RECONSTRUCTION OF INTERNAL COMBUSTION ENGINES TO RUN ON BIOGAS

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Abstract: Environmental pollution should be understood as a permanent process caused mostly by anthropogenic factors, that is man. The products of combustion from internal combustion engines are toxic and harmful effects on humans and the environment. This is one reason for research of biogas as an alternative fuel and its benefits for smaller amounts of harmful products in its combustion. For this purpose is reconstructed diesel engine that runs with a mixed fuel diesel- biogas where diesel fuel used for combustion and biogas propulsion engine combustion. Thus it is given the overall internal construction of this type of engine. There is calculated speed characteristics of the diesel engine and the reconstructed motor biogas. Thus these diagrammatic comparisons will indicate the nature of the changes in both engines.
Keywords: BIOGAS, INTERNAL COMBUSTION ENGINE, RECONSTRUCTED DIESEL ENGINE, SPEED CHARACTERISTICS;

1. Introduction

Pollution is a qualitative and quantitative change of physical-chemical and biological characteristics of the main components of the environment that is geospatial. It is the result of rapid development, which is a consequence of technical - technological revolution in our century, but based on the opportunities to meet the growing energy demand. At one point due to mismatch of needs and opportunities the world has experienced an energy crisis. The consequence of this has increased interest of better and more rational use of existing and search for new energy sources.

Environmental pollution should be understood as a permanent process caused mostly by anthropogenic factor ie man, who with his greed seeks natural resources to make the most of their own interests. The more people wanted to change the environment, the more burdened globe with different degradation problems that require urgent resolution.

Until the beginning of the rapid development of industrialization, urbanization and motorization, which in different countries occurred at different times, it was believed that the sources of the essential components of the environment, air and water are limitless. Clean air and water were in abundance, and pollution occurred as a product of human activity were easily assimilated and removed becouse of gread power of selfcleaning of the media.

But directly with growth of all kinds of activities, begin to appear the first warning signs that the forthcoming crisis of survival, not only for the surrounding ecosystems, but also human, if not urgently start control the sources of pollution. This would mean that environmental degradation gradually penetrated deep into all aspects of the environment in which a person lives, so it is difficult to determine its dimensions and consequences it causes. Source of pollution or environmental pollutant is any object that somehow emitted (discharged) harmful substances in the environment.

The products of internal combustion engines (fixed or embedded in various vehicles) are toxic and harmful effects on humans and the environment. This is one reason for exploring the various types of alternative fuels. On these fuels are made investigations from various aspects, but one of the most important is the smaller amount of harmful products of internal combustion engines over conventional fuels. This enables better quality of air safety and health of people, energy conservation and economic development.

2. Reconstruction of diesel engine

For diesel engines that run on a mixed fuel diesel- biogas, diesel fuel used for combustion of biogas which is fed into the intake manifold of the diesel engine through a special diffuser in which the gas and air are mixed to form a homogeneous mixture.(Fig.1) At the end of the compression tact it is injected a small amount of diesel fuel used for combustion of the mixture.

The regulation of engine power depends on the regulation of the fuel mixture and method of regulation. Method of regulating the fuel mixture is: qualitative, quantitative and combined.

In qualitative way of regulation changing the composition of the combustion mixture is performed by the feed regulation valve in the gas, but at low loads the mixture is homogeneous and it can lead to absence of ignition. In quantitative regulation, the change of power is done by changing the quantity of a mixture at a constant composition.

At combined regulation of power in the field of high loads is used qualitative, but in areas of low loads is using quantitative way of regulation. This mode of regulation further complicates the construction and regulation of gas-diesel system.

