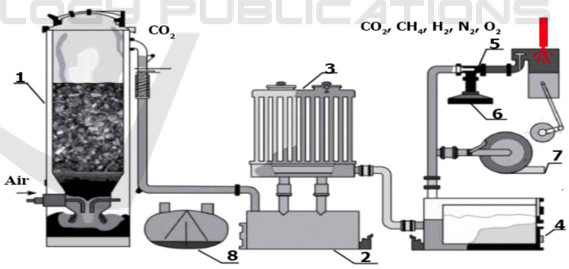

Figure 2: General view of the gas-generator: 1-hopper, 2– coarse filter, 3– cooler, 4– fine filter, 5– mixer; 6– air-leaner. 7 - fan, 8 - ash pan.

Gas generator vehicles are divided into two groups: (1) running on liquid fuel, converted for temporary operation on generator gas; (2) specially manufactured for continuous operation on generator gas. The first group of liquid-fueled vehicles converted for temporary operation on generator gas was selected for the research. So, a widely used vehicle of the Gazelle 3302 brand was chosen, with a ZMZ - 4063.10 engine, running on AI 92 gasoline, having the following technical characteristics: carburetor engine, in-line, 4-cylinder, 4-stroke, 16-

valve; rated power at 4500 rpm 110 hp (kW); maximum torque 19.5 kgcm (Nm) at 2500 rpm; carrying capacity 1500 kg with a gross vehicle weight of 3500 kg; minimum specific fuel consumption up to 195 g / hp from 2000 to 3000 rpm; maximum speed 115 km / h and maximum power 125 hp at a shaft speed of 5000 rpm; transmission: mechanical, five-speed, three-shaft, fully synchronized, gear ratios: 4.05 - 2.34 - 1.395 - 1.0 - 0.849 (GAZEL, 2005). One of the ways to increase fuel efficiency during the operation of a Gazelle vehicle is its converting from gasoline to compressed gas methane CH_4, which is accompanied by a decrease in engine power (by 15% or more) when a calorific value of combustible gas is reduced, the filling of cylinders and the combustion rate of fuel-air mixtures are decreased (Zolotnitskiy, 1997). In addition, the actual Gazelle vehicle carrying capacity, when 6 cylinders with compressed methane (total weight 360 kg) are installed, decreases from 1500 kg to 1140 kg, i.e. by 14%. Also, the average speed of cargo delivery and vehicle performance are reduced. For most vehicle owners, the determining factor is the difference in price between gas engine fuel and gasoline, which is two to three times lower (the cost of 1 liter of AI-92 gasoline in the central region of Russia is 42 rubles / liter or more, and gas - about 14 rubles. / l.). The cost of re-equipping a Gazelle vehicle with a gas installation will amount to 15 thousand rubles. Payback, with a fuel consumption in the urban cycle of 17 l / 100 km, will be achieved in 2-3 months - and this is without taking into account the reduction in oil costs and an increase in engine distance between overhauls.

Thus, the absence of dissolving and flushing properties in the gas contributes to an increase in the service life of engine oil by 1.5 - 2 times and a decrease in its consumption by 10 ÷ 15%. At the same time, the engine distance between overhauls is increased by 1.5 - 2 times. The operation of the ignition system also is improved, the service life of the spark plugs increases by 40%. The toxicity of carbon monoxide (CO) is significantly reduced - by 2-3 times, for nitrogen oxide (NO) - by 1.3-1.9 times. No resinous deposits build up in the fuel system and combustion chamber. Gas is a high-quality fuel with an octane rating of about 105, therefore knocking knocks in the engine are completely eliminated. If the vehicle is equipped with a catalytic converter, its safety when running on gas is guaranteed. In addition, the noise level is reduced by 2-3 dB, and the engine itself runs smoother. However, it should be taken into account that when converting from gasoline to gas, the engine power decreases under the same operating modes. The reason is a decrease in the filling factor of the cylinders and a 6-8% decrease in the release of heat by gas per unit volume of the combustible mixture, despite the fact that a unit of gas mass releases more heat (propane gas - 10972 Kcal / kg; butane gas 10845 Kcal / kg, gasoline - 10500 Kcal / kg).

