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Exploring How Hydrogen Fuel Can Be Used in The Automotive Industry

Academic Skills ACHA4005

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2205525

25.11.2022

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1 Introduction

The need for an alternative power source for the automotive industry that is cleaner, more efficient and is renewable has become more and more prevalent in recent years. "The transport sector was responsible for ~18% of the total Green House Gasses (GHG) emissions globally in 2016. Nearly 24% of total anthropogenic CO₂ (the main GHG) was generated by the transport sector worldwide in 2017 and road transport vehicles were responsible for nearly three-quarters of the total transport CO₂ emissions" (Agarwal and Mustafi, 2021). There are many possible alternatives. The two most researched solutions are a change to Battery Electric Vehicles (BEV's) or the other being the use of Hydrogen (H₂) as a fuel source, either in an internal combustion engine or used in a fuel cell. The aim of this report is to discuss the current and future potential of H₂, the basic concepts on how H₂ is used, stored and produced and to talk about the many advantages and possible drawbacks it has to offer.

2 Literature review

2.1 Current usage

Manoharan (2019) suggests although hydrogen is a molecule with a relatively low energy content it has one of the highest energy contents compared to its weight of any known fuel. This means it is already used widespread as a combustible fuel in industry. Uses include rockets due to it being a very abundant element although it is energy intensive to produce. Further research from Manoharan (2019) shows it can be as much as three times more expensive to produce compared to its fossil fuel counterparts, however research is being advanced to produce it in a less costly way. Hydrogen Fuel Cell Vehicles (FCV's) are currently being produced for the consumer market by only a few automotive manufacturers such as Honda, Toyota and Hyundai. Data from Manoharan (2019) shows that over 6500 FCV's have currently been sold globally. One of its advantages it shares with BEV's is its lack of emissions produced while the vehicle is being used. (Manoharan *et al.*, 2019).

2.2 Hydrogen Storage in Vehicles

Hydrogen as a fuel source can be stored in several ways. Cousins and Zhang (2019) says the two most common and simple ways to store H₂ is either as a gas in a high-pressure tank or as a liquid at very low temperatures (below 20 kelvin). Although both methods work well, they are not efficient as they use a lot of energy to store in these conditions. Another drawback is that research from Cousins and Zhang (2019) has shown that hydrogen can cause steel