At starting, engine running on diesel fuel. Once you reach the temperature 60 °C to 70 °C with a special switch includes an electronic control unit which activates a solenoid valve connected to the pneumatic installation of the vehicle and activates the pneumatic working cylinder which is coupled with the lever pump for high pressure and limited the number of revolutions engine on 800rpm (by limiting the amount of fuel supplied). With an increase in the load (increase in engine speed) and limited notched rack pump for high pressure through the accelerator pedal is operated dispenser biogas and proportional to the load increases the amount of biogas from the gas reducer through limiter maximum speed and the diffuser (mixer) which is fitted between the air filter and the engine suction manifold. Upon reaching the maximum engine speed set by the Electric Control Unit impulse given by electric generator which excludes electro magnetic valves for high and low pressure, and with this is interrupted the addition of biogas. Also impulses from electric generator perform opening electro magnetic valves for high and low pressure biogas when to restrain diesel fuel by stopping the notched rack pump high pressure, and further power control is performed by dosing of biogas.

The consumption of gaseous fuel is inspect from the control unit which is placed in a prominent position on the dashboard of the vehicle.When the pressure in steel bottles (tank biogas) will fall to 0.5 MPa pilot light turns on red light that signals that you need to load the biogas.

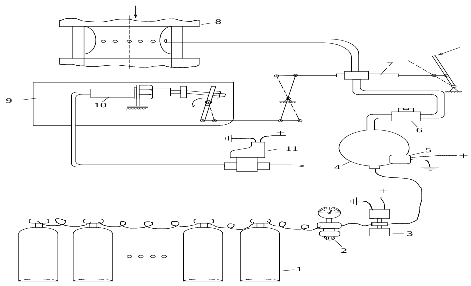

Fig. 1 *Reconstructed Internal combustion engines working on biogas***.**

1-steel bottle, **2**-filling valve biogas with pressure gauge, **3**- electro magnetic valve for high pressure, **4**-reducer of pressure, **5**- limiter of maximum speed, **6**-electro magnetic low pressure valve, **7**- pedal for power regulation, **8**-diffusor, **9**-high pressure pump, **10**-the pneumatic cylinder for limit the amount of diesel fuel at high pressure pump, **11**-electro magnetic valve to activate pneumatic cylinder.

3. Operating modes and features engine

The totality of the main indicators of the engine - the rotational speed of crankshaft axis, load (power or torque), thermal condition and others, characterize the regime of his work. Depending on the purpose of the engine, ie the machine, which it propelled, power (torque) and rotational speed of crankshaft axis must be changed in a wide range without impairs its reliability. The lattest is connected with the thermal and mechanical load on the parts of the engine depending on the conditions of leaks workflow. So each speed mode, the effective power (torque) of the engine changes from zero (ie idle motion) to a maximum value that the engine can develops. Change of power at a given speed is achieved through appropriate control devices – for example drajsler regulator in Spark Ignition engines and mechanism for fuel injector to diesel engines or engines with injection benzin. Both end positions for device management determines the interval of the possible modes of operating engines.

Mode engine (operating mode) includes the operating conditions of the engine, characterized by the totality of the values of the main indicators of its worka. Some of the indicators or factors may be viewed as basic, and other factors are constant or not taken into consideration. Then emphasizes that the basic indicator is given the term "speed mode engine", "mode of engine load" etc.

When the mode of operation of the engine is characterized by continuous or indicator changes around an average value of indicators, it called constant mode of engine operation. But when indicators (parameters) will change over time, the regime is called irregular.

Operation mode influenced by pressure, temperature and humidity of the environment that surrounds it. They are known as external (atmospheric) conditions of work engine. For standard external (atmospheric) conditions are taken those in which the values of temperature, pressure, humidity and more are in the group of appropriate standards. They are used to draw the performance of the engine and under the standard conditions.

Engine power depending on the conditions under which recording (defined) and may have several types: Effective power - power that engine to a working machine. Useful power efficient - the difference between the effective powewr of the engine and power losses for bringing into operation of the auxiliary mechanisms necessary for operation of the engine, but not actuated it. Maximum power - it is an effective power that can develop in engine with fully open drajsler regulator or fully bringing the fuel. Nominal power - it is the effective power of the engine, which is guaranteed by the factory - manufacturer for specific operating conditions. In this, depending on the engine type and its characteristics are determined one or several power ratings, which are the standards and have different names. Exploitation power - effective power that the engine can develop in conditions of exploitation indefinitely. Economic power - extended effective power, in which the engine has the lowest specific fuel consumption. Minimum power - the smallest effective engine power with which it can work indefinitely.

