



### RESEARCH THE INFLUENCE OF SPARK PLUGS TYPES ON THE PERFORMANCE OF THE ENGINE OPERATING ON GASEOUS FUELS

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#### RESEARCH ARTICLE

**ABSTRACT:** Topical issue in recent years is the search for methods of reducing fuel consumption and improve environmental performance of internal combustion engines. In spark-ignition engines great importance is the type of ignition system and its components. This report examined the performance of the internal combustion engine running on gaseous fuels and with different types of spark plugs. Presented are the power-economic and environmental characteristics of different fuels and different types of spark plugs. Conclusions are practical and economic terms..

**KEY WORDS:** spark plug, LPG, CNG, ICE, performance

#### ISTRAŽIVANJE UTICAJA TIPOVA SVEĆICA NA PERFORMANSE RADA MOTORA SA GASNIM GORIVIMA

**REZIME:** Aktuelno pitanje poslednjih godina je potraga za metodama smanjenja potrosnje goriva i poboljsanja ekoloske performanse motora sa unutrašnjim sagorevanjem. U motorima sa paljenjem svecicama, vazan je tip sistema paljenja i njegove komponente. Ovaj izvestaj je ispitivao performanse motora sa unutrašnjim sagorevanjem probanjem razlicitih gasnih goriva i sa razlicitim tipovima svećica. Predstavljene su energijsko-ekonomske i ekološke karakteristike razlicitih goriva i razlicitih tipova svećica. Zaključci su praktični i ekonomski uslovi.

**KLJUČNE REČI:** svećica, LPG, CNG, ICE, performanse

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## 1. INTRODUCTION

Despite the low prices of the oil in the recent years the gaseous fuels continue to be widely used as an alternative to the traditional liquid fuels. In most cases, when transforming engines so as to be able to operate with gaseous fuels, we speak about vehicles with significant mileage. As regards those vehicles, the main objective is to ensure the proper and normal operation of the engine ignition system. The question what type of spark plugs to be used - the standard ones recommended by the manufacturer of the vehicle or spark plugs intended specifically for gaseous fuels - is raised. In the recent years, the iridium spark plugs for which the manufacturers promise better performance of the engines using them and longer life of the spark plugs themselves have become widely popular. This study puts the beginning of the implementation of a more comprehensive project covering spark plugs manufactured by the most leading companies and several types of gaseous fuels.

## 2. SUBJECT OF RESEARCH

In the operation of internal combustion engines with external carburation and positive ignition it is essential to provide reliable combustion of the gaseous mixture in the cylinder space. This is mainly determined by several factors:

- technical condition of the engine
- composition of the fuel-air mixture
- quality of the electrical spark
- condition of the ignition system
- type of fuel used.

We will not comment on the impact of the engine technical condition, since it is clear that the engine must be in a full working order.

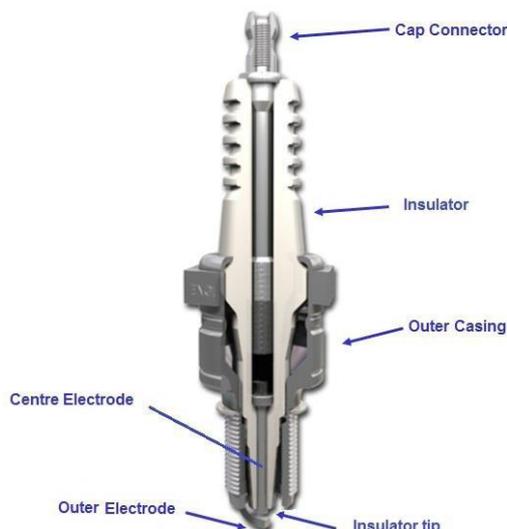
The use of gaseous fuels for operation of internal combustion engines has some features which must be taken into account in the choice of gas modified ignition system:

1. It is known that the flashpoint of the various fuels is different and varies:
  - Methane it is 545 - 800°C
  - Ethane - 530 - 694°C
  - Propane - 504 - 588°C
  - Propylene - 455 - 550°C
  - N-butane - 430 - 570°C
  - Isobutane - 490 - 510°C
  - Isobutylene - 400 - 440°C
  - Gasoline - 480 - 530°C.

This means that a high energy ignition system (especially when working with methane) must be used for the gaseous fuel ignition.

2. To obtain effective and cost-efficient operation of the engine using gaseous fuel leaner mixtures must be used. This requires that high effective and reliable ignition system should be used to ensure the timely combustion of the aggregated fuel-air mixture.

A spark plug (figure1) is composed of a shell, insulator and the central conductor. It passes through the wall of the combustion chamber and therefore must also seal the combustion chamber against high pressures and temperatures without deteriorating over long periods of time and extended use.