For engines, two types of gas fuel are mainly used: liquefied petroleum gas (propane-butane) and compressed natural gas (methane). The highest distance between overhauls without refueling is provided by a system running on liquefied gas, for example, with the same volume of cylinders, about 3 times more than on compressed methane. And thanks to the latest developments of specialists, it can be assumed that the future belongs to installations powered by methane. Methane is significantly cheaper than liquefied propane-butane obtained from oil. In addition, methane is 1.6 times lighter than air, and in case of a leak it instantly evaporates (propane-butane is 1.5 - 2 times heavier than air and, if it leaks, can accumulate in rooms, forming an explosive mixture with air.). Methane is less explosive: for an explosion to occur, it must accumulate 2.5 times more than propane. Servicing gas is no more dangerous than handling gasoline, but requires other rules to be followed.

The research and production company “SAGA” (Moscow) and JSC “INKAR” (Perm) have developed and have already launched the production of the automobile gas fuel system (AGFS) “SAGA-7” for compressed natural gas (CNG) - methane. It is installed as the additional equipment on any models of passenger vehicles, light trucks and minibuses of domestic and foreign production with an engine capacity of up to 4 liters. The system compares favorably with similar systems, design and technological solutions and quality of manufacturing.

Integrated use of the SAGA-7 gas fuel system (AGTS) device and a new arrangement of gas generating equipment under the body will eliminate the shortcomings of the experimental model of the gas generating vehicle. This decision, in our opinion, opens up the possibility of creating a universal vehicle on alternative fuels for use in agriculture and forestry, as well as in remote villages, both in everyday life and in emergency situations, since it does not need fuel and financial injections from the side of state budget. One, two or three cylinders can be installed depending on the vehicle brand, size and weight of the cylinders. The metal cylinder body is covered with a fiberglass reinforcement layer, which increases strength and reduces weight. The inner surface is coated to protect against corrosion. The gas reserve in three cylinders is designed for about 250 km. In (Makarova, 2019), an approach to the layout of an automobile gas generator shown in Fig. 3, which is fundamentally new and has not been described in the well-known literature on gas-generating vehicles. The layout of the proposed automobile gas generator is based on the principle of its division into bunker and reaction zones (Fig. 4). In this case, the bunker, the gasification chamber and the ash pan are installed under the truck body. The bunker is installed horizontally, while the gasification chamber and ash pan are installed vertically (Gubacheva, 2012). Since the bunker is installed separately from the gasification chamber, an automated stoker burner must be used for continuous and metered fuel supply from the bunker to the gasification chamber.

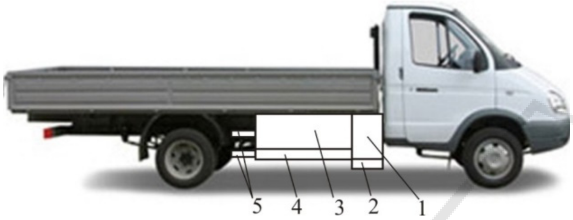

Figure 3: GAZ-330202 GAZel vehicle with the elongated base: 1 – gasification chamber; 2 – ash-bin; 3 - agitating tank; 4 – pellet burner; 5 – reductor engine.

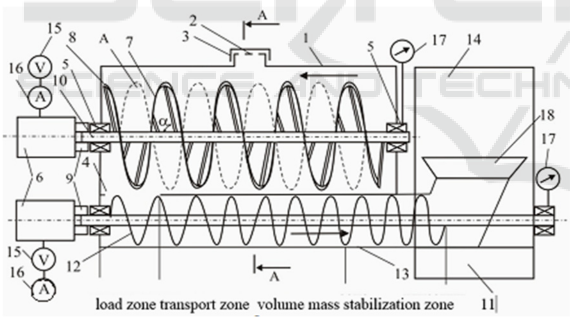

Figure 4: Automobile gas generator feeder construction: 1 - bunker-turner; 2 - loading hatch; 3 - hatch cover; 4 - unloading window; 5 - bearing units; 6 - drives of the screws of the pellet burner and bunker - turner; 7 - rib-blade; 8 - tape auger; 9 - clutch; 10 - the shaft of the tape auger 8; 11 - ash pan; 12 - continuous auger of a pellet burner; 13 - pellet burner; 14 - gasification chamber.

At the same time, any measures aimed at increasing the environmental efficiency of vehicles are accompanied by changes in their operational and technical indicators, and not always for the better.