Rotation Speed of crankshaft in the engine, which in some modes of operation of the engine, can have several types. Nominal Rotation Speed - speed of rotation of the crankshaft of the engine, which the plant manufacturer recommends using at nominal and exploitation power. Maximum turning at idle - maximum speed of rotation at idle, set out in the technical conditions of the engine. Minimum speed of rotation at idle - the minimum speed of rotation at idle, set out in the technical conditions of the engine which provides reliable continuous work of the engine idle for no less than 10 minutes.

Minimum working speed of rotation - the minimum speed of rotation at fully open drajsler regulator or completely bringing fuel, in which the engine is running steadily for a long time.

Rotation speed corresponding to the maximum torque - the rotational speed of the crankshaft at which the engine develops maximum torque. Maximum operating speed of rotation - the highest speed of rotation of the crankshaft in a completely open drajsler regulator or completely bringing fuel (diesel engines), provided the technical conditions of the engine. Usually the speed matches with nominal.

4. Calculation of internal combustion engine speed features and their diagrammatic display

The design of internal combustion engines particular interest is the absolute value and the expected nature of the changes to its basic parameters: power, torque, mean effective pressure, fuel consumption ratio, hour fuel consumption, coefficient of excess air, charge ratio, etc. Certain idea about that can get by setting external speed characteristic.

4.1. For Diesel engine

1. The range of change in the rotational speed of crankshaft of the engine:

$n_{min} = 350 \div 700\ min^{-1}$; $n_{min} = n_N$;

$n_{min} = 400\ min^{-1}$; $n_{max} = n_N = 1500\ min^{-1}$;

2. Draw the power curve

$$P_{ex} = P_e \cdot \frac{n_x}{n_N}\left[0{,}87 \cdot 1{,}13\frac{n_x}{n_N} - (\frac{n_x}{n_N})^2\right] \quad kW$$

$P_e = 16{,}5\ kW$; $n_N = 1500\ min^{-1}$;

3. Draw the curve of torque

$$M_{ex} = \frac{3 \cdot 10^4 \cdot P_{ex}}{\pi \cdot n_x} = 9554\frac{P_{ex}}{n_x} \quad Nm$$

4. Draw the curve mean effective pressure

$$p_{ex} = \frac{P_{ex} \cdot 30 \cdot \tau}{V_p \cdot n_x} \quad MPa$$

Vp = 1,86 dm^3 (technical information) - working volume of the engine;

5. Draw the curve of specific fuel consumption

$$g_{ex} = g_{eN}\left[1{,}55 - 1{,}55\frac{n_x}{n_N} + (\frac{n_x}{n_N})^2\right] \frac{g}{kWh}$$

ge$_N$ = 4,1 ℓ / h (technical information) or ge$_N$ = 243,07 g / kWh

6. Draw the curve hour fuel consumption

$G_{\sim h} = g_{ex} \cdot P_{ex} \cdot 10^{-3}$ kg/h

7. Draw the curve of the coefficient of excess air

α_x= (0,7÷0,8) $\cdot$ α_N - (0,0001÷0,0004) $\cdot$ n_x

α_N=1,2÷2,2

Selected value for αN=1,7

The final formula is: α_x= 0,75 $\cdot$ α_N - 0,0001 $\cdot$ n_x

8. Draw the curve charge ratio

$$\eta_{vx} = \frac{p_{ex} \cdot \ell_o \cdot \alpha_x \cdot g_{ex}}{3600 \cdot \rho_B}$$

For naturally filling α <1

4.2. For Gas engine

1. The range of change in the rotational speed of crankshaft of the engine:

n_{min} = 400÷600 min^{-1} ; n_{max} = (1,1÷1,2)$\cdot$ n_N ;

n_N = 1500 min^{-1} ; n_{max} = 1,1 $\cdot$1500 = 1650 min^{-1} ;

