цев, А. Ф. Шеховцов; за ред. А. П. Марченка та А. Ф. Шеховцов. - Харків: Прапор, 2004. – 344с.

Bibliography (transliterated):

1. Trinjov A.V. Uluchshenie napryazhenno-deformirovannogo sostoyaniya vyipusknyih klapanov forsirovannyih traktornyih dizeley: avtoref. dis. kand. tehn. nauk: 05.04.02./ Trinjov A.V. - H. – 1995. – 24s. 2. Trinjov A.V. Issledovanie usloviy lokalnogo vozdushnogo ohlazhdeniya dnischa golovki tsilindrov s ispolzovaniem bezmotornogo stenda / A. V. Trinjov, A. N. Avramenko, S. V. Oboznyiy, V. I. Vahrushev // Dvigateli vnutrennego sgoraniya.- 2007.- №2.- s. 15-20. 3. Trinjov A.V. Otsenka effektivnosti lokalnogo ohlazhdeniya golovki tsilindrov dvigatelya KaMAZ v bezmotornom eksperimente / A. V. Trinjov, V. T. Kovalenko, S. V. Oboznyiy, A. N. Klimenko // Dvigateli vnutrennego sgoraniya. - 2011.- №2.- s. 19 – 24. 4. Trinjov A.V. Eksperimentalnyiy analiz teplovogo sostoyaniya vtulki vyipusknogo klapana traktornogo dizelya / A. V. Trinjov, A. F. Minak, V. T. Kovalenko, A. N. Avramenko, S. V. Oboznyiy // Dvigateli vnutrennego sgoraniya.- 2007. - №2. – s. 15-20. 5. Marchenko A. P. Dviguni vnutrishnogo zgoryannya: u 6t. t. 3 Komp'yuternI sistemi keruvannya DVZ / A. P. Marchenko, M. K. Ryazantsev, A. F. Shehovtsov; za red. A. P. Marchenka ta A. F. Shehovtsov. - HarkIv: Prapor, 2004. – 344s.

Поступила в редакцию 28.05.2013

Тринёв Александр Владимирович - канд. техн. наук, доцент, доцент кафедры двигателей внутреннего сгорания, Национальный технический университет «Харьковский политехнический институт», Харьков, Украина, тел. 0967596021.

Сивых Дмитрий Георгиевич - канд. техн. наук, доцент, доцент кафедры колесно-гусеничных машин, Национальный технический университет «Харьковский политехнический институт», Харьков, Украина, e-mail: sivikh@rambler.ru

Синявский Евгений Валериевич – магистр кафедры двигателей внутреннего сгорания, Национальный технический университет «Харьковский политехнический институт», Харьков, Украина, e-mail: nardtron@mail.com.

Пилипенко Олег Юриевич - магистр кафедры колесно-гусеничных машин Национальный технический университет «Харьковский политехнический институт», Харьков, Украина, e-mail: andgak@gmail.com.

АВТОМАТИЧНЕ РЕГУЛЮВАННЯ ТЕПЛОВОГО СТАНУ КЛАПАННОГО ВУЗЛА ШВИДКОХІДНОГО ДИЗЕЛЯ

О. В. Триньов, Д. Г. Сівих, Є. В. Синявський, О. Ю. Пилипенко

Розроблена електронна система автоматичного регулювання теплового стану клапанного вузла форсованого швидкохідного дизеля. Проведена перевірка алгоритму роботи системи та надійності робочих елементів в умовах безмоторного експерименту. Для охолодження клапанного вузла і міжклапанної перетинки використовується стиснене повітря. Передбачається впровадження системи регулювання на форсованих дизелях вантажних автомобілів.

AUTOMATIC CONTROL OF THE THERMAL STATE OF THE VALVE UNIT IN HIGH-SPEED DIESEL ENGINE

A.V. Trinjov, D.G. Sivyh, E.V. Sinyavskii, O.Y. Pylypenko

Developed an electronic system of automatic control of the thermal state of the valve unit of the high-speed diesel engine. The algorithm of the system and the reliability of the work items in a non-motorized experiment was audited. For cooling the valve unit and the arch between the valves a compressed air was used. It is expected to use such controll system at high-load lorry diesels.

