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ALTERNATIVE FUELS FOR TRANSPORT

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Summary. The review of automotive gas generators to produce generator gas for internal combustion engines is made. the properties of different types of gas-producing fuels and their comparative analysis are considered. The indicative equivalent of different kinds of fuel mass to gasoline and diesel fuel, and analysis of prices of major fuels is shown. A comparative environmental analysis of various types of fuels is conducted. The main parameters of the gasification process, depending on the type of fuel are calculated. The comparative analysis of standards on pellet fuel in Germany, Austria and Sweden is represented.

Key words: automobile gas generator, biofuel, pellets, gasification options.

INTRODUCTION

In accordance with the National Energy Program of Ukraine up to 2010 the need for fuel resources will amount to 273 million tones of a.f.\year. Now Ukraine covers its needs in energy resources at the expense of domestic production less than 50%, while the rest is imported. In addition, the steady decline in world reserves of fossil fuels and their constantly growing price makes energy supply of Ukraine one of the most important national problems. One of the strategic objectives is the efficient use of both renewable and non-renewable energy resources. [1, 2]

The alternative to hydrocarbon raw materials for the internal combustion engines operation is the use of transportational gasgenerators, that process the local solid fuel oil or fossil (wood, peat and brown coals), as well as derivatives of these fuels (wastes of timber and wood, plants biomass, mixture of coal fines (upto 25mm) and coal dust, in ratio 1:2, peat bricks, semi). [Geletukha 1998, Samylin 2005]

OBJECTS AND PROBLEMS

Produced at present, automotive gasifiers, do not require any major alterations in the car are set: on the trailer - towing gas generator as «Imbert» company VOLVO, company «Attik» Ukraine; inside the body of trucks - gasification truck, Framce; between body and cab - УГК-150 with the size of the gas generator, diameter 600 mm,

height 1800 mm, total weight - 300 kg, which uses waste wood as fuel for engines for ZIL and GAZ - upto LAZ and LuAZ, Ltd. «Nasha Energia», Ukraine, Group of Companies "Adaptika", Russia; on the the cockpit - a tractor with the gas generator as "Imbert" France [Samylin 2005]

A disadvantage of known automobile gas generators is, that they reduce the effective area of the vehicle or require the use of trailer.

To increase the effective volume and area of gas generator truck body seems appropriate to create new automated gas-motor vehicles, that would have minimum dimensions for height in order to install them under the car body.

One of the variants of solutions to this problem is the separation of the reaction and bunker zone gasifier. To implement such separation it is necessary to choose the form of solid fuel.

The aim of this work is to choose the solid fuel for automated gas-producing installations, that are used for industrial vehicles, minimised in height and weight.

The fuel for gas-producer vehicles, must have: a certain size pieces; specific humidity, lowest ash content and ash melting, which should not exceed the established limits; a certain amount of volatile; high reactivity capacity; sufficient mechanical strength or abrasion, that the fuel couldn't be scattered during transportation, storage and gasification in the gasifier; high specific heat value; low cost. The last figures determine the profitability of a particular type of fuel, and other parameters affect the flexibility and stability of the process of gasification gas generator vechicle, reliability of gas generators, frequency of reloading. According to indicators, fuel is divided into classes: 1 - fuel of good quality, 2 – fuel quality is quite satisfactory, 3 – fuel of satisfactory quality. Characteristics of gas-producing fuels are presented in Table.1 [19, Ovsyanko 2007, Fomin 2005, Yudushkin 1955, Obemberger 1998, Shchadov 2007].

Table 1. **Characteristics of gas-producing fuels**

The fuel	Class	Size pieces, mm	Content in % by weight not more than				The melting point of ash, C^0 not less than	Bulk density, kg / m^3	Calorific value of bulk volume, MJ / kg	Abradability, %
			moisture $W_{a\acute{o}c}$	Ash A^e	Volatile V^r	Sulphur S^c				
Waste wood	1	30x40x60	30	0,4 -1	75 - 80	- - - -	1400	220 - 360	10,3	
Pellets with low crust (first grade)		<∅8 *l* 0,5-30	5-7%	< 0,7	8-12			600	18,9	Not more 1
Industrial pellets the content of the crust over 0,7-1,5%		∅ 8-12 *l* 0,5-30	5-7%	>0,7				500	18,9	Notmore 1
Semi	2	10-40	9	8-11	9	1,0	1100	400-450	12,2	
Anthracite	3	6-13	3-8,5	7-10	5-7	1-1,5	1250	900-1000	26,9	

