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Ignition System Element Service Life Influence on the Parameters of Waste Gas Toxicity among Modern Vehicles with Petrol Engines

[1]N.A. Baganov, [1]T.G. Bekhtold, [2]V.S. Kuhar and [2]P.S. Krivonogov
[1]Kostanai Engineering and Economic University Named after M. Dulatov, Chernyshevskogo 59, 110004 Kostanay, Republic of Kazakhstan
[2]Ural State Agrarian University, Ekaterinburg, Karl Liebknekht Str. 42, Yakaterinburg, Russian Federation

Abstract: The urgency and the necessity of timely diagnosis for electrical equipment elements is specified. The diagnosis problems of modern electronic engine control systems are presented. The study considers the analysis of platinum and iridium spark plug effect on the toxicity of exhaust gases among modern passenger cars. The dependences of exhaust gas toxicity indicators are obtained depending on a spark plug run. The results of the study will allow to increase the life of a spark plug and an exhaust gas converter.

Key words: Toxicity, spark plugs, life, diagnosis, electronic systems, exhaust gases, engine, power system, converter

INTRODUCTION

It is known that the concept of technical diagnostics in the automotive industry and operation is that it becomes one of the most important factors in the production and operation of a car. The diagnostics in production performs the role of information "supplier" concerning the reliability of operated equipment and influences the production sphere, improving the quality and the technical level of products. Diagnostics is one of the main elements of a car reliability and durability control. As we know diagnosis (Kruglik, 2015) is designed to solve one or several problems:

- Check of serviceability; performance check
- Troubleshooting
- Determination of a device operation parameter stability

According to a purpose, the diagnosis can be divided into periodic diagnosis to determine the technical condition of aggregates, nodes and systems; periodic diagnosis for the determination of power and economic indicators; permanent diagnosis on a car board to determine an optimum performance, to identify and fix a malfunction.

Thus in all cases, a user is interested in the understanding of operation principle and in the effectiveness of diagnostic systems. The main purpose of on-board diagnostics among modern vehicles is to ensure the safety of traffic, the determination of violations during the operation of electrical equipment and electronic systems, etc. Now a days, the structure of electrical equipment, connection and control circuits are known and reviewed earlier and diagnostic techniques were worked out and do not cause any particular difficulties during operation (Motoyama *et al*., 1992). However, a widespread introduction of electronics and electronic system elements complicated the diagnostic process. Modern automotive electrical and electronic systems are complex technical facilities operating within a complex of destabilizing factors (Chowanietz, 1995). The destabilizing factors vary in a wide range and are mostly random.

MATERIALS AND METHODS

Main defect of ignition system: The entry of new imported cars to the marketwith a service life of 4-5 years gradually leads to electrical equipment and electronic system operation problems, especially among spark plugs. This in its turn, conditioned the creation of new technical diagnostic tools on a modern electronic base.

According to the experience of modern car diagnosis, the diagnostic information about the presence of a malfunction is not always reliable and accurate. Very often there is a need to use additional diagnostic indicators or parameters. So, in the presence of "dips and jerks" when

Corresponding Author: N.A. Baganov, Kostanai Engineering and Economic University Named after M. Dulatov, Chernyshevskogo 59, 110004 Kostanay, Republic of Kazakhstan

you drive a car, it is not always enough to use modern diagnostic tools in order to establish an accurate diagnosis. The appearance of malfunctions in an ignition system as a spark formation failure can be caused not only by the malfunction of spark plugs. This is influenced by the state of an ignition coil, high-voltage wires, spark plug holders, etc. (Ball, 2001). Therefore, the diagnosis of an ignition system state may be inaccurate and not reliable. In this case, in order to eliminate these malfunctions many service companies or service stations offer alternate replacement of all ignition system elements as a rule. In this case, they change spark plugs, high voltage wires, etc. Although, in fact the spark plugs did not have a great service life and could serve more than a dozen thousand kilometers of run. This is especially true for iridium and platinum spark plugs. The cost of these spark plugs is quite high and their change is not always appropriate and profitable at a small mileage. It was stated by Nabokih (2006) and Jutt (2000) that the operation of spark plugs influences to a large extent on the combustion of a fuel-air mixture and accordingly, the composition of exhaust gases. Therefore, in order to solve this issue we offer to use the toxicity of exhaust gases as an additional diagnostic parameter during the evaluation of a spark plug technical condition. This parameter was considered repeatedly by Baganov (2005) and Baganov *et al*. (2005). These works indicate that plugs influence the technical and economic performance of an engine but only on classic power and ignition systems. Now a days, there is no established relationship between the performance of spark plugs and the exhaust gas toxicity of modern engines.