УДК 621.43.052

A.P. Marchenko, D.E. Samoilenko, Omar Adel Hamzah

THE PROBLEMS OF UTILIZATION OF FLARE GASES IN INTERNAL COMBUSTION ENGINES

The problem of flare gases utilization in internal combustion engines is considered. Flaring associated gas from oil drilling sites is the most promising fuel for such purpose. Also the problems of detonation arising during the operation of internal combustion engines on flare gases are also studied. It is shown that the only independent parameter that affects the occurrence of detonation during operation of a gas engine is methane number which is a physical characteristic of the gas. The new conception of the internal combustion engine with on-board steam reformer to avoid the problem of detonation is offered in present study.

Introduction

Flare gases such as flaring associated gas from oil drilling sites can be utilized in Internal Combustion Engines. At present, such gas is just flaring in gas combustion devices that is harmful for human health, and is a contributor to the worldwide anthropogenic emissions of carbon dioxide. For example, oil refinery flare stacks may emit methane and other volatile organic compounds as well as sulfur dioxide and other sulfur compounds, which are known to exacerbate asthma and other respiratory problems. Other emissions include, aromatic hydrocarbons (benzene, toluene, xylenes) and benzapyrene, which are known to be carcinogenic.

As of the end of 2011, 150 billion cubic meters of associated gas are flared annually. That is equivalent to about 25 per cent of the annual natural gas consumption in the United States or about 30 per cent of the annual gas consumption in the European Union [1].

The top ten leading contributors to world gas flaring at the end of 2011, were (in declining order): Russia (27%), Nigeria (11%), Iran (8%), Iraq (7%), USA (5%), Algeria (4%), Kazakhstan (3%), Angola (3), Saudi Arabia (3%) and Venezuela(3%) [2].

That amount of flaring and burning of associated gas from oil drilling sites is a significant source of carbon dioxide (CO2) emissions. Some 400 million tons of carbon dioxide are emitted annually in this way and it amounts to about 1.2 per cent of the worldwide emissions of carbon dioxide. That may seem to be insignificant, but in perspective it is more than half of the Certified Emissions Reductions (a type of carbon credits) that have been issued under the rules and mechanisms of the Kyoto Protocol as of June 2011 [1, 3].

Satellite data on global gas flaring show that the current efforts to reduce gas flaring are paying off. From 2005 to 2010, the global estimate for gas flaring decreased by about 20%. The most significant reductions in terms of volume were made in Russia and Nigeria [1,4].

From the other side flare gas can produce energy by using it in internal combustion engines.

The problem of utilization flare gases is solved in Ukraine at mine named after Zasjadko [5]. In 2004 at mine named after Zasjadko started designing powerful cogeneration plant using coal mine gas as a motorfuel. The first phase of the station with electrical capacity of 36 MW and 35 MW was equipped with 12 pre-chamber gas-powered GE Jenbacher engines. The station was commissioned in 2006 on the eastern industrial area of the mine.

To study the possibility of using flare gases in Internal Combustion Engines it is important to know the properties and fuel characteristics of such gases. The major flare gas fuel properties are: Specific Gravity & Density, Moles and Molecular Weight, Heat Value.

The major physical properties of Gases are shown in Table 1[6].

Table 1: Physical Properties of the main components of flare Gases (Metric Units)