**Figure 1.** Spark plug construction

A modern spark plug must meet the following requirements:

- Reliable high-voltage transmission, even at ignition voltages of up to 40,000 volts;
- Good insulation capability, even at temperatures of 1,000 °C, prevention of arcing and flashover;
- Resistance to thermal shock (hot exhaust gases – cold intake mixture);
- Good thermal conduction by insulator tip and electrodes;
- Pressure-tight and gas-tight sealing of the combustion chamber, resistance to oscillating pressures up to approx. 100 bar;
- High mechanical strength for reliable installation;
- Resistance to spark erosion, combustion gases and residues;
- Prevention of build-up of deposits on the insulator.

The thermal rating is a measure of the thermal structure of a spark plug. It indicates the maximum thermal loading on the spark plug in equilibrium between heat absorption and heat dissipation. It is vital to choose the correct thermal rating when selecting a spark plug. The central electrode is connected to the terminal through an internal wire and commonly a ceramic series resistance to reduce emission of RF noise from the sparking. Non-resistor spark plugs, commonly sold without an "R" in the plug type part number, lack this element to reduce electro-magnetic interference with radios and other sensitive equipment. The tip can be made of a combination of copper, nickel-iron, chromium, or noble metals.



**Figure 2.** Flame speed at different Spark plugs

The development of noble metal high temperature electrodes (using metals such as yttrium, iridium, tungsten, or palladium, as well as the relatively high value platinum, silver or gold) allows the use of a smaller center wire, which has sharper edges but will not melt or corrode away. These materials are used because of their high melting points and durability, not because of their electrical conductivity (which is irrelevant in series with the plug resistor or wires). The smaller electrode also absorbs less heat from the spark and initial flame energy (figure 2). Some of the characteristics of metals are shown in Table 1.

**Table 1.** Metal characteristics

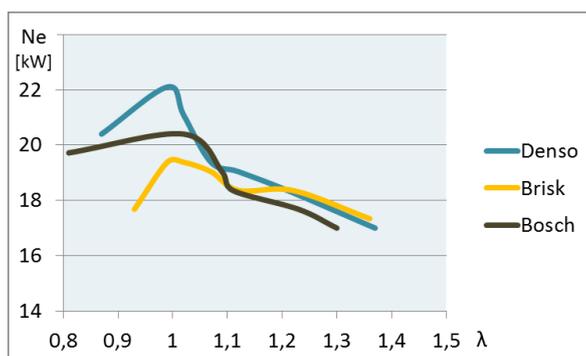
Material	Melting point [°C]	Hardness [Hv]	Strength [kg/mm <sup>2</sup> ]
Iridium	2450	450	110
Platinum	1770	50	15
Nickel	1450	160	70

### 3. RESULTS AND DISCUSSION

The map dependent value determined based on the composition of the fuel-air mixture at 3,400 rpm and partial throttle has been presented. Liquefied petroleum gas (LPG) and compressed natural gas (CNG) are used as fuels to operate the engine Rover 1.3. We use different spark plugs (figure 3) - regular nickel Denso, iridium Denso, especially designed for gas fuels silver Brisk and platinum iridium Bosch. These spark plugs cover different price range and reputation.



**Figure 3.** Spark plugs used in our experimental research



**Figure 4.** Effective power, fuel CNG

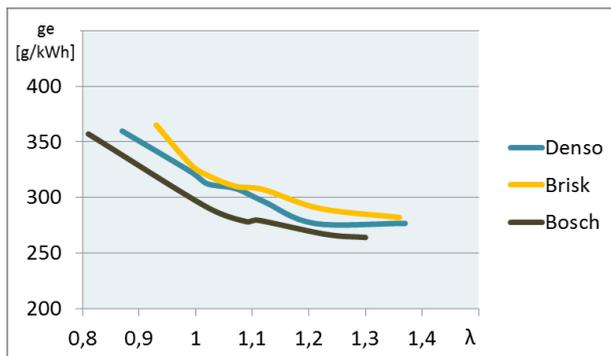


Figure 5. Effective specific fuel consumption, fuel CNG

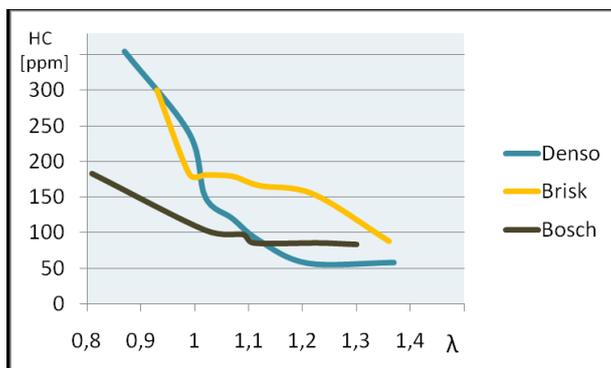


Figure 6. Hydrocarbon emissions, fuel CNG

The change of the engine effective power based on the change of the map dependent value – figure 4 - shows that if the fuel-air mixture has a stoichiometric composition and if spark plugs Denso are used the maximum power is 22.1 kW; if spark plugs Bosch are used the maximum power is 20.4 kW, and if spark plugs Brisk are used the maximum power is 19.3 kW. The effective specific fuel consumption (ge) – figure 5 - is significantly affected by the type of spark plug at low air–fuel equivalence ratio which means: lowest value is for spark plugs Bosch, consumption for spark plug Denso and Brisk is respectively 6.2% and 14 % more.