2. Draw the power curve

$$P_{ex} = P_e \cdot \frac{n_x}{n_N}\left[0{,}87 \cdot 1{,}13\frac{n_x}{n_N} - (\frac{n_x}{n_N})^2\right] \quad kW$$

3. Draw the curve of torque

$$M_{ex} = \frac{3 \cdot 10^4 \cdot P_{ex}}{n \cdot n_x} = 9554\frac{P_{ex}}{n_x} \quad Nm$$

4. Draw the curve mean effective pressure

$$p_{ex} = \frac{P_{ex} \cdot 30 \cdot \tau}{V_p \cdot n_x} \quad MPa$$

Vp = 1,82 dm^3 (technical information) - working volume of the engine;

5. Draw the curve of specific fuel consumption

$$g_{ex} = g_{eN}\left[1{,}2 - \frac{n_x}{n_N} + 0{,}8 \cdot (\frac{n_x}{n_N})^2\right] \frac{m^3}{kWh}$$

ge$_N$ = 2,1 m^3/h (технички податок) или ge$_N$ = 0,15 m^3/kWh

6. Draw the curve hour fuel consumption

$G_{\sim h} = g_{ex} \cdot P_{ex} \cdot 10^{-3}$ kg/h

7. Draw the curve of the coefficient of excess air

α_x= (0,7÷0,8) + 0,0006 $\cdot$ n_x за n_x = n_{min} до 0,8 n_N ;

α_N = 1,2÷2,2

Selected value for α_N=1,7

8. Draw the curve charge ratio

$$\eta_{vx} = \frac{p_{ex} \cdot \ell_o \cdot \alpha_x \cdot g_{ex}}{3600 \cdot \rho_B}$$

Table 1: *Calculation data for DIESEL engine.*

n(min^1)	P	M	p	g	G	α	η_v
400	4.845	115.6	0.781	293.57	1.42	1.235	0.972
450	5.54	117.62	0.794	285.61	1.58	1.23	0.958
500	6.25	119.43	0.806	278.18	1.74	1.225	0.943
550	6.96	120.9	0.816	271.29	1.89	1.22	0.927
600	7.67	122.13	0.825	264.95	2.03	1.215	0.912
650	8.38	123.17	0.832	259.14	2.17	1.21	0.896
700	9.08	123.93	0.837	253.87	2.31	1.205	0.879
750	9.78	124.58	0.841	249.15	2.44	1.2	0.863
800	10.46	124.92	0.844	244.96	2.56	1.195	0.848
850	11.12	124.99	0.844	241.31	2.68	1.19	0.832
900	11.76	124.84	0.843	238.21	2.8	1.185	0.817
950	12.38	124.5	0.841	235.64	2.92	1.18	0.803
1000	12.97	123.92	0.837	233.62	3.03	1.175	0.789
1050	13.53	123.11	0.831	232.13	3.14	1.17	0.775
1100	14.05	122.03	0.824	231.19	3.25	1.165	0.762
1150	14.53	120.71	0.815	230.78	3.35	1.16	0.749
1200	14.97	119.19	0.805	230.09	3.44	1.155	0.735
1250	15.36	117.4	0.793	231.59	3.56	1.15	0.725
1300	15.7	115.38	0.779	232.81	3.66	1.145	0.713
1350	15.99	113.16	0.764	234.56	3.75	1.14	0.701
1400	16.22	110.69	0.747	236.86	3.84	1.135	0.69
1450	16.39	107.99	0.729	239.69	3.93	1.13	0.678
1500	16.5	105.09	0.71	243.07	4.01	1.125	0.667

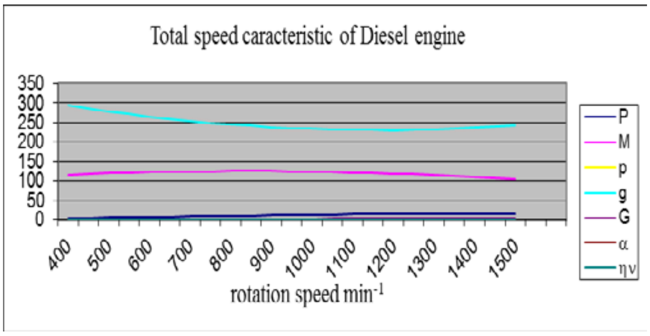

Fig. 2 *Total speed characteristics of diesel engine depending on rotation speed*