Gas Density, 0°C, 101,31 kPa Heat Value: At 0°C													
Gas	Formula	Boiling Pt at 101.3 kPa	Specific Gravity (Air = 1)	Nm³ Gas/kg	Nm³ Gas/L Liquid	kg/L Liquid	MJ/Nm³ Vapor (LHV)	MJ/Nm³ Vapor (HHV)	MJ/kg Liquid (LHV)	MJ/L Liquid (LHV)	Air Required For Combustion (Vol/Vol)	Flammability Limits Volume Percent In Air Mixture	
												Lower	Higher
Methane	CH_4	−161,51	0,5539	1,3997	0,4190*	0,2994*	35,746	39,700	50,034	14,980*	9,53	5,00	15,00
Ethane	C_2H_6	−88,59	1,0382	0,7468	0,2656	0,3556	63,626	69,558	47,516	16,897	16,67	2,90	13,00
Propane	C_3H_8	−42,07	1,5226	0,5119	0,2578	0,5062	90,992	98,900	46,579	23,578	23,82	2,00	9,50
iButane	C_4H_{10}	−11,79	2,0068	0,3864	0,2171	0,5619	117,937	127,823	45,571	25,606	30,97	1,80	8,50
nButane	C_4H_{10}	−0,51	2,0068	0,3864	0,2253	0,5831	118,346	128,231	45,729	26,665	30,97	1,50	9,00
iPentane	C_5H_{12}	+27,83	2,4912	0,3112	0,1940	0,6234	145,397	157,264	45,248	28,208	38,11	1,30	8,00
nPentane	C_5H_{12}	+36,05	2,4912	0,3112	0,1961	0,6301	145,589	157,578	45,307	28,548	38,11	1,40	8,30
Hexane	C_6H_{14}	+68,72	2,9755	0,2606	0,1728	0,6630	173,104	186,940	45,111	29,909	45,26	1,10	7,70
Heptane	C_7H_{16}	+98,37	3,4598	0,2241	0,1539	0,6869	200,478	216,287	44,927	30,860	52,41	1,00	7,00
Octane	C_8H_{18}	+125,65	3,9441	0,1966	0,1387	0,7056	227,831	245,626	44,792	31,605	59,55	0,80	6,50
Carbon Monoxide	CO	+156,44	0,9670	0,8018	+	+	12,598	12,598	10,101	+	2,39	12,50	74,20
Carbon Dioxide	CO_2	+42,91	1,5196	0,5103	0,4167	0,8167	0	0	0	0	+	+	+
Hydrogen	H	+217,17	0,0696	11,1651	+	+	10,766	13,451	120,203	+	2,39	4,00	74,20
Hydrogen Sulphide	H_2S	−60,27	1,1767	0,6589	0,5272	0,8001	23,065	25,043	15,198	12,160	7,20	4,30	45,50
Oxygen	O_2	−182,95	1,1048	0,7018	0,8002	1,1403	0	0	0	0	+	+	+
Nitrogen	N_2	−195,80	0,9672	0,8016	0,6478	0,8081	0	0	0	0	+	+	+
Air		−194,34	1,0000	0,7754	0,6771	0,8733	0	0	0	0	+	+	+

The most important flare gas characteristics are stoichiometric air/fuel ratio and methane number (MN). All these properties and characteristics have a core influence on detonation of the engine.

The purpose of this paper is to analyze the problems of detonation arising during the operation of internal combustion engines on flare gases, and finding possible ways to overcome it.

Detonation and Pre-ignition

Detonation and pre-ignition are two forms of abnormal combustion that involve uncontrolled burning of the fuel-air mixture in the cylinder. Pre-ignition is the term used to describe premature ignition of the fuel-air mixture before the spark plug has fired. Detonation describes the scenario where the fuel-air mixture is ignited at the proper time by the spark plug and a second ignition event takes place in the unburned fuel-air mixture before the normal combustion sequence can go to completion. Both events are potentially damaging to the engine due to their potential to produce localized high temperatures and sharp rises in pressure.

Pre-ignition is typically a result of a “hot spot” in the combustion chamber. Such hot spots may occur at sharp edges on the engine parts (such as valves or spark plugs) if they get too hot, or from carbon deposits in the combustion chamber. If these hot spots cannot cool between combustion cycles, they can get hot enough to serve as an ignition source themselves and will light the fuel-air charge before the spark plug gets the chance. Detonation is the result of a more complex set of circumstances, involving the combined influence of fuel quality, engine design, engine set-up, site construction, ambient conditions, and engine loading. If enough of these inputs stray from their proper ranges during engine operation, combustion that begins normally can suddenly see a portion of the unburned gas self-ignite before it has been met by the primary flame front. The flame fronts from these two combustion sources will eventually collide, creating a sharp metallic “ping” sound that is the audible evidence of detonation.

Detonation is the event often called “knocking” in car’s gasoline engine.

Normal combustion

Burning of the fuel-air mixture is started by the spark plug. The flame front progresses uniformly across the combustion chamber until the entire fuel-air charge is burned. Heat released by combustion produces a rise in pressure that pushes the piston down in the cylinder, producing useful work at the crankshaft. Refer to Fig. 1.

