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Technical communication

Fuel economy improvement by on board electrolytic hydrogen production

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1. General

Fuel economy is a major area of interest for the public and policy makers. There are several reasons for this interest [1]:

- fuel economy is directly related to CO_2 emissions which constitute a greenhouse gas that traps the Earth's heat and contributes to the potential for global warming;
- most of the fuel consumed is derived from crude oil and world crude oil reserves are depleting fast;
- fuel economy is related to vehicle travel cost and world vehicle travel has doubled since 1970.

Therefore, it is of great importance to increase the fuel economy to the extent of the current level of technology limits. Many scientists and researchers tried to develop new technologies to achieve low fuel consuming cars and vehicles. Some came up with the utilisation of alternative fuels, some improved the engine designs and some invented new ways to power the vehicles. This study presents a hydrogas system, basically a hydrogen generator by the electrolysis of water. The system can be used for both spark ignited and compression ignition internal combustion engines. Within the compact structure of the system, tap water is electrolysed by so called "closed cell electrode technology". Coal particles bonded together by a novel material constitute one pole of the electrolyser circuitry making non-corrosive and wear free operation possible for years, without using any catalysers like caustics and acids. Thus, produced hydrogen gas along with oxygen are fed to the intake manifold. Due to the simultaneous production and consumption of hydrogen, no storage is necessary, which results in safe operation.

2. The hydrogas system

The technology of using hydrogen as a combustion enhancement method in internal combustion engines has been investigated and verified for many years [2–4]. The results show that a small amount of hydrogen added to the incoming fuel-air mixture would enhance the flame velocity and permit the engine to operate with leaner mixtures. Consequently, hydrogen having a catalytic effect causes a more complete burn of the existing fuel, and yields significant reduction in exhaust emissions with more power and better mileage. The effort in trying to develop practical systems to enhance internal combustion engine performance with hydrogen as a fuel supplement, yielded few products reaching marketing phase [5,6]. But these products require that some type of additive be added to the electrolysis water, which is not the case with the hydrogas system.

The device presented in this study produces hydrogen and oxygen on-board, using water electrolysis and can be installed on different vehicles of various types and sizes of engines. The system is primarily based on

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the electrolysis of water in closed cell electrodes, and the feeding of the thus produced hydrogen and oxygen directly into the intake manifold of the engine. The general structure of the system is shown in Fig. 1. Unlike its predecessors, no additives and catalysts such as acids and salts are used in the electrolysis of normal tap water. Consequently, the possibility of the evaporation of additives and their entrance to the combustion chamber which leads to corrosion, is eliminated. As illustrated in Fig. 1, carbon powder, together with a special bonding material, is compressed into a spherical shape and placed inside the electrolysis cell (1), which serves as cathode electrode (5). This carbon layer does not dissolve in water due to the special bonding material used. Because of the use of carbon electrode, electrolysis efficiency is increased and heating of the electrodes is reduced. A secondary circuitry (2) added to the alternator (11) increases the voltage to 90 V and reduces current to 3 A. This alternating current is converted to direct current in a 3-phased diode and is fed to the anode electrode (4) of the electrolysis cell. The anode electrode is made of platinum. The electrolysis cell is cooled by water circulating around it. The whole system and operation are electronically controlled. Water levels in the electrolysis cell and water tank are maintained between pre-defined intervals by a water level control unit.

No modifications to the engine are necessary. The system and operation are very simple. For each electrolysis cell, water needs to be added for every 650 km of operation. Hydrogen is not stored in the system and is produced only when the engine is running and the

