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THE EFFICIENCY OF A LAVAL NOZZLE SPARK PLUG

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Annotation

In order to eliminate the shortcomings of the conventional classic spark plug, the spark plugs were improved in 2 ways: by drilling a hole from the outer L-shaped electrode and cutting out the outer L-shaped electrode of a long threaded spark plug and installing the spark plug into the engine through the supports in the form of a Laval nozzle. Spark plugs installed on cars manufactured by Uzavtomotors JSC have passed laboratory and road tests. The effective fuel consumption of the engine operating with a spark plug with a Laval nozzle was 218 g/kWh, which is 1.31 times less than that of a conventional classic spark plug (control). The acceleration time of the car to a speed of 100 km / h was 11.4 seconds, which is 1.21 times less than the control one. The content of carbon monoxide CO in the exhaust gases was 1.86%, which is 2.10 times less than the control.

Keywords: car, engine, spark plug, L-shaped electrode, hole, Laval nozzle, fuel consumption, exhaust gas, carbon monoxide, spark, power, economy.

Introduction

In accordance with the Decree of the President of the Republic of Uzbekistan dated October 30, 2019 No PF-5863 “On approval of the Concept of environmental protection of the Republic of Uzbekistan until 2030”, the efficient use and economy of fuel used in vehicles is provided [1].

Amendments and additions to the Law of the Republic of Uzbekistan "On the Protection of Atmospheric Air" also developed measures to reduce fuel consumption in vehicles [2]

At the present stage, the main directions for improving the internal combustion engine of vehicles are aimed at reducing fuel consumption and toxicity of exhaust gases. In modern automotive industry, there are several ways to reduce the toxicity of exhaust gases. The main ones are the direct impact of the exhaust gases of the engine (the use of various neutralization systems), the use of alternative fuels (Hydrogen compressed and liquefied gas, etc.) and the impact on the working process of the internal combustion engine, i.e. basis of toxic substances in exhaust gases.

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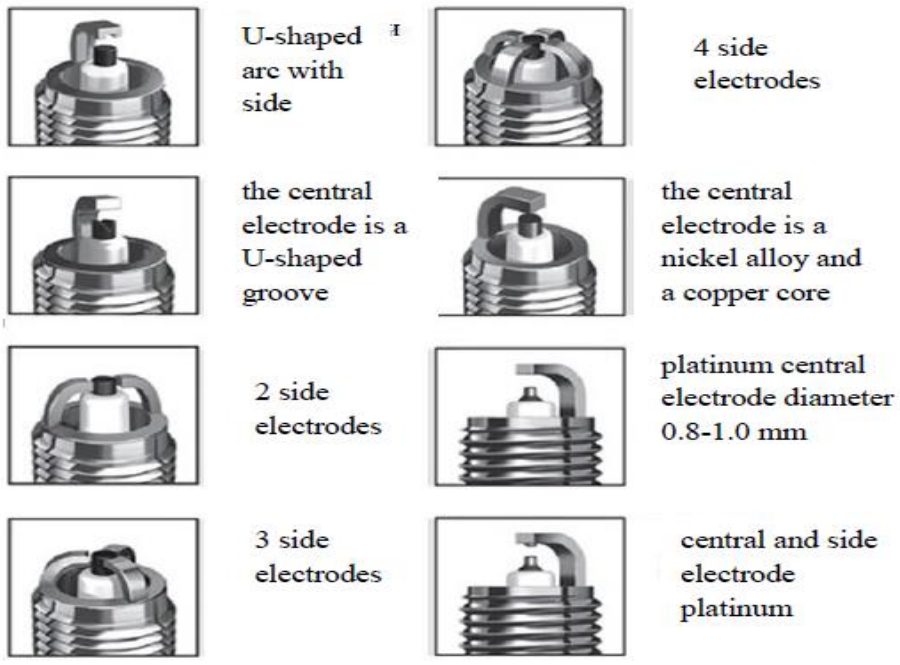
Catalytic converters installed on car mufflers are expensive and reduce engine efficiency, so we will look at more promising ways to reduce exhaust emissions, i.e. their immediate causes. One of them is to increase the efficiency of the spark plug, which ensures the completeness of the combustion process [3-5].

To date, UzAutomotors JSC produces such cars as Damas, Labo, Spark, Nexia-3, Cobalt, Jentra, Tracker and others. Their engines are equipped with spark plugs that vary in design and size, such as a conventional spark plug with one, two, three, and four L-shaped outer electrodes. The diameter of the threaded part mounted on the engine is also 12, 14 and 16 mm. The size of the gap between the electrodes is also from 0.8 to 1.1 mm. There are other types of spark plug design with long insulator, resistor, semiconductor, surface discharge, and others. The design of the electrodes is standard, with a V-shaped central electrode, with an electrode having one grounding two groundings, with a special electrode and an electrode from a platinum tip (Fig. 1). All this leads to confusion among automotive specialists when choosing the most efficient spark plug. Therefore, there is a need to clarify the situation and determine which of the spark plugs works most efficiently [6].