Dimensions of fuel affect their bulk density and consequently on the volume of equipment, as well as on the efficiency of passage through the auger feed system for automated generator sets and attrition. Bulk density - a indicator which is associated with the cost of pellets transporting and storing. The lower price - more expensive transportation. Bulk density of pellets depends on the density of fuel pellets and their diameter. The density – the rate, which affects the efficiency of the furnace, burning rate, transportation costs, storage. The greatest bulk density is anthracite and then pellets with low bark. For these fuels is possible to use bunker of smaller volume. For screw feed system of small diameter the use of anthracite is most effective and then pellets with low bark. Moreover, Many well-known modern heating plants because of the construction of supply system, work better with a 6 mm pellet. Equipment manufacturer specifies the type and diameter of the pellets to be used. The use of pellets of other sizes is not recommended, as to begin with, automatic system of the boiler is configured for optimal air flow and pellet diameter of this particular, secondly the use of pellets of larger size than it is recommended, leads to increase the stress on the mechanics of the boiler, that can lead to premature failure of the system. With regard to abrasion it is obviously, it will be the smallest of anthracite, because it has the greatest strength [Tokarev 1955], and further waste.

Humidity - indicator that affects not only the calorific value, but also on storage stability, excluding the self-ignition, minimizing losses. This indicator also affects the gas generator, reducing its efficiency. This is due to the fact that part of the energy in the gasification of wood goes to evaporating the water contained therein. The smallest is approximately the same value of moisture content has coal and pellets of different varieties.

Ash content is a necessary measure, as its content in the fuel leads to a decrease in the efficiency of gas generators, complicates the application of automation. In the gas generators the gasification chamber is slaggingIn the case of ash with a low melting point (fuel of the second and third class) and leads to emissions of particulate matter. The lowest ash content in fuels is in the fuels of the first, and the highest – of the second and third class.

Although, that most of the sulfur refers to combustible matter of fuel - it is a harmful impurity. Resulting during the combustion of sulfur dioxide pollutes the environment and destroys the metal surfaces of the gas generator, purification systems for gas and engine. From the above data follows that the most appropriate fuel for the gasification is the fuel of the first class.

Indicator of volatile substances is used to select the type of gas generator. Obviously, for fuel made of wood waste gasifier must be applied with a reversed process, and for other fuels – direct gasification process [Geletukha 1998, Bridgwater 2002]. The reduce of volatile substances in the fuel pellet is connected with the peculiarities of their manufacture.

The great importance has the economical efficiency of the fuel. Approximate equivalent of different types of fuel mass (German fuel classification for gas generators) using (vistapellets.com) data is presented in Table. 2 .

Table 2. **Approximate equivalence of different types of fuel by mass**

Fuel Type	Amount of solid fuel in kilograms attributable	
	to one liter of gasoline	To one liter of diesel fuel
Wood (Holz)	2-3	3,2-3,8
Peat (Torf)	2,5-3	4,5 кг
Lignite (Braunkohle)	2,5	3,5
Charcoal (Holzkohle)	1,3	-
Anthracite (Anthrazit)	1,2-1,6	1,8-2,2
Pellets	1,25-1,87	2

The expected price of fuel depends on the size of calculated working calorific value capacity taking into account the moisture and ash content. This index has a value in terms of the cost of transporting fuel in large volumes. Recent calculations and analysis of prices of major fuels show, that the pellets are in many cases superior to traditional fuels (not only waste wood and coal, and diesel fuel) by the economy of use. It is necessary to consider not the price of 1 ton of fuel, but the cost of 1 kilowatt of energy, produced when using this fuel (table. 3) [19].

Table 3. **Analysis of prices of major fuels**

Fuel Type	Heating value, kW•h/ kg	Efficiency, %	Fuel price, EUR / tonne	The cost of heat, EUR / kW • h
Diesel fuel	11,63	80	250	0,027
Coal	4,65	50	45	0,019
Electricity		95		0,033
Waste wood	2,0	60	19	0,016
Pellets	4,8	85	90	0,022

When burning pellets the efficiency reaches 85%, which corresponds the use of gas and liquid fuels. The cost of heat using wood pellets can be reduced with the increase in combustion efficiency upto 97%, that is achieved by burning pellets in boilers with burners bulk-type [Geletukha 1998, Obemberger 1998].