Figure 6 shows the change of the hydrocarbon amount (HC) in the exhaust gases. Higher values are reported when CNG is used (140 ÷ 235 ppm), while the values reported when the engine is operated by LPG are 65 ÷ 125 ppm.

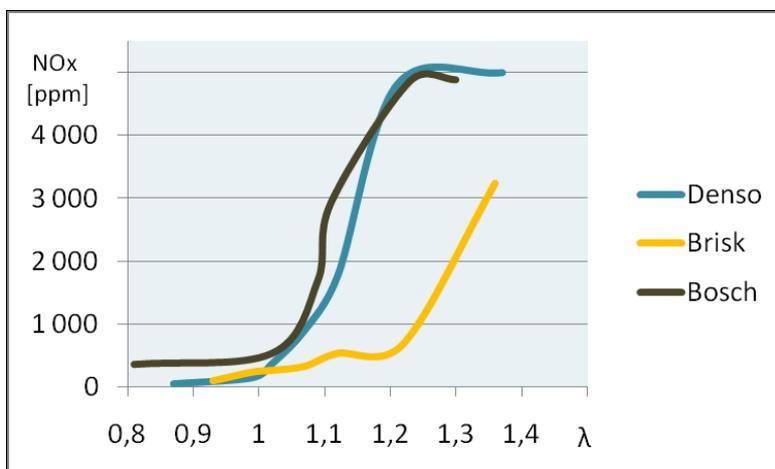
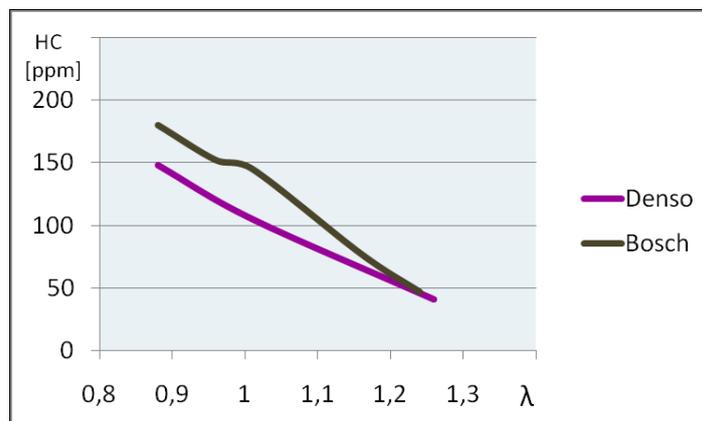


Figure 7. Mono-nitrogen oxides emissions, fuel CNG

The nitrogen oxides grow with the increase in fuel air ratio, as lowest are at spark plugs Brisk (figure 7). The values are changing from 89 to 3233 ppm for Brisk, from 42 to 4999 ppm for Denso and from 351 to 4880 ppm for Bosch.



**Figure 8.** Hydrocarbon emissions, fuel LPG

Experiments were performed on a comparison of the two types of iridium spark plugs (Bosch and Denso) by fuel LPG. There hasn't significant difference in the power and economic engine performance. Visible differences has only in the toxicity of exhaust emissions especially in hydrocarbons (figure 8). The values are changing from 41 to 148 ppm for Denso and from 47 to 180 ppm for Bosch.

#### 4. CONCLUSIONS

- With fuel CNG higher engine power close to the stoichiometric fuel-air mixture is achieved when the engine is equipped with spark plugs Denso. Lowest hourly fuel consumption is achieved when spark plugs Bosch are used.
- As regards the environmental performance, lowest hydrocarbon emissions are reported when spark plugs Bosch are used, as only in case of large amount of lean fuel-air mixture the use of spark plugs manufactured by Denso leads to lower hydrocarbon emissions. Lowest nitrogen oxide emissions are reported when spark plugs Brisk are used.
- When natural gas is used the type of spark plugs have greater importance for the performance and emissions of the engine compared to LPG
- Comprehensive and more detailed studies must be conducted to conclusively determine the advantages of the spark plugs intended specifically for engines operated with gaseous fuels.

#### ACKNOWLEDGMENTS

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