Fig 1: Types of candles currently produced



Methods

It is known that spark plugs are not yet produced in Uzbekistan, and spark plugs from the following companies are installed on manufactured cars: Denso, NGK, Bugaets, Bosch, Champion, Helix ultra, GETZ, IMXO, Tough, Brisk and some other Russian factories.

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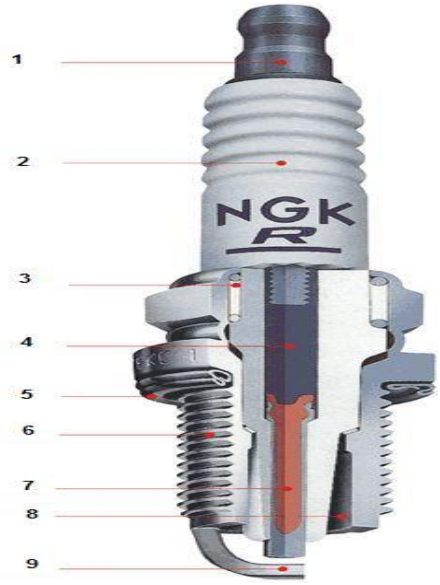
However, no matter how perfect these spark plugs are, they cannot significantly improve the energy and environmental performance of internal combustion engines.

An ordinary classic spark plug consists of a metal case 3, an insulator 4 and a central electrode 7 (Fig. 2). Output terminal 1, located at the top of the spark plug, is for connecting the spark plug to the high voltage wires of the ignition system.

Figure 2: General structure of the spark plug



1st output terminal; 2- insulator ribs; 3 - body; 4- electrode insulator; 5- sealing ring; 6- threaded section; 7- central electrode; 8th space; 9- yon electrode.

In this candle, the space between the central 7 and the outer L-shaped side electrode 9 forms a working gap. Such spark plugs are effectively used in carbureted engines, but when used in injection engines, the fuel in the cylinders does not burn completely and various toxic substances are formed. As a result, unburned fuels and toxic substances are emitted into the atmosphere along with the exhaust gases. In addition, every 5000 km of the vehicle run, a spark from the central electrode of the spark plug hits the L-shaped outer electrode and bends it by 0.1 mm, which leads to incomplete combustion and subsequent failure.

In injection engines, the external L-shaped side electrode 9 prevents the spraying of gasoline from injectors and sparks from the central electrode [7]. Also, due to the fact that the inner surface of the outer electrode and the insulator between the electrodes are filled with debris in the form of soot, rust and coke formation, the candle overheats, loses efficiency and fails.

In addition, in cold weather, especially during the winter months, spark plugs get wet due to poor fuel evaporation in a cold engine, which makes it difficult to start the engine due to engine oil leakage and a naturally low battery charge. This is due to the fact that the high pressure created during the compression process in the cylinders is reduced and even the spark from the spark plug stops.

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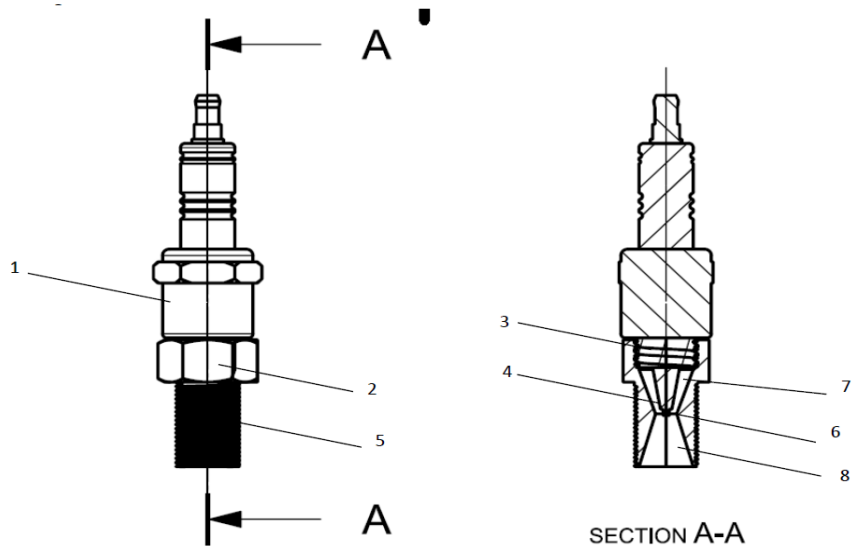
Results and discussions

These shortcomings pointed to the need to improve conventional classic candles. The institute improved spark plugs in two ways: by drilling a hole in the outer L-shaped electrode of a conventional classic spark plug (Fig. 3) and cutting the outer L-shaped electrode of a conventional classic long-threaded spark plug to the length of the threaded part of a conventional short spark plug, and the central electrode and its outer insulator - left intact (Fig. 4) [8].