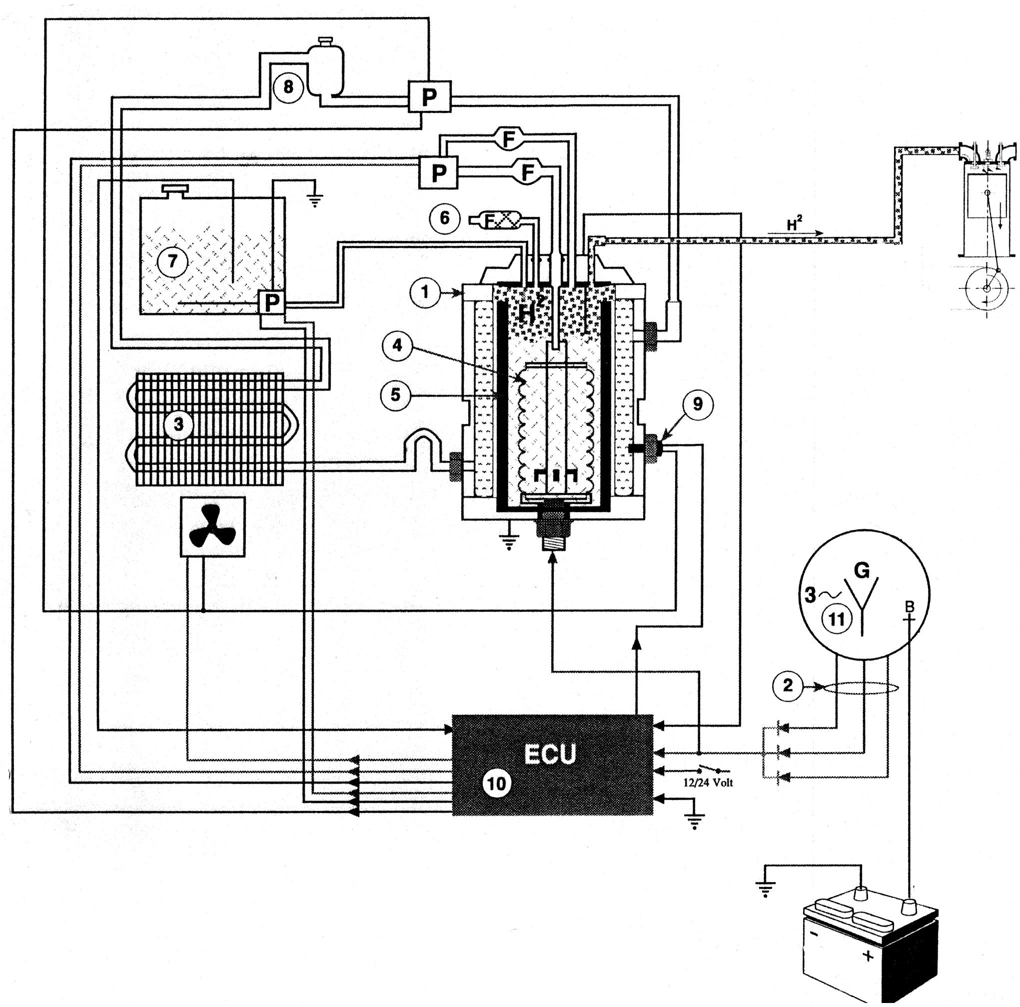

Fig. 1. General structure of the system (1. Electrolysis cell; 2. Secondary circuitry; 3. Radiator; 4. Anode electrode; 5. Cathode electrode; 6. Air filter; 7. Water tank; 8. Cooling water tank; 9. Water temperature sensor; 10. Electronic control unit of the system; 11. Alternator. P — water pump; F — water filter).

Table 1
Technical specifications

Maximum gas supply	20 l/h
Cathode electrode	Carbon
Anode electrode	Platinum
Electrolysis voltage	90 V
Electrolysis current	3 A
Water	Normal tap water
Water tank volume	2.5 l
Water consumption	100 ml/250 km
Water supply control	Electronically controlled
Water temperature range	45–50°C
Cooling	Water cooled
Dimensions	150 × 140 × 135 mm
Weight	2 kg

gas is immediately introduced into the intake manifold. Therefore, there is no safety problem. The technical specifications of the system are given in Table 1.

3. Results and conclusions

The system was installed in four cars in order to demonstrate its effect on fuel consumption. These cars are a 1993 model Volvo 940, a 1996 model Mercedes 280, a 1992 model Fiat Kartal and a 1992 model Fiat Doğan. The driving tests under city traffic conditions showed that the fuel consumption for the Volvo 940 dropped to 6 l/100 km from 10.5 l/100 km, a reduction of 43% in fuel consumption. The figures for the Mercedes 280 were a drop from 11 l/100 km to 7 l/100 km, a reduction of 36%. The Fiat Kartal engine consumed 9.5 l/100 km without the system. With the system installed, the fuel consumption was 7 l/100 km which corresponds to a 26% reduction. The Fiat Doğan engine yielded 9 l/100 km without the system and 6 l/100 km with the system, a reduction of 33%. These results demonstrate the fuel savings potential of the hydrogas system. However, if a device is to reduce fuel consumption, it also has to comply with exhaust emissions regulations. Emission tests show that exhaust emissions such as CO, CO_2 and hydrocarbons are not affected negatively by the system. Moreover, these emissions reduce up to a margin of 40–50% depending on the type of the engine. Also, no performance penalty is observed. Acceleration, torque and maximum power remains unchanged. Therefore, without altering any performance criteria, the system yields 35–40% fuel savings and reduces exhaust emissions.

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