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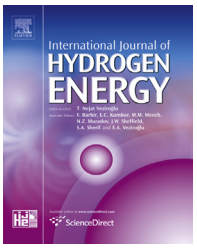

Integration of low-pressure hydrogen storage cylinder and automatic controller for carbon deposit removal in car engine

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ABSTRACT

This study has completed the preliminary test of the "automotive hydrogen gas release controller with low pressure hydrogen storage module" in the carbon removal of cars engine, this product has integrated (1) a low pressure hydrogen storage cylinder (metal hydride) and (2) a solenoid valve controller with flow meter. Under normal temperature and pressure settings, this system is able to transfer hydrogen gas to the vehicle's intake air system and mixing with the air, entering the engine chamber. The solenoid valve controller and flow meter can control the optimized hydrogen gas output flow rate, activating the carbon deposit removal. The results of this study show that in the example for a 1,600 cc vehicle, 1690 USD may be saved for gasoline in a year with reducing 164.8 ton of CO_2 emission (The enhancing of fuel utilization 11.6%). For a 2,000 cc vehicle, 3070 USD may be saved for gasoline in a year with reducing 291 ton of CO_2 emission (The enhancing of fuel utilization 20.6%). A set of low pressure hydrogen storage system has been developed in this research, it is safe and convenient for consumers, the Solenoid Valve Controller and Flow meter allows for optimized use of hydrogen gas, reducing the waste of excess hydrogen gas.

Introduction

Hydrogen gas is known to be one of the most ideal energy sources for future automobile fuel. Hydrogen gas storage is one of the main challenges in the hydrogen gas development industry. Insofar, current high pressure gaseous hydrogen or liquid hydrogen storage methods are not able to satisfy the future storage objectives. The physical storage method of combining metal and other materials has a greater potential

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advantage over other storage methods. Recently, numerous researches on metallic hydride storage have improved the performance of hydrogen fuel [1]. There are two main objectives worth noting of the application of hydrogen gas storage to transportation: First of all, the transportation industry is the largest consumer in oil, the largest source of carbon and nitrogen-oxide pollutants in the atmosphere. Secondly, due to efficiency and economic requirements, a greater challenge exists in hydrogen storage compared to fossil fuel storage. There have been several researches studied on low pressure hydrogen storage (metallic hydride) [2–8].

Automobile engine retention in carbon deposition has a severe impact on the engine. This effect is echoed not only in the physical structure of the damage to the engine itself, also make the work efficiency reduced [9]. Many researchers described investigation of the carbon deposit formation phenomenon in Gasoline Direct Injection engine [9–13]. According to the statistics of February 2014 from the Ministry of Transportation's data in Taiwan, the registered number of motor vehicles in Taiwan includes 21,583,375 cars and motorcycles. The main pollutants emitted from cars and vehicles are particulate matters (PM), carbon monoxide (CO), hydrocarbon (HC), nitrogen oxides (NOx), lead (Pb), sulfur oxides (SOx) etc. [14–19], not only are these pollutants harmful to human health, nitrogen oxides and hydrocarbons are also sources of the formation of photochemical smog and ozone. According to the Ministry of Transportation's statistics in Taiwan, since 2003, the country's number of motor vehicles has been increasing every year, reaching its peak in 2012 with a total of 22,340,000 motor vehicles. The number may have dropped in 2013, but as of December, 2013, but there are still at least 21,560,000 motor vehicles, about 1.17 times the number of motor vehicles in 2003 (18,500,000). Through related investigations, we can see that the motor vehicle-emitted pollution is the one of the public's greatest concern in improving air quality. Therefore, reducing vehicle pollutant emissions to improve the public's living environmental quality is a problem that government policies must deal with immediately; it is also an objective that industries and academics are working towards.

In terms of pollutant emission, under low-speed revolution and low load conditions, high concentrations of mixed gas may easily lead to incomplete combustion, increasing pollutant emission. As revolution and intake flow increases, CO, HC, NO_x are reduced while CO_2 is increased. Under high-speed revolution and high load conditions, combustion intervals are reduced and the hydrogen cannot be fully mixed with the air, leading to reduced combustion efficiency, NO, HC, NO_x are increased while CO_2 is reduced. Differentiating from traditional toxic and corrosive chemical substances for carbon deposit removal [20,21]. Mixed gas carbon removal is a new method of removing the engine carbon deposit, not only without stripping the engine, but also on the environment protection. Recently, the removing carbon deposition engine with mixed gas is widely used in engine maintenance [9,22].

However, hydrogen is usually transferred into the internal combustion engine through its air intake system which prevents hydrogen from mixing with the external air; as a result, the hydrogen will not be able to reach its highest performance. Furthermore, too much or too little amount of hydrogen entering the vehicle's internal combustion engine will lead to the waste of hydrogen which cannot effectively reduce the air pollution. This study intends to develop an "integrated Low Pressure Hydrogen Storage and Transfer Device." This is a type of low pressure hydrogen storage and transfer device with a hydrogen storage cylinder and mixing device. The inside of the hydrogen storage cylinder is of metallic hydride used for hydrogen storage, the hydrogen is fully mixed with the external air in the mixing chamber before entering the vehicle's internal combustion chamber, this will effectively reduce pollution and achieve the purpose of efficient energy saving.

Experiment method and procedure

This research is in coordination with China New Energy Cooperation LTD's by using "Automotive Carbon Deposit Removal Module". An appropriate amount of hydrogen gas is directly channeled into the engine chamber for combustion. Burning mixed gas and hydrogen will increase the temperature in the combustion chamber, in turn burning the carbon deposit and subsequently discharging it. This will effectively remove carbon deposits from the engine, catalytic converter, fuel system, combustion chamber and throttle, improving mobility instability, loss in idling, thus resulting in carbon deposit removal. The devices design and experimental procedures is follows:

Assembly of the Low Pressure Hydrogen Storage and Transfer Device

This study's design includes the modification hydrogen gas release from manual operation to automatic operation, an automatic control for hydrogen gas flow and output, it convenient to operate and the parts and components are effectively integrated. Not only is the device well integrated, its volume and costs are also reduced.

1. In the preliminary concept, lanthanum pentanickel ($LaNi_5$) is selected as the alloy storage medium, with stainless steel as the outer material for the gas cylinder.
2. To prevent connector leakage, the output section of the solenoid valve is connected by quick coupling (female), this is only to be closed off when the quick coupling (male) has completed transfer of the connected hydrogen gas.
3. The design module for Low Pressure Hydrogen Storage ($LaNi_5$ hydride as hydrogen storage material) and Transfer Device is selected, the assembly completed.
4. The assembly of the low pressure hydrogen storage cylinder and solenoid valve completed, quick coupling and piping are assembled to be used for subsequent development of module prototype, the completed module is shown in Fig. 1.

Integrated Solenoid Valve-Controlled Hydrogen Activation and Flow Device

The design for the Solenoid Valve-Controlled Hydrogen Activation and Flow Device is shown in Fig. 2, including (1)

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