Figure 3: A candle with a hole in the outer Г-shaped electrode: a- side view; b- view from the bottom

а Б

Figure 4: A candle equipped with a laval nozzle



1- standard candle; 2- base body; 3- rezbovaya chasts vechi; 4- positive electrode; 5 – rezbovaya chast podstavki; 6- nozzle Lavalya; 7- verxnyaya polost sopla Lavalya; 8- nijnyaya polost sopla Lavalya.

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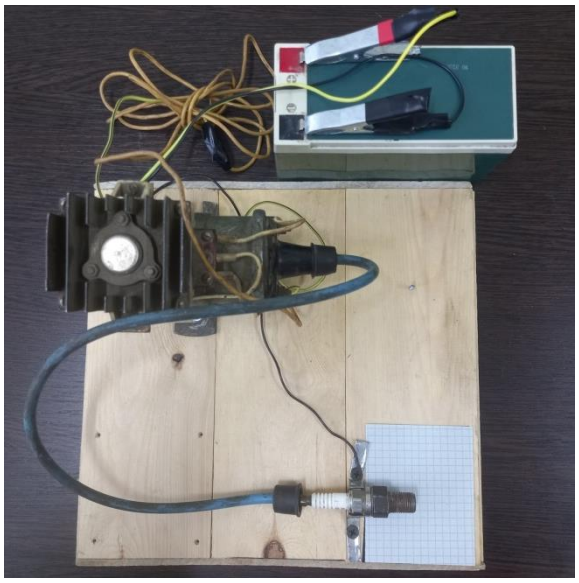
The proposed improved spark plug with Laval nozzle works as follows. In gasoline engines, air is supplied to the cylinder through the intake valve, during the compression process, the fuel-air mixture is compressed to 1.0-1.2 MPa, heated to 300-400 ° C and fuel is sprayed through the nozzles and a spark is formed on the spark plug. As a result, combustion takes place in the cylinder. In turn, the piston is pushed down, and the process of expansion occurs - the process of generating mechanical energy. Then the piston rises up and the exhaust gases are released through the exhaust valve, while unburned light fuel fractions, hydrogen, oxygen and other combustible gases are stored in the upper 7 and lower 8 cavities of the Laval nozzle (Fig. 4). These residual gases heat the air entering the subsequent intake and, when a spark is formed, ignite faster than the air-fuel mixture formed at the end of the compression process and thus ensure complete combustion of the fuel [9, 10].

To test the effectiveness of these improved spark plugs, comparative experiments were carried out in comparison with spark plugs currently installed on cars manufactured by UzAutomotors JSC. To test the performance of spark plugs, a special laboratory stand was made and all selected spark plugs were numbered (Fig. 5). The value of the spark emitted by the candles on the stand was taken as the main indicator. For this, the values of the area and volume of sparks formed in the gap between the electrodes during the operation of the candles were measured and compared.



Rice: 5. Laboratory stand for testing candles: 1- rechargeable battery; 2- ignition coil; 3- relay interrupter; 4- high voltage wire; 5-terminals for accumulators; 6- clip for the spark plug.

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1 - Table: Indicators of ignition spark plugs

№	Types and main indicators of spark plugs	General view	Spark output
1	Carving diameter: 12.0 mm Thread length: 19 mm The gap between the electrodes: 0.9 mm Key size: 16.0 mm Number of external electrodes: 1		
2	NGK BK6E Carving diameter, mm 14 Thread length, mm 19 The gap between the electrodes: 0.8 mm Key size, mm 16 Number of external electrodes: 1		
3	DENSO W20EP-U Carving diameter, mm 14 Thread length, mm 19 The gap between the electrodes: 0.8 mm Key size, mm 20.6 Number of external electrodes: 1		
4	DENSO XU22TT Carving diameter, mm 12 Thread length, mm 19 The gap between the electrodes: 0.8 mm Key size, mm 16 Number of external electrodes: 1		
5	NGK R BKR5EK Carving diameter, mm 14 Thread length, mm 19 The gap between the electrodes: 0.8 mm Key size, mm 16 Number of external electrodes: 1		
6	NGK R BKUR6TN 10 Carving diameter, mm 14 Thread length, mm 19 The gap between the electrodes: 1.0 mm Key size, mm 16 Number of external electrodes: 3		