RESULTS AND DISCUSSION

Waste gas toxicity evaluation: In modern cars, the operation of an ignition system and a power supply system are inextricably linked. Electronic sensors and devices are responsible for all processes. The obtained experimental studies conducted in this direction can not be fully used for modern electronic engine control systems. Based on the stated above we conducted experimental studies to establish the dependencies of exhaust gas toxicity and the run of spark plugs in modern engines.

For this purpose, a certain number of new cars with known serviceable engine systems and mechanisms was selected. After every 5 thousand kilometers of run, the plugs were removed and installed on the engine with electronic ignition and power control systems. The engine was installed on a brake stand. In order to obtain an accurate and a reliable diagnosis of exhaust gas state, no adjustments in engine systems and mechanisms were carried out during all experimental studies. After that, they measured the toxicity of exhaust CO and CH gases in two modes of operation: at a minimum engine speed and at an average engine speed ($n = 0.6\ n_{max}$) (Fig. 1).

The toxicity of exhaust gases was measured in an exhaust system up to an exhaust gas converter. This allowed to exclude its work and influence on the process of exhaust gas afterburning. The results of exhaust gas toxicity testing showed that the increase of spark plug life leads to the combustion process change in a combustion chamber of an engine cylinder. The test of new spark plugs over 60 thousand kilometers of run (L) leads to a constant increase of exhaust gas harmful emissions both at idle and at average operating mode of an engine.

Further tests of exhaust gas toxicity showed its increase as the result of the combustion process deterioration in a fuel-air mixture. This is invoked by the fact that during a long-term operation of iridium or platinum spark plugs (over 85...100 thousand km) the current-carrying bridges are formed on an insulator which shunt the spark gap thus developing the resistance $R_{ш}$ (Jutt, 2000; Chowanietz, 1995). The $Co_{x.p}$, $CH_{x.p}$ the content of carbon monoxide and hydrocarbons, respectively at the minimum engine speed of a crankshaft; $CO_{cp.p}$, $CH_{cp.p}$ content of carbon monoxide and hydrocarbons at the average engine speed of a crankshaft ($n = 0.6\ n_{max}$), respectively.

This resistance leads to the increase of the ignition factor $\eta_з$ which in its turn reduces the secondary voltage on the ignition coil and the breakdown voltage of the spark plug U_{pr}. It follows from Jutt (2000) that the decrease of the breakdown voltage reduces the energy of the spark discharge W_{pr}:

$$W_{Пр} = \int_0^{t_{Ир}} U_{Пр} \times i_2(t)\,dt$$

Where:

W_{pr} = The energy of a spark discharge J
$t_{Ир}$ = The time of spark discharge c
i_2 = The current strength in the secondary winding (A)
$U_{пр}$ = Breakdown Voltage (V)

The decrease of the spark discharge energy W_{pr} leads to a “weak” spark on a spark plug which results in incomplete combustion of a mixture thus forming an increased content of toxic components in exhaust gases. Besides, an incomplete combustion may develop “jerks and dips” when an accelerator pedal is pressed hard.