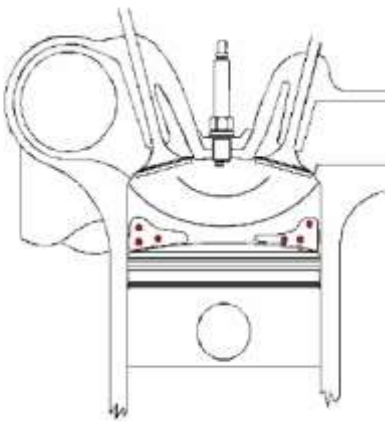

Fig. 1. Normal combustion

Detonation

The advancing flame front compresses the unburned fuel-air mixture, pushing its temperature beyond the auto-ignition point. The unburned portion of the mixture self ignites, creating a sharp rise in pressure and localized high temperatures. Refer to Fig. 2.

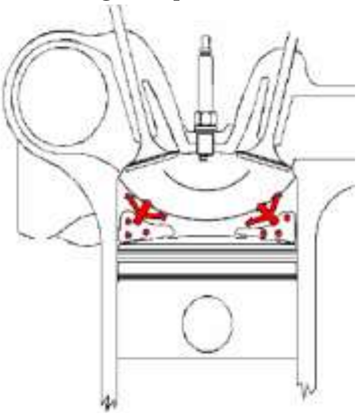

Fig. 2. Combustion with detonation

As described earlier, detonation results from one of several factors being out of range either at the start of, or during, the combustion sequence. The basic driver for detonation is the temperature of the unburned gas, or “end gas”, before it is ignited by the flame front. Because of this, the list of direct causes for detonation can be pretty well defined (although the root causes for those conditions can sometimes be more difficult to establish).

Direct causes of detonation include:

Fuel-air charge temperature too high: High starting temperature of the fuel-air mixture results in temperature rise in the end gas beyond the auto-ignition threshold.

Low fuel MN: Fuel gas does not have sufficient resistance to detonation. The fuel autoignition temperature is low compared to the standard fuel resulting in auto-ignition under normal combustion pressure rise conditions.

Focusing just on engine attributes that directly play into detonation sensitivity, four design issues come to the forefront:

- Compression Ratio
- Ignition Timing
- Aftercooler Temperature
- Power Rating
- Methane number.

In the next investigation will be studied how several of the factors are directly related to one another.

Compression Ratio

The compression ratio of the engine and the fuel MN go hand-in - hand when searching for the proper engine for a given flare gas fuel. High compression ratios tend to increase in-cylinder pressures, making factors sensitive to the pressure rise critical with regard to detonation. Low MN fuels burn faster than higher MN fuels, creating steeper pressure rise rates that are not well matched to high compression ratios. In general, low MN fuels require low compression ratio engines.

Ignition Timing

Ignition timing is also directly tied to fuel MN and pressure rise rate. Achieving peak combustion pressure at the proper time in the piston's movement in the cylinder requires that the spark plug fire at a precise moment in advance of that point. The timing of that "spark advance" depends heavily on the burning rate of the fuel, which is closely related to the fuel's MN. Lower MN fuels require the use of less spark timing advance.

Aftercooler Temperature

The aftercooler serves as the final control over the starting temperature of fuel-air charge. Because this plays directly into the risk of detonation, any design or installation issues that can compromise the aftercooler's ability to achieve the appropriate temperature in the inlet charge are critical detonation risk factors. The aftercooler can fail to provide adequate cooling of the inlet air by not being large enough to handle the heat removal demand placed on it or by being fed aftercooler water at too high a temperature. High aftercooler water temperatures can stem from improper selection of the aftercooler water thermostat set point, or an inadequately sized radiator, or by high ambient air temperatures reducing the cooling capabilities of the radiator.

Power Rating

Engine power output is the most challenging to see how it contributes to detonation because it involves the movement of the piston. Normal operation of the engine uses the pressure rise in the cylinder to push the piston and eventually drive the load attached to the crankshaft. If the driven load on the crankshaft becomes too great it restricts the movement of the piston. With the piston movement restricted, the pressure rise in the cylinder gets steeper, eventually resulting in detonation.

All previously mentioned factors have unequal impact on the detonation during operation of the particular design engine. Thus, compression ratio is a design parameter that determines the efficiency of burning in the cylinder, and therefore can not be changed or optimized. Thus, the only independent parameter that affects the occurrence of detonation during operation of a gas engine is methane number which is a physical characteristic of the gas.