So, to assess the indicators, a Gazelle 3302 vehicle with a ZMZ 4063.10 engine was chosen, using various types of fuel: gasoline AI 92 (total weight of the vehicle is 3400 kg, carrying capacity - 1500 kg); methane CH_4 (the total weight of the vehicle is 3400 kg, the reduction in carrying capacity due to the installation of 6 compressed methane cylinders with a total weight of 360 kg - up to 1140 kg); gas obtained in the modernized installation of a horizontal type gas generator (the total weight of the vehicle is 3400 kg, a decrease in carrying capacity due to the installation of a gas generator with a total weight of 260 kg - up to 1240 kg).

The assessment was carried out according to the methodology for calculating the traction and speed qualities of vehicles, taking into account the distinctive features. This is especially important for the deteriorating quality of the road surface, which after each autumn - winter period turns into a direction covered with holes for moving vehicles.

Fig. 5a shows the comparative calculated traction and speed characteristics of a Gazelle vehicle with an engine of the ZMZ - 4063.10 type, which operates on: a) gasoline; b) on gas obtained in a conventional gas generator on wood; c) on gas obtained in a modernized gas generator on a mixture of wood and polyethylene-containing waste (modernized engine ZMZ - 4063.10). Analysis of the obtained characteristics shows that the calculated maximum traction force when operating on conventional gas-generating gas falls from 1120 kgf to 690 kgf, i.e. by 39%, as in the case of experimental trips of the Gazelle 3302 vehicle with a ZMZ engine - 4063.10.

According to the requirements listed above, it is most advisable to install gas generators on trucks that have a large power reserve when operating on gasoline and diesel fuel. These can be medium and large-capacity vehicles. Re-equipment of these vehicles with gas generators is carried out with minimal power loss (up to a maximum of 30% if the engine is petrol) and without any chassis changes. In diesel engines (especially in turbocharged engines), the convert of a vehicle to generator gas can be carried out without any noticeable power loss at all. Let us consider as an object of research another vehicle, a MAZ-Sapphire garbage truck powered by a gas engine - YaMZ-53644 CNG (Fig.5b). The garbage truck is designed to remove garbage from the territory of towns and settlements to landfills, waste transfer stations or garbage incineration plants (Garbage, 2018). This 6-cylinder gas engine (CNG), 4-stroke, in-line cylinder, liquid cooling system, turbocharging and charge-air cooling in an air-to-air heat exchanger was mounted on a vehicle. Compression ratio 12. The YaMZ 53644 CNG engine is 90% unified with diesel, but transferred to the Otto cycle.

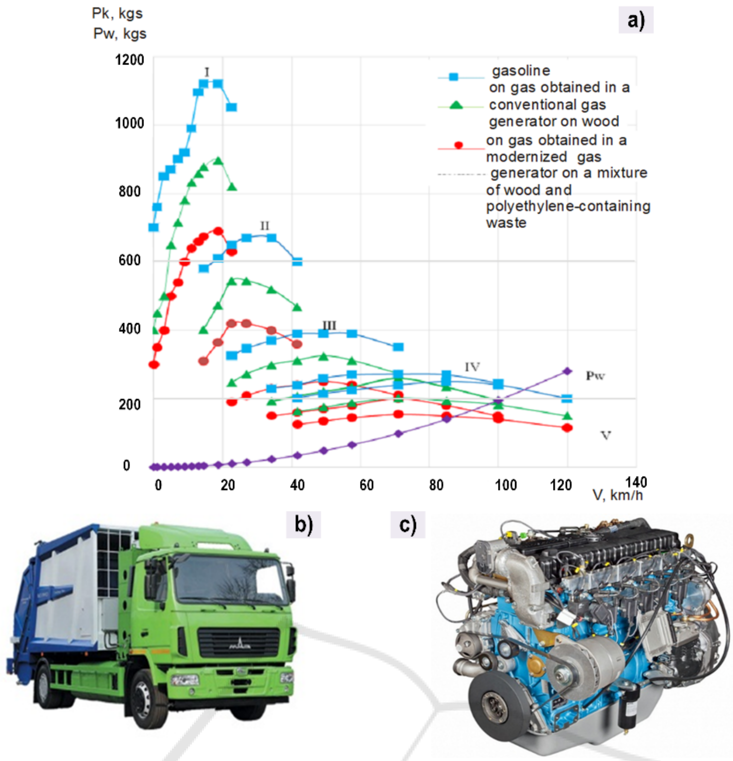

Figure 5: a) Comparative design traction and high-sheed characteristics of Gazellevcar 3302 with the ZMZ engine- 063.10; b) Vehicle MAZ-Sapphire on a gas engine- YaMZ- 53644CNG (Sapphire-eco, 2018); Gas engine- YaMZ- 53644C (YaMZ,2015).