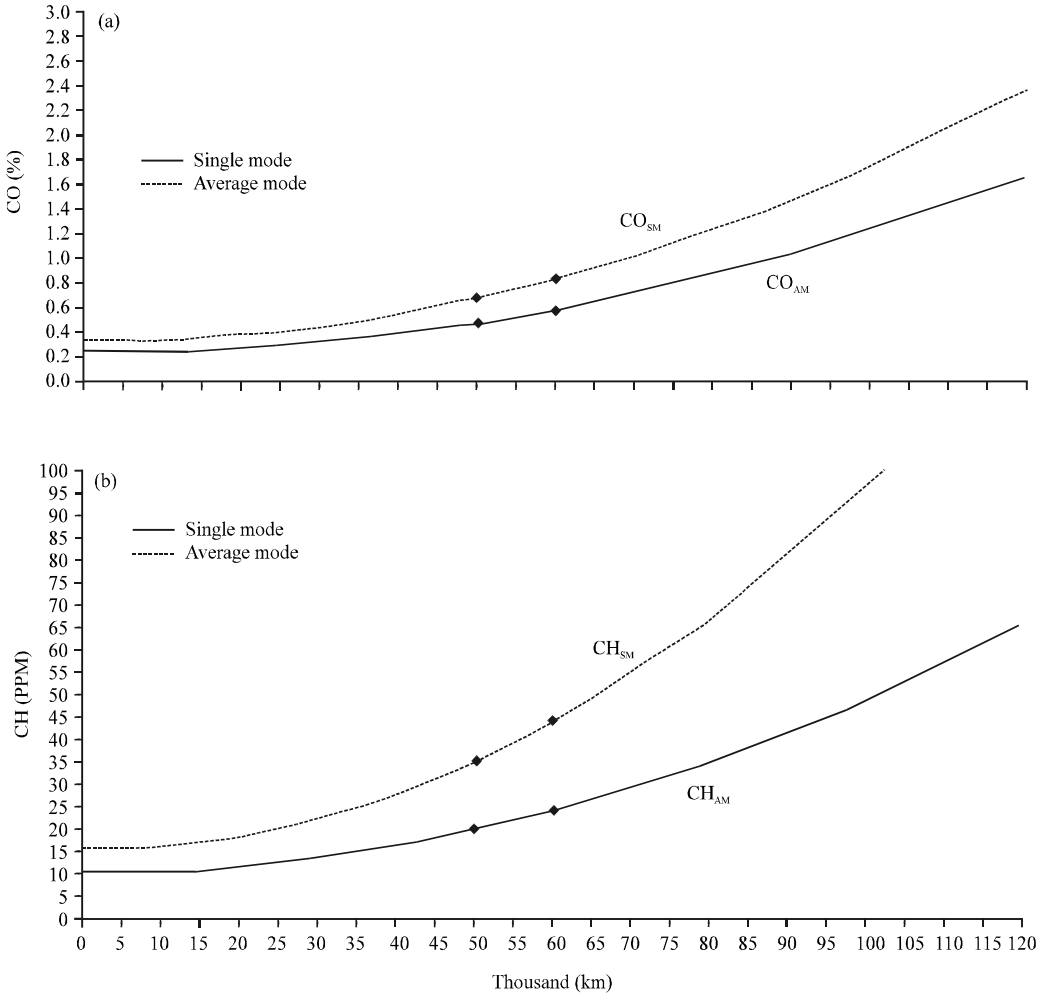

Fig. 1: The influence of spark plug resource on the composition of exhaust gases

Summary: The above mentioned research results in the process of a power supply system and the ignition system diagnosis by modern diagnostic testers and stands in conjunction with the exhaust gas toxicity indicators will allow:

- To evaluate the effect of spark plug life on the toxicity of exhaust gases
- To increase the service life of a neutralizer and maximize the use of spark plugs
- To exclude the influence of spark plugs on engine work according to toxicity parameter and their run
- To save money refusing from unjustified purchase of spark plugs for auto companies and car owners

CONCLUSION

Based on the mentioned above, we can conclude that the resource of spark plugs influences the composition of exhaust gases and respectively, the resource of a neutralizer and the dynamics of a car. In order to reduce the emissions of harmful substances into the atmosphere, to increase the life of a neutralizer, it is recommended to replace the spark plugs each 65-70 thousand kilometers. This will allow to exclude the effect of spark plugs on the operation of sensors and power systems during the diagnosis of an engine.

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