Methane number

The key property of flare gas as was mentioned before is the ability of the fuel gas to resist detonation. For this reason, having a measure of this detonation resistance property provides a valuable tool for assessing the suitability of a gas to use as engine fuel. Earliest attempt at a detonation resistance scale was using the octane rating method, a tool long established for use with gasoline engines. The octane rating method uses a special test engine with variable compression ratio to establish the critical compression ratio for a fuel, the compression ratio at which detonation occurs. Unknown fuels are tested in this engine and their results are compared to a baseline set of results for blends of iso-octane and nheptane. The octane rating number represents the percent of iso-octane in the baseline blend. The problem with using the octane rating is that octane is not an effective reference point for flare gases and methane-based natural gas. Flare gas typically contains a high percentage of methane, the smallest, lightest paraffin fraction. Octane is a much heavier paraffin series molecule with very different combustion properties, including the fact that it tends to exist as a liquid under normal conditions -good for gasoline engines, but not so good for natural gas engines. To use the octane rating for gas engines, each hydrocarbon fraction (methane, ethane, propane, and so on) must be tested to establish its octane rating number. These value are then used to compute a weighted average octane rating for each gas mixture being evaluated. This approach has two significant drawbacks. First, it assumes a linear contribution by each fraction to the overall average result. In fact, the heavier fractions tend to have more impact than the lighter ones on the behavior of the mixed gas. Secondly, the octane rating system provides no way to take into account the beneficial effects of inert gases like carbon dioxide or nitrogen. In certain blends, these gases can help to cool combustion, allowing a small improvement in resistance to detonation. The octane rating method was acceptable when used with processed "pipelinequality" natural gas, but it usefulness was limited when applied to the broad range of gas compositions found at the well. These applications needed a more reliable rating method.

The methane number rating method was first developed in Austria in the mid-1960s by AVL company. Instead of octane, it uses methane as the reference for establishing resistance to detonation. The methane number scale sets a value of 100 for pure methane and uses hydrogen, with a value of 0, as the reference for a very fast-burning gas prone to detonation. Caterpillar adopted this method in the 1980s, continuing to refine the system through extensive research and testing on a wide range of fuels from field gas to landfill gas [6]. Calculating the methane number requires a set of complicated computations using computer program to perform these calculations and allow field determination of the methane number. All these programs are commercial ones.

Table 2. Methane numbers of some individual component of flare gases

Component	Methane number
Methane (CH_4)	100
Ethane (C_2H_6)	46.6
Propane (C_3H_8)	33
i- Butane (C_4H_{10})	15
n-Butane (C_4H_{10})	10

It can be seen from Table 2 that content of i-butane and n-butane in flare gas will reduce methane number and increase the risk of detonation in the engine. So, these components should be removed or cracked. In the word practice there are two ways of solving mentioned problem. One is to remove butanes with debutanizer and burn the rest of flare gas in Internal Combustion Engine. But this way is not good because of the low efficiency of utilization. Another way is to reform heavier hydrocarbons to Methane and Hydrogen with no intermediate products. This process can be implemented using steam reforming.

Steam Reforming

Steam reforming converts higher hydrocarbons to Methane components with no intermediate products. The typical operating temperature is from 400 to 550°C. The temperature is chosen to avoid hydrocarbon cracking which results in carbon precipitation. Methane reforming is completed in a final stage at higher temperatures and higher steam to carbon ratios are used to suppress carbon precipitation. Below are the reactions that occur.

C_nH_m + nH_2O → nCO + (n +1/2m)H_2 (-ΔH°298 = -1108kJ/mol, n = 7) (1)

CO + 3H_2 ↔ CH_4 + H_2O (-ΔH°298 = 206,2 kJ/mol) (2)

CO + H2O ↔ CO2 + H2 (-ΔH°298 = 41,2 kJ/mol) (3)

A detailed review of the process is given in a [7]. Reaction (1) is irreversible whereas the other two reactions establish equilibrium, which is temperature dependent. Carbon dioxide and water will be present in the product as well as carbon monoxide and hydrogen since reactions (2) and (3) are equilibrium reactions. The reaction mechanism for steam reforming involves the adsorption of the hydrocarbons onto the catalyst surface, leaving of all the carbon-carbon bonds, and leaving only single carbon components (i.e. methane, carbon monoxide).

