Potential of using Solid-state Hydrogen Storage in Vehicles

Ng Pei-Qi K00265932

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Aim of the Project

The purpose of this research is to investigate the potential of implementing solid-state hydrogen storage in transportation.

Objectives

- Research current technology level of using hydrogen fuel in vehicles.
- Research current difficulties and challenges of using solid-state hydrogen storage in real life.
- Investigate & explore the applications of Solid-state Hydrogen Fuel Storage in different fields.
- Study and conclude the criteria/requirement for using Solid-state Hydrogen Fuel Storage in vehicles.

Background

This project includes fundamental information of using hydrogen solely as a type of renewable fuel source in vehicles, and current technology in solid state hydrogen storage. This dissertation also outlines the development and challenges of using solid-state hydrogen storage in real life and automobiles. At the end of this dissertation, conditions and parameters required to implement solid hydrogen storage in vehicles are concluded with evidence.

Figure 1: Hydrogen-fuelled Car

Hydrogen-fuelled Vehicles

- A hydrogen-air mixture has about 6 times the higher energy content than petrol in the combustion chamber. This contributes to higher engine efficiency compared to traditional fuels.
- Hydrogen can be used as fuel in both Spark Ignition (SI) and Compression Ignition (CI) engines, without major modifications to the existing systems.

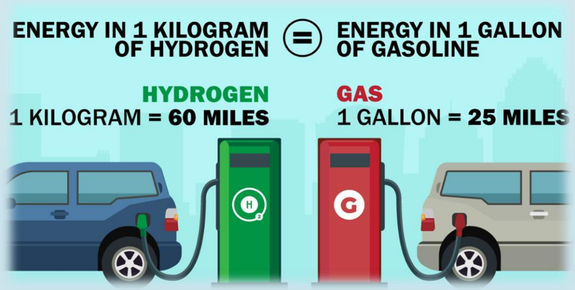

Figure 2: Hydrogen fuel vs Gasoline

- It depends on several factors to determine the amount of hydrogen needed to run a vehicle, including engine efficiency, vehicle weight, driving conditions and fuel storage methods.
- Recently, JCB has develop the first fully working hydrogen motor in the industry.
- The modified engine has equivalent performance compared to diesel engines in both torque and power. It is a huge milestone in the automobile industry.

Figure 3: JCB Hydrogen Engine

Solid Hydrogen Storage

Figure 4: McPhy Hydrogen Storage

- Usually, hydrogen are stored in gaseous and liquid state, but they are relatively dangerous compared to solid state hydrogen.
- There are several common and useful materials for storing hydrogen in solid-state, including Magnesium Hydride (MgH_2), other Metal Hydrides, Complex Hydrides and other materials.

Challenges

- It requires high temperature and pressure for operating solid-state hydrogen storage as it required high amount of energy during the process.
- The other challenge is to increase the storage capacity of storage materials, where the benchmark required by USDOE 6.5%.
- MgH_2 have approximately 7.6% of volumetric capacity, which it is just over the minimum requirement.

MgH2 Operating Characteristic	Value
Temperature	250-300°C
Pressure	1bar (100kPa)
Volumetric Capacity	7-7.6%

Table 1: Characteristic of Magnesium Hydride

Findings

- A typical diesel vehicle requires 1646.8MJ of energy to drive up to 500km, which is approximately 14kg of hydrogen needed for the same spec of vehicle.
- In this case, approximately 184.21 kg of MgH_2 is needed for the storage system.
- The operating temperature ranges from $250 - 375℃$, where operating pressure ranges from 0.1 – 3MPa.
- The by product for the storage systems is steam, which is just water.

Figure 5: Hyundai NEXO Hydrogen Fuel-cell car

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