In connection with the entry into force the Kyoto Protocol to the UN Framework Convention Climate Change becomes a legitimate format for JI projects (Article 6 of the Kyoto Protocol). This means, that when we choose the fuel for automobile producer gas plants its environmental safety must be taken into account. One of the indicators of the environmental security is the amount of ash appeared after combustion according LLC “Resayklers.ru”:

- the burning of brown coal ash produces up to 40% by weight of fuel burned;
- coal combustion – appr. 20%;
- the burning of wood – 0,5-3%.

The obvious advantage when used as fuel wood has. In this case, the ashes from wood burning can be used as fertilizer, and slag from coal combustion contains heavy metals and has though weak, but the high radioactivity [Hasler Ph , Jorgensen 1996].

The next indicator of environmental security is the amount of pollutants emitted into the atmosphere by burning of fuels (Table. 4).

Table 4. **Emissions of harmful substances during combustion of different fuels (According to "Promgaz")**

Fuel Type	Particulates (kg/Gkal)	Benzapyrene (kg/Gkal)	Heavy metals (10^{-6} kg/Gkal)
Gas	0,004-0,017	0,057-0,129	-
Fuel oil	0,2-0,4	0,046-0,69	1,1
Lignite	0,26-26,0	0,1600,67	-
Coal	8,7-12,3	0,07-0,44	0,96-64,0
Peat	3,8-11,4	1,0	0,8-3,1
Firewood	8,07	1,36-4,95	-

Heavy metals – in this case this is the sum of the content of vanadium pentoxide, arsenic, chromium and mercury in gas emissions.

These data show, that wood fuel is more environmentally friendly, than coal, with preference, apparently, should be given to the gasification plants.

The calculation of basic parameters of the gasification process, depending on the type of fuel, presented in Table 1, is presented on the elements in accordance with procedures [Samylin 2005, Yudushkin 1955, Tokarev 1955] for gasoline 4-stroke engine UMP-4215.10 (EURO-0) [5, 6] in Table 5. Working volume, 2890 куб. см. Compression ratio 8.2. The filling ratio of the engine generator gas 0.53. Engine speed 2400 rpm.

Table 5. **The main parameters of the gasification**

Parameter	Fuel				
	Waste wood	**Pellets** (first class)	Industrial Pellets	Semi	Anthracite
Gas output of 1 kg of fuel, m^3/kg	1,84	2,579	2,566	4,059	4,299
Air consumption for the gasification of 1 kg of fuel, m^3/kg	1,162	1,628	1,619	2,557	2,915
Gas moisture content, kg /m^3	0,392	0,183	0,184	0,063	0,015
Efficiency of the gas generator, %	78,7	83,9	83,9	66	81
Air consumption for combustion of 1 m^3 of gas generator, m^3/m^3	1,014	1,129	1,129	0,824	1,138
Calorific value of gas-air mixture, kkal/m^3	561,4	591,157	591,157	514,77	572,11
Hourly consumption of solid fuel, kg / h	27,372	18,48	18,578	13,73	11,038
The diameter of the gasification chamber, mm	264,39	183,62	184.18	241,76	237.44

Anthracite along with pellet fuel has good performance, but the process of burning coal can not be automated, gas contains a high content of sulfur compounds, should be disposed of slag.

Based on the drawn analysis, it is obvious, pellet fuel is the best for the creation of automated gas-producing installations, used for industrial vehicles, with minimum dimensions for height and weight.

Since the pellets are made from different kinds of raw materials it is necessary to determine their effect on quality (table 6).

Table 6. **Indicators of pellets quality, made of different raw materials according to the companies "EKOROSS"**

Quality indicators	Feedstocks		
	Sawdust		
	Soft-wood	Soft-hardwood	Mixture (50% pine and 50% hardwoods)
Density	1,147	1,141	1,144
Bulk density, kg/dm^3	526	511	520
Ash content, %	05		
Calorific value, MJ / kg	18,9	18	18,4
Abradability	0,21	0,2	0,2
Humidity	8,5	8,5	8,3
The content of SO and SCb in gases of pellets combustion , %	0		
Homogeneity, the absence of impurities	No extraneous		

Table 6 should be clear that the quality of pellets, obtained from softwood and soft-hardwood by pelleting sawdust do not differ from each other. Since the content of the fuel component (C и H) in the wood of different species varies slightly (the softwood contains carbon 50,5 %, hardwood 49,6%, hydrogen is equal -6,2%), the influence of wood on the calorific value of pellets is not much.