Experiments have shown that the higher hydrocarbons slowly decrease through the catalyst bed and that no intermediates are created. Because the rates of reactions (2) and (3) are relatively fast, the kinetics of the steam reforming of the higher hydrocarbons is the rate determining step.

Steam reforming unit can be installed as part of the power unit with internal combustion engine. All the fuel will be burnt in the engine and this fact makes such method of flare gas utilization much better than method debutanization. In present study the next scheme (Fig. 3) of internal combustion engine with on-board steam reformer is offered.

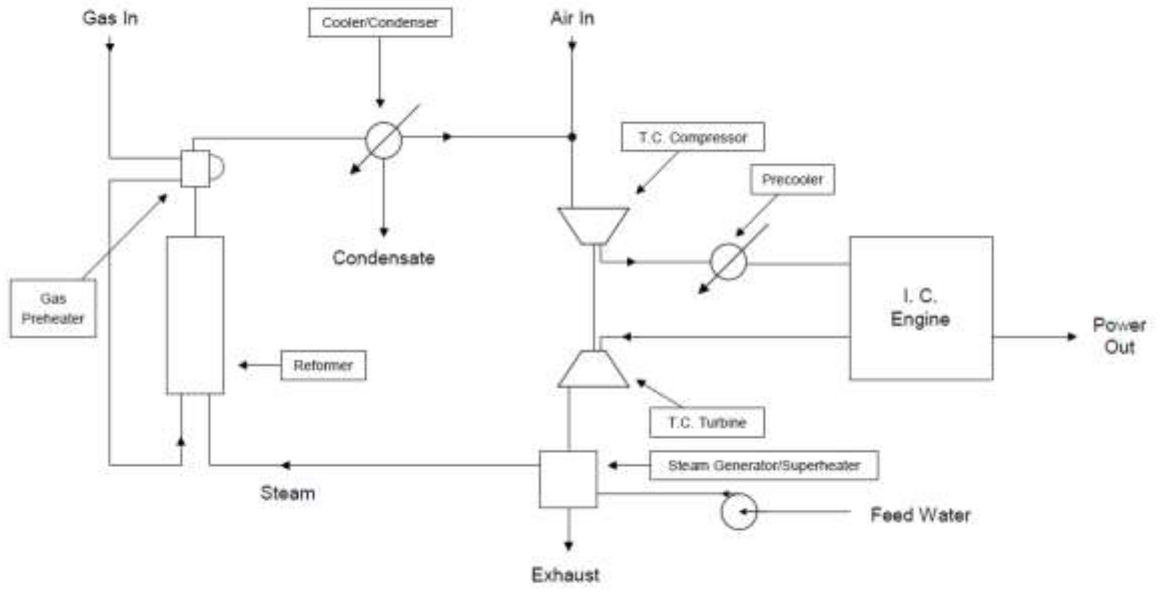

Fig.3. Internal combustion engine with on-board steam reformer

Figures 3 showing how a steam reformer system could be incorporated into the fuel delivery system for reciprocating engine systems. A more efficient method would be to use low temperature steam for some of the engine cooling duty and to use the heat recovered for superheating. The schemes in Figures 3 could be improved by closer integration with specific engine systems.

Conclusions

From the wild rage of flare gases, flaring associated gas from oil drilling sites is most beneficial for utilization in internal combustion engines.

Ukraine already has experience in the implementation of projects with flare gases. At mine named after Zasjadko the powerful cogeneration plant running on a mine gas was build with electrical capacity of 36 MW and 35 MW.

The main problem for ICE running on flare gases is detonation or "knocking". It is established that the most significant non-structural factors affecting the detonation is Methane Number of the fuel.

The new conception of Internal combustion engine with on-board steam reformer is offered in present study. Such concept solves the problem of detonation by on-board reforming of heavier hydrocarbons (like butane) and allows utilizing full energy of flare gases and getting useful energy.

