Translation from Bulgarian language

REPORT

Under Contract No 6524-4/2016

Comparison in stand conditions of the indicators of diesel engine *Volkswagen* 1,9 during its operation with standard diesel fuel and in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture prepared by a generator developed by the Contracting Authority

Contracting Authority

Company NEW ENERGY CORPORATION LTD, represented by Deyan Ivanov Delchev, address: city of Sofia, 2B, Rozhen Blvd.

Contractor: Scientific and Research Sector with Technical University - Sofia, address: 8, Kl. Ohridski Blvd.

1. Objective of the comparative tests

The objective of the comparative tests is to determine in stand conditions the values of the power (effective moment of rotation - M_e, average effective pressure - p_e and effective output - N_e), the economic (hourly - G_e and specific - g_e fuel consumption) and the toxic (contents of: carbon monoxide - *CO;* carbon dioxide - CO_2; hydrocarbons - CH; nitric oxide - *NO;* nitric oxides - NO_x; oxygen - O_2 and smokiness - R_b of the exhaust gases) indicators of a diesel engine at work with standard diesel fuel and in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture (OHGM - ОВГС) prepared by a generator developed by the Contracting Authority.

An analysis should be conducted on the grounds of the analysis of the obtained results and a quantitative evaluation should be made of the impact of the oxy-hydrogen gas mixture supplied at the entrance of the filling up collector over the effective indicators of a diesel engine working in conformity with a gas-diesel cycle.

2. Methodology for conduct of the tests

2.1. The target of the test is a diesel four-stroke engine *Volkswagen 1,9* with the following more significant parameters and indicators: number of cylinders $i = 4$; stroke volume i.$V_h = 1{,}896$ dm^3 ; degree of compression $\varepsilon = 22{,}5$; nominal effective output $N_e = 47$ kW with $n = 4400$ min^{-1}.

2.2. Conditions which the tests are conducted under:

- Equal adjustment (in conformity with the instructions of the company manufacturer) of: the gas distribution mechanism (gaps in the kinematic chain) and the combustible installation (the initial angle of anticipation of the injection Θ, maximal cycle quantity of fuel $C_{гц}$ and injection pressure $p_{вп}$);
- Equal thermal state of the engine (equal temperature of the cooling liquid $T_{от}$ and of the oil in the crank case $T_м$).

2.3. Volume of the tests

The indicators of the engine are determined in conformity with load characteristics with frequency of rotation n = 2000 min^{-1}, taken respectively during its work with standard diesel fuel and in conformity with a gas-diesel cycle with two working regimes of the generator for production of oxy-hydrogen gas mixture.

2.4. Technical means used during the tests:

- System for loading the engine – electric brake *SAK* - 50 with ultimate output 50 kW with n = 4000 min^{-1}, which the braking force is measured by *Pcn* (N);
- Electronic frequency meter for measurement of the frequency of rotation of the crank shaft n (min^{-1});
- Volumetric consumption fuel indicator – the time is measured $t_г$ (s), which selected volume of diesel fuel is consumed for;
- A thermocouple with a reporting device for measurement of the temperature of the exhaust gases $T_{ог}$ (^oC);
- Gas analyzer "*MultiGas-473 Box"* of Company *Tecnotest* (Italy);
- Gas analyzer "*Boston"* of Company *Tecno control* (Italy)
- Smoke meter type *"EFAW* 68A" of Company *Bosch* for measurement of the smokiness of the exhaust gases (units according to *Bosch* - 0...10);

2.5. Measured values

The following values are measured in each point of the load characteristics: the frequency of rotation - n (at taking each load characteristics it is maintained constant); the braking force - $P_{сп}$; the time for consumption by the engine of a selected volume of diesel fuel - t_e; the toxicity - *CO, CO_2, CH, NO,* NO_x, O_2, R_b and the temperature - $T_{ог}$ of the exhaust gases; the parameters of the environment – the temperature of the air at the input of the filling up conduit of the engine T_0 (^oC) and atmospheric pressure (mm Hg ст.).