The YaMZ-53644 CNG engine - in terms of emissions of harmful substances, corresponds to environmental class 5: UN Regulation No. 49-05B2 (G) Euro 5 (Fig. 5c). Figure 6 shows the speed characteristics (rotational speed (n, min^{-1})) for the YaMZ-536 CNG engine, depending on the net engine power (N_e, hp) and torque (M_e, Nm).

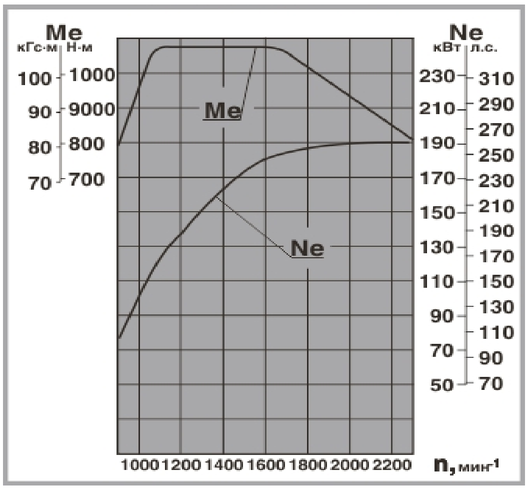

Figure 6: Speed characteristics for the YaMZ-53644 engine (YaMZ,2015).

The technologies under consideration for the use of polyethylene containing solid waste may be of interest for further improving the systems when using alternative generator gas to increase the environmental level of gas-diesel transport vehicles. The Mercedes-Benz engine is refitted and can operate in both diesel and gas-diesel modes. In gas-diesel mode, the engine simultaneously consumes both diesel fuel, which acts as an igniter, and gas, which contributes to better combustion of the mixture, while all the power characteristics of the engine are preserved. The power reserve of the KAMAZ-5490 NEO in gas-diesel mode is 450 km. If the gas runs out of cylinders, the vehicle automatically enters diesel mode and can drive another 950 km until the next gas station. The figure 7 also presents the estimated power of the gas-diesel engine Mercedes-Benz in the case of conversion to generator gas produced from the mixture of wood with plastic waste.

As a design of the gas-diesel process is considered when using wood generator gas at 90% of engine power and 10% of power on diesel fuel with an air excess coefficient $\alpha = 1.4$.

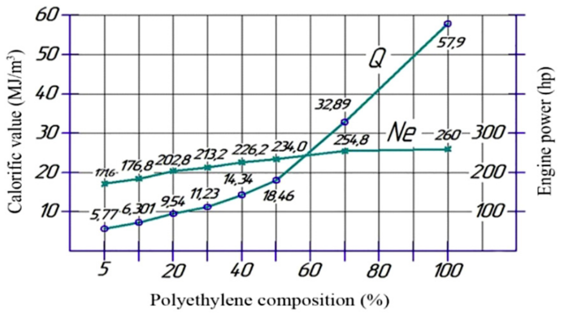

Figure 7: Graph of the generator gas calorific value Q and engine power Ne versus the polyethylene content in MSW.

The balance equation represents approximate composition of the generator gas produced from wood with 20% initial humidity and containing in 1 m3 97 g of moisture, 3.5 g of dust, 0.5 g of resin.

$$0{,}054(C_6H_{10}O_5+2{,}2H_2O) + 0{,}097(O_2+4N_2) = 0{,}161H_2 + 0{,}209CO + 0{,}092CO_2 + 0{,}023CH_4 + 0{,}388N_2 + 0{,}009O_2 + 0{,}117\ H_2O + Q_3$$

where Q_3 — the heat generated by the reaction of producing the generator gas from wood.

After cooling and cleaning, the generator gas in a mixture with air enters the ICE cylinders and is ignited by diesel fuel injection.