As mentioned above, the cost of pellet fuel is substantially affected by transport costs, therefore it is not less important to produce it in Ukraine. Pellet market in Ukraine today is at an early stage of development and according to the results of the company D & P Consult analysts estimation the annual pellet production in Ukraine in 2008 is about 190-200 tons (about 90% of it is exported to Europe). Shaped pellets production in Ukraine today are represented by maximum of 15-18 local companies. The volume of pellet production in Ukraine since 2007 to 2010 is shown in Fig. 1 (assessment of D & P Consult).

As seen in Figure, wood pellets occupy about 30-35% of total pellet production other pellets are made of sunflower husk and other crops. It is impossible to show the structure of the Ukrainian market of pellets according to product quality (first grade, industrial). The company D & P Consult explaines this fact as the specific of the Ukrainian pellet market. A large number of medium and small enterprises make pellets for their own consumption and often do not pay special attention to the quality and composition. In Ukraine there are no standards for the quality of the product. Companies that manufacture wood pellets for European markets follow standards:

- German Standard DIN 51731/DIN plus, grade 2;
- Swedish Standard SS 18 7120;

- Britisch BioGen/ United Kingdom, the Code of Fair Trade Practices;
- Austrian standard ONORM M 7135.

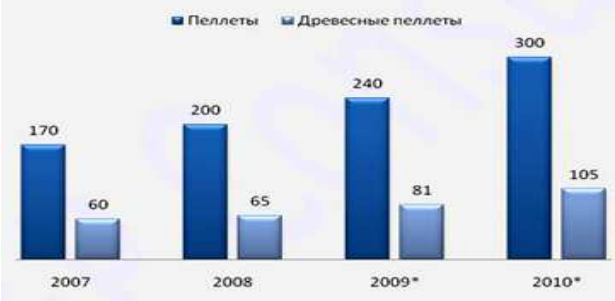

Fig. 1. Volume of pellet production in Ukraine from 2007 to 2010 (evaluation of the company D&P Consult).

CONCLUSIONS

It is established, that for automated gas plants producers for vehicles the first class pellets, low bark, diameter of 6 mm optimum fuel pellets are the most optimal choice. The cost of pellets of the first class is up to 2-2,5 times lower than the cost of gasoline. The use of pellet fuel enables to organize its continuous supply from the horizontal separately located from the gasifier storage bunker by the screw conveyor to the zone of fuel gasification. This allows the low-power sets to run on a single load during the whole day without unsealing the gasifier and install the gas generator under the body of the truck. The volume of gasification chamber for pellets is correspondingly smaller than that for other fuels, and so the size of the entire gas generator is reduced as a whole. With the gasification of the pellets gasifier efficiency is 85%, while using the bulk-type burners the efficiency of the use of pellets could increase to 97%. The use of pellets facilitates automation - gasification process is subject to certain physical conditions (temperature, pressure), that control microprocessors, automation and other analyzers. Lambda probe and the air sensor, for example, are installed almost in all modern cars. Pellets are environmentally friendly type of fuel.

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АЛЬТЕРНАТИВНОЕ ТОПЛИВО ДЛЯ ТРАНСПОРТА

Лариса Губачева, Александр Андреев, Дарья Шевченко

Аннотация. Сделан обзор автомобильных газогенераторов с целью получения генераторного газа для ДВС. Рассмотрены свойства различных видов газогенераторных топлив и проведен их сравнительный анализ. Представлен ориентировочный эквивалент разных видов топлива по массе к бензину и дизельному топливу и анализ цен на основные виды топлива. Проведен сравнительный экологический анализ различных видов топлив. Рассчитаны основные параметры процесса газификации в зависимости от вида топлива. Представлен сравнительный анализ норм на пеллетное топливо Германии, Австрии и Швеции.

Ключевые слова: автомобильный газогенератор, биотопливо, пеллеты, параметры газификации.