All the values are measured with the needed (according to BDS-14816) precision.

2.6. Calculated values

The following indicators of the engine are calculated on the grounds of the measured values: effective moment of rotation M_e (N.m); effective output N_e (kW); average effective pressure p_e (MPa); hourly consumption of diesel fuel $G_{дг}$ (kg/h); specific consumption of diesel fuel $g_{едг}$ (g/kWh); coefficient of bringing the indicators of the engine to standard atmospheric conditions - $T_{во}$ = 293 K and p_{bo} = 760 mm Hg ст. (101,3 kPa). The volumetric flow rate of the oxy-hydrogen gas mixture supplied at the input of the filling up collector of the engine – $V_{овгс}$ (l/min) is calculated in conformity with methodology developed by the Contracting Authority.

The following formulae were used:

(1) $N_e = 10^{-3}.P_{сп}.n$, *kW* – effective output of the engine;

(2) $M_e = L_{сп}.P_{сп} = 0{,}9736.P_{сп}$, N.m – effective moment of rotation,

Where $L_{сп}$ = 0,9736 m is the arm of the measurement mechanism of the dynamometer of the brake;

(3) $$p_e = \frac{30.\tau.N_e}{i.V_h.n}$$, MPa – average effective pressure,

where: $i.V_h$ = 1,896 dm^3 is the stroke volume of the engine; τ = 4 – the stroke frequency of the engine;

(4) $$G_{дг} = \frac{3{,}6.V_г}{t_г}\rho_г$$, kg/h – hourly consumption of diesel fuel

where: $V_г$ is the volume of the consumed diesel fuel at the measurement, cm^3; $t_г$ – the time, which this fuel is consumed for, s; $\rho_г$ = 0,83 g/cm^3 – the thickness of the diesel fuel;

(5) $$g_{едг} = \frac{G_{дг}}{N_e}.10^3$$, g/k W.hm – specific consumption of diesel fuel

(6) $$k_o = \left(\frac{101{,}3}{p_b}\right)^{0.65}.\sqrt{\frac{T_в}{298}}$$ - coefficient for bringing the indicators of the engine to

standard atmospheric conditions (p_o – the atmospheric pressure during the test; T_0 – the temperature of the air in the box at the input of the filling up conduit of the engine);

(7) $N_e^0 = k_0.N_e$, kW – effective output of the engine brought to standard atmospheric conditions;

(8) $M_e^0 = k_o.M_e$, N.m – effective moment of rotation of the engine brought to standard atmospheric conditions;

(9) $p_e^0 = k_0.p_e$, MPa – average effective pressure of the engine brought to standard atmospheric conditions;

(10) $g°_{едг} = g_e/k_o$ – specific consumption of diesel fuel brought to standard atmospheric conditions.

2.7. Fuels which the tests were conducted with

The comparative stand tests were conducted with standard diesel fuel and with work of the engine in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture supplied at the input of its filling up collector.

3. Results of the comparative stand tests

The results of the comparative stand tests of engine *Volkswagen 1,9* at work with standard diesel fuel and in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture are indicated in a tabular (tables 1-3) and graphic (Fig. 1 – Fig. 8) kind, presented in the attachment to the report. Their analysis indicates the following:

3.1. Economic indicators

At work of the engine under the investigated frequency regime in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture its economic indicators change as follows:

- With volumetric flow rate of the oxy-hydrogen gas mixture – $V_{овгс}$ = 100 l/min there is reduction of the hourly – $G_{дг}$ and the specific - $g_{едг}$ consumption of diesel fuel, respectively up to 4 % and up to 15,7 %, at work of the engine in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture with regard to that with standard diesel fuel;
- With volumetric flow rate of the oxy-hydrogen gas mixture - $V_{овгс}$ = 30 l/min no differences in the economic indicators of the engine are observed.