The approximate equation of combustion of the fuel-air mixture with an excess air coefficient α = 1.4 in the engine cylinders can be

$$0{,}161H_2+0{,}209CO+0{,}092CO_2+0{,}023CH_4+0{,}388N_2+0{,}009O_2+0{,}117H_2O+1{,}4\cdot 0{,}222(O_2+4N_2)+1.4\cdot 0.0444(O_2+4N_2)+0.00165C_{14}H_{30}=0.349H_2O+0.357CO_2+0.116O_2+1.888N_2+Q_3$$

where Q_3 the released heat can be determined by the formula

$$Q_3 = 3.8\cdot 1.2\cdot 0.222\cdot 112 = 113\ \text{MJ}.$$

The estimated volume of the burnt fuel-air mixture is determined by the formula:

$$V_2 = 22.4\cdot(0.349 + 0.357 + 0.116 + 1.888) = 60.5\ m^3$$

The estimated mass of the gas mixture is determined by the formula:

$$m3 = m3CO_2 + m3H_2O + m3N_2 + m3O_2 = 6{,}29 + 15{,}7 + 53 + 3{,}7 = 78{,}69\ \text{kg}.$$

The estimated increase in gas temperature in the ICE cylinders after combustion of the fuel-air mixture is determined by the formula

$$t3 – t0 = Q3/m3 = 113\cdot 106/78.69\cdot 103 = 1440°C,$$

and the full temperature will reach 1652°C.

The estimated heat density in the engine cylinders is determined by the formula

$$Q31 = Q3/V3 = 113/60.5 = 1.87\ \text{MJ/m3}.$$

The estimated coefficient of diesel engine power reduction after conversion to diesel plus generator gas will be

$$Kne31 = Q31/Q1 = 1.87/1.90 = 0.982.$$

Figure 8 presents comparative diagrams: of the coefficients of excess air α (figure 8a), temperature rise of the fuel-air mixture (t3 – t0)°C (figure 8b), and the heat density of the gas working mixture Qpci (MJ/m3) (figure 8c).The diagrams respect various options of engine power supply systems when operating in the mode of a conventional diesel engine (1), gas-diesel engine (2) and generator gas-diesel engine (3).

The estimated coefficient α1 = 2 for a conventional diesel engine and α2 = 1.9 for a gas-diesel engine running on methane CH_4 was taken proceed from combustion of the hydrocarbon components. For option 3, the estimated coefficient α3 = 1.4 was taken based on the combustion of hydrocarbons, CnHm, carbon monoxide CO and hydrogen H_2.

The estimated values of the temperature rise of the fuel-air mixture in ICE cylinders during combustion reach values of 1640-1730°C. Heat density varies between 1.90-1.74 MJ/m3.

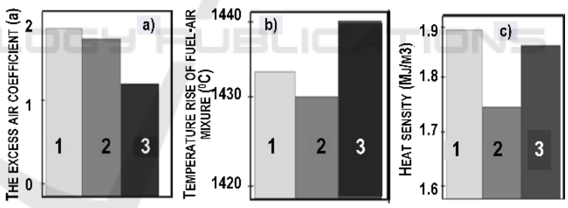

Figure 8: Comparative diagrams for various options of engine power supply system's when operating in the mode of a conventional diesel engine (1), gas-diesel engine (2) and generator gas-diesel engine (3): a — air excess coefficients αi; b — temperature rise of the fuel-air mixture; c — heat density of the gas working mixture.

The analysis shows that when converting the diesel engine of option 1 to the gas-diesel mode of option 2 with the consumption of methane CH4, a power drop of 8-9% occurs due to losses of combustion and evaporation of the H2O being formed. For gas-generator with a diesel engine, a lower power drop will occur due to the presence in the generator gas of a large amount of carbon monoxide CO, the combustion temperature of which in air is 2300°C.

4 CONCLUSIONS

1. One of the ways to solve the problem of environmental pollution with polyethylene-containing waste is proposed. It consists in processing their mixture with wood solid waste into generator gas.

2. Maintaining the transport infrastructure and the vital activity of small villages and remote settlements requires additional expenditures from the budget for energy carriers, including liquid motor fuel, the delivery of which is difficult in the absence of transport infrastructure and seasonal operation of river transport.

Under these conditions, in remote areas, it is advisable to re-equip vehicles of the type: "Gazelle 3302", with a ZMZ 4010.63 engine, for dual power: ordinary gasoline and generator gas obtained from both wood waste and a mixture of wood and polyethylene-containing waste.

3. The advantages of gas engines include minimal emissions of harmful substances and the absence of soot emissions. The engine has less noise compared to diesel one. As a result, it will significantly improve the environmental situation in big cities, when it is installed on a transport.

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