Bibliography:

1. Global Gas Flaring Reduction Partnership (GGFR) [Electronic resource], World Bank,. October 2011 Brochure. – 13p. – Mode of access: http://siteresources.worldbank.org /INTGGFR/Resources/GGFR_NewBrochure%28Oct2011%29.pdf. 2. Estimated Flared Volumes from Satellite Data [Electronic resource], 2007-2011. World Bank. – Mode of access:http://web.worldbank.org/WBSITE/EXTERNAL/ TOPICS/EXTOGMC/EXTGGFR/0,,contentMDK:22137498~ pagePK:64168445~piPK:64168309~theSitePK:578069,00.html. 3.Global Gas Flaring Reduction [Electronic resource]. – Mode of access: http://web.worldbank.org/WBSITE/ EXTERNAL/NEWS/0,,contentMDK:21032487~menuPK:34480~pagePK:64257043~piPK:437376~theSitePK:4607,00.html. 4. Estimation of Gas Flaring Volumes Using NASA MODIS Fire Detection Products. NOAA's National Geophysical Data Center (NGDC) [Electronic resource].– annual report, February 2011. – Mode of access: http://ngdc.noaa.gov/eog/. 5.Пылев В.А. Шахтный газ – моторное топливо для двигателей внутреннего сгорания / В.А. Пылев, С.А. Кравченко, А.А. Прохоренко, Е.Г. Заславский, В.В. Шпаковский // Двигатели внутреннего сгорания. – 2007. – №1. –С. 10-15. 6. Application and Installation Guide. Gaseous Fuels. - Caterpillar. -2008 . – 48 pp. 7. Christensen T. S. Adiabatic Performing of Hydrocarbons An Important Step in Syngas Production / T. S. Christensen // Applied Catalysis. – A: General. –138 (1996). – pp. 285-309.

Bibliography (transliterated):

1. Global Gas Flaring Reduction Partnership (GGFR) [Electronic resource], World Bank,. October 2011 Brochure. – 13p. – Mode of access: http://siteresources.worldbank.org/INTGGFR/Resources/ GGFR_NewBrochure%28Oct2011%29.pdf. 2. Estimated Flared Volumes from Satellite Data [Electronic resource], 2007-2011. World Bank. – Mode of access:http://web.worldbank.org/ WBSITE/EXTERNAL/TOPICS/EXTOGMC/EXTGGFR/0,,contentMDK:22137498~pagePK:64168445~piPK:64168309~theSitePK:578069,00.html. 3. Global Gas Flaring Reduction [Electronic resource]. – Mode of access: http://web.worldbank.org/WBSITE/EXTERNAL/ NEWS/0,,contentMDK:21032487~menuPK:34480~pagePK: 64257043~piPK:437376~theSitePK:4607,00.html. 4. Estimation of Gas Flaring Volumes Using NASA MODIS Fire Detection Products. NOAA's National Geophysical Data Center (NGDC) [Electronic resource].– annual report, February 2011. – Mode of access: http://ngdc.noaa.gov/eog/. 5.Pylev V.A. Shahtnyj gaz – motornoe toplivo dlja dvigatelej vnutrennego sgoranija / V.A. Pylev, S.A. Kravchenko, A.A. Prohorenko, E.G. Zaslavskij, V.V. Shpakovskij // Dvigateli vnutrennego sgoranija. – 2007. – №1. –S. 10-15. 6. Application and Installation Guide. Gaseous Fuels. - Caterpillar. -2008 . – 48 pp. 7. Christensen T. S. Adiabatic Performing of Hydrocarbons An Important Step in Syngas Production / T. S. Christensen // Applied Catalysis. – A: General. –138 (1996). – pp. 285-309.

Поступила в редакцию 11.07.2013

Марченко Андрей Петрович – доктор техн. наук, профессор, заведующий кафедрой двигателей внутреннего сгорания Национального технического университета "Харьковский политехнический институт", Харьков, Украина, e-mail: dvs@kpi.kharkov.ua

Самойленко Дмитрий Евгеньевич – канд. техн. наук, старший научный сотрудник кафедры двигателей внутреннего сгорания Национального технического университета "Харьковский политехнический институт", Харьков, Украина, e-mail: dvs@kpi.kharkov.ua

Омар Адель Хамза - аспирант кафедры двигателей внутреннего сгорания Национального технического университета "Харьковский политехнический институт", Харьков, Украина, e-mail: dvs@kpi.kharkov.ua