3.2. Toxic indicators

At work of the engine of the investigated frequency regime in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture the measured toxic indicators change as follows:

- The change of the contents of carbon monoxide - *CO* is not unambiguous. With small loadings the contents of carbon monoxide is lower by up to 29 % at work of the engine with standard diesel fuel with regard to a gas-diesel cycle with volumetric flow rate of oxy-hydrogen gas mixture – $V_{овгс}$ = 100 l/min, whilst with these regimes the differences in the contents of carbon monoxide with work of the engine with standard diesel fuel and in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture - $V_{овгс}$ = 30 l/min are insignificant. With the average and the high loadings there is significant reduction of the contents of carbon monoxide at work of the engine in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture – $V_{овгс}$ = 100 l/min with regard to that with standard diesel fuel and in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture – $V_{овгс}$ = 30 l/min – respectively: up to 6 times and up to 3,7 times;
- The change of the contents of carbon dioxide - CO_2 at work of the engine work of the engine with standard diesel fuel and in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture is within the framework of the precision of the measurement;
- The contents of hydrocarbons - *CH* does not change;
- The contents of nitric oxide - *NO* at work of the engine in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture – $V_{овгс}$ = 100 l/min is significantly lower than that at its work with standard diesel fuel and in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture - $V_{овгс}$ = 30 l/min - respectively: up to 2,7 times and up to 1.9 times;
- The contents of nitric oxides NO_x at work of the engine in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture – $V_{овгс}$ = 100 l/min is significantly lower than that at its work with standard diesel fuel and in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture – $V_{овгс}$ = 30 l/min - respectively: up to 2,7 times and up to 1,9 times;
- The change of the contents of free oxygen - *O*2 at work of the engine with standard diesel fuel and in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture is within the framework of the precision of the measurement;
- The smokiness of the exhaust gases - R_b at work of the engine in conformity with a gas-diesel cycle both with volumetric flow rate of the oxy-hydrogen gas mixture – $V_{овгс}$ = 100 l/min, and with volumetric flow rate of the oxy-hydrogen gas mixture – $V_{овгс}$ = 30 l/min is significantly lower than that at its work with standard diesel fuel – up to 1.4 times. The smokiness of the exhaust gases - R_b at work of the engine in conformity with a

gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture - $V_{овгс}$ = 100 l/min is up to 30 % lower with regard to that with work in conformity with a gas-diesel cycle with volumetric flow rate of the oxy-hydrogen gas mixture - $V_{овгс}$ = 30 l/min.

3.3. Temperature of the exhaust gases

With the investigated frequency regime no changes in the temperature of the exhaust gases of the engine at its work with standard diesel fuel and in conformity with a gas-diesel cycle with oxy-hydrogen gas mixture are observed.

4. Conclusion

The conclusion may be drawn on the grounds of the results of the conducted stand tests that the oxy-hydrogen gas mixture prepared by a generator developed by the Contracting Authority, which is supplied at the input of the filling up collector of the engine, target of the tests, exerts a substantial impact over the economic and toxic indicators of the engine, when its volumetric flow rate is – $V_{овгс}$ = 100 l/min. With volumetric flow rate of the oxy-hydrogen gas mixture $V_{овгс}$ = 30 l/min there is improvement solely of the toxic indicators of the engine, target of the tests, available at hand.

23.12.2016

The test was conducted by:

1. /Sgd. Ill./

/Assoc. Prof. Dr. Eng. Evgeni Dimitrov/

2. /Sgd. Ill./

/Chief Ass. Dr. Eng. Vladimir Serbezov/

I, the undersigned, Meglena Dimitrova Bazhdarova, certify that this is a true and accurate translation done by me from Bulgarian into English of the attached document: Report. The translation comprises 6 pages.
Translator: Meglena Dimitrova Bazhdarova