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7	NGK DCPR7EGP Carving diameter, mm 14 Thread length, mm 19 The gap between the electrodes: 1.0 mm Key size, mm 20.6 Number of external electrodes: 1		
8	CHAMPION RN9YC (peredelannaya) Carving diameter, mm 14 Thread length, mm 19 The gap between the electrodes: 0.8 mm Key size, mm 19 Number of external electrodes: 1 (ring)		

Conclusions

According to the test results, the values of sparks generated by 1-6 candles differed by only 5-10%. This was not enough to select the most suitable, since such sparks were not able to completely ignite the fuel-air mixture inside the engine cylinder. Therefore, there was a need to find a spark plug design that could generate a spark of more than 30-40% more than the spark values of the spark plugs currently used, and the spark plugs were improved. Such candles are the 7th candle with a hole in the L-shaped electrode and the 8th candle with a Laval nozzle [11-12].

Figure 6: Operation of a plug with a hole in the Γ-shaped electrode

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Rice 7: Work of a candle with a Laval nozzle

2 – Table: Results of laboratory tests

№	Indicator name	Unit of measurement	Normal Г-shaped electrode candle (control)	Normal Г-shaped electrode perforated candle	Laval nozzle improved candle
1	Engine power	kW	26,7	30,8	32,5
2	The number of revolutions of the crankshaft	rev/min	3500	3500	3500
3	Fuel consumption	g / kWh	286	242	218
4	Carbon monoxide CO	%	4,15	1,86	1,21
5	Unburned hydrocarbons CH	%	5,26	3,72	3,14

3 – Table: Results of road tests

№	Indicator name	Unit of measurement	Normal Г-shaped electrode candle (control)	Normal Г-shaped electrode perforated candle	Laval nozzle improved candle
6	Time for the car to reach a speed of 100 km / h	sec	13,8	12,1	11,4
7	Fuel consumption	l / 100 km	9,04	7,64	6,53
8	Carbon monoxide CO	%	3,89	2,59	1,86
9	Unburned hydrocarbons CH	%	4,68	3,63	3,15

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According to the results of laboratory tests (Table 2), it was found that the power of the F8C engine from the Tiko car with a conventional spark plug was 26.7 (control), with a drilled L-shaped electrode 30.8 and an improved spark plug with a Laval nozzle 32.5 kW. The effective hourly fuel consumption of the engine was 286 (control), 242 and 218 g/kWh, respectively. The content of carbon monoxide CO in the exhaust gases was 4.15 (control), 1.86 and 1.21%, respectively. The content of unburned hydrocarbons CH is 5.26 (control), 3.72 and 3.14%, respectively. As can be seen from all indicators, the improved spark plug with a Laval nozzle has advantages, for example, engine power is 1.22 times higher than a conventional spark plug, hourly fuel consumption is 1.31 times, carbon monoxide CO output is 3.43 times and unburned hydrocarbons CH 1.68 times.

According to the results of road tests (Table 3), it was found that the acceleration time of a Cobalt car with a conventional spark plug up to 100 km/h was 13.8 (control), with a drilled L-shaped electrode 12.1 and an improved spark plug with a Laval nozzle 11 .4 sec. The fuel consumption of the vehicle was 9.04 (control), 7.64 and 6.53 g/kWh, respectively. The content of carbon monoxide CO in the exhaust gases was 3.89 (control), 2.59 and 1.86%, respectively. The content of unburned hydrocarbons CH is 4.68 (control), 3.63 and 3.15%, respectively. As can be seen from all indicators, an improved spark plug with a Laval nozzle has advantages, for example, the acceleration time of a car to a speed of 100 km / h is 1.21 times higher than a conventional spark plug, fuel consumption is 1.38 times, and carbon monoxide output CO 2.09 times and the yield of unburned hydrocarbons CH 1.49 times.

The economic efficiency of the proposed new spark plug has been determined. There are more than 5 million cars, tractors, self-propelled vehicles and motorcycles in Uzbekistan. If each of them consumes an average of 10 kg of standard gasoline per day, then he will consume 50,000 tons of fuel per day. The introduction of a new ignition spark will save 10,000 tons of fuel per day and 10,000 x 365 = 3,650,000 tons of fuel per year while saving 20% of fuel. Today, with an average price of 1 ton of gasoline of 8 million soums, 3,650,000 x 8 = 29,200,000 million soums per year will be saved [13].

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