Table 2 *Calculation data for GAS engine (test engine)*

n(min^{1})	P	M	p	g	G	α	η_v
400	4.8	114.17	0.788	0.149	0.712	0.824	0.5793
450	5.5	115.71	0.799	0.146	0.796	0.827	0.5768
500	6.1	116.75	0.806	0.143	0.874	0.83	0.5742
550	6.8	117.77	0.813	0.141	0.956	0.833	0.5718
600	7.4	118.47	0.818	0.139	1.034	0.836	0.5692
650	8.1	119.06	0.822	0.138	1.118	0.839	0.5675
700	8.7	119.29	0.823	0.136	1.189	0.842	0.5656
750	9.4	119.49	0.825	0.135	1.266	0.845	0.5633
800	10	119.31	0.823	0.134	1.339	0.848	0.5609
850	11	118.92	0.821	0.1335	1.412	0.851	0.5592
900	11	118.47	0.818	0.1332	1.487	0.854	0.5572
950	12	117.77	0.813	0.1331	1.563	0.857	0.5553
1000	12	116.75	0.806	0.1333	1.629	0.86	0.5533
1050	13	115.65	0.798	0.1338	1.701	0.863	0.5512
1100	13	114.21	0.788	0.1345	1.769	0.866	0.5494
1150	14	112.62	0.777	0.136	1.844	0.869	0.5472
1200	14	110.83	0.765	0.137	1.907	0.872	0.5451
1250	14	108.84	0.751	0.138	1.965	0.875	0.5425
1300	15	106.56	0.735	0.14	2.03	0.878	0.5395
1350	15	104.17	0.719	0.142	2.09	0.881	0.5373
1400	15	101.48	0.7	0.145	2.156	0.884	0.5349
1450	15	98.64	0.681	0.147	2.201	0.887	0.5319
1500	15	95.54	0.659	0.15	2.25	0.89	0.5281
1550	15	92.27	0.637	0.153	2.29	0.893	0.5249
1600	15	88.73	0.612	0.157	2.333	0.896	0.5211
1650	15	85.06	0.587	0.16	2.35	0.899	0.5177
1700	14	81.1	0.56	0.164	2.367	0.902	0.514

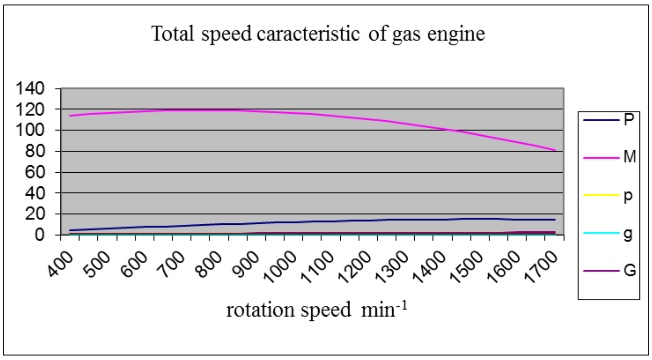

Fig. 3 *Total speed characteristics of gas engine depending on rotation speed (test engine)*

5. Conclusion

There ara analyzed of the parameters derived from speed characteristics of the internal combustion engine ie effective power Pe, torque Me, average effective pressure pe, specific fuel consumption ge, hour fuel consumption Gr, coefficient of excess air α, charging ratio □. Analytical method used to draw features based on mathematical, theoretical and partly empirical relationship between the basic parameters of the working cycle and the factors affecting them. So, it got the correct course of movement speed characteristics (graphically expressed depending on each indicator of the rotation speed) that were compared with curves on a test engine and thus can determine all modes of engine operation. Thus it became evident that the curves of the gas engine have the correct course of motion curves and thus proved that the reconstruction of diesel engine was completely relevant.

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