ПРОБЛЕМЫ УТИЛИЗАЦИИ ПОПУТНЫХ ГАЗОВ В ДВИГАТЕЛЯХ ВНУТРЕННЕГО СГОРАНИЯ

А.П. Марченко, Д.Є. Самойленко, Омар Адель Хамза

Рассмотрена проблема утилизации попутных газов в ДВС. Попутный нефтяной газ является одним из наиболее привлекательных источников энергии для такого рода утилизации. Рассмотрена проблема детонации в ДВС при работе на таких газах. Показано, что единственным независимым параметром, влияющим на возникновение детонации в газовом двигателе при его эксплуатации является метановое число. Предложена новая схема утилизации попутных газов на базе ДВС с модулем паровой конверсии попутного газа, которая позволяет решить проблему детонации в двигателе.

ПРОБЛЕМИ УТИЛІЗАЦІЇ ПОПУТНИХ ГАЗІВ В ДВИГУНАХ ВНУТРІШНЬОГО ЗГОРЯННЯ

А.П. Марченко, Д.Е. Самойленко, Омар Адель Хамза

Розглянуто проблему утилізації попутних газів у ДВЗ. Попутний нафтовий газ є одним з найбільш привабливих джерел енергії для такого роду утилізації. Розглянуто проблему детонації у ДВС при роботі на таких газах. Показано, що єдиним незалежним параметром, що впливає на виникнення детонації в газовому двигуні при його експлуатації є метанове число. Запропоновано нову схему утилізації попутних газів на базі ДВЗ з модулем парової конверсії попутного газу, яка дозволяє вирішити проблему детонації в двигуні.

УДК 621.036.038

А.В. Грицюк, А.Н. Врублевский, А.А. Овчинников

АПРОБАЦИЯ НОВЫХ ВОЗМОЖНОСТЕЙ ТОПЛИВНОЙ СИСТЕМЫ НЕПОСРЕДСТВЕННОГО ДЕЙСТВИЯ ПРИ ФОРМИРОВАНИИ ВНЕШНЕЙ СКОРОСТНОЙ ХАРАКТЕРИСТИКИ АВТОМОБИЛЬНОГО ДИЗЕЛЯ

Продолжен цикл исследований, направленных на разработку "механической альтернативы" аккумуляторной топливной системе Common Rail с электронным управлением для современного отечественного автомобильного дизеля 4ДТНА1. Описаны объёмы работ по отработке гидропневмомеханического регулятора новой системы на требуемые параметры адаптивного задания топливоподачи и дальнейшая апробация новых возможностей доведенной топливной системы при формировании внешней скоростной характеристики (ВСХ) автомобильного дизеля. Представлены ожидаемые при разработке дизеля 4ДТНА1 ВСХ и характеристики изменений эффективного крутящегося момента и удельного эффективного расхода топлива при работе по этой характеристике.

Введение

Стремительное развитие топливных систем автомобильных дизелей с электронным управлением в последние годы XX и в начале XXI века сформировало устойчивое мнение об их безальтернативности. Небольшое количество известных зарубежных фирм, а именно "R. Bosch" (Германия), "Delphi" (США), "Siemens" (Германия), "Zexel" (Япония), "L'Orange" (Германия), первыми освоивших производство топливоподающей аппаратуры (ТПА) аккумуляторного типа с электронным управлением, стали "законодателями моды" и монополистами в разработке ключевой системы автомобильного дизеля, взяв под контроль всё дальнейшее развитие дизельной индустрии в мире. Особенно преуспевает фирма "R. Bosch".

Передав все свои производства ТПА непосредственного действия с механическим регулированием в азиатские филиала, фирма "R. Bosch" фактически прекратила их развитие и сделала (по крайней мере для себя) временным само явление сохранения на автомобилях "механической альтернативы" аккумуляторным системам типа Common Rail (CR). Наглядным подтверждением этому является информация, представленная на одном из последних Техническом и диагностическом форуме Bosch (Минск, 22.11.2012 г.). Так, для дизелей выпуска после 2012 года мощностью от 37 до 129 кВт, фирма Bosch не видит альтернативы системе Common Rail (рис. 1).

Рис. 1. Прогнозирование фирмой Bosch перспективности применения топливных систем для транспортных дизелей мощностью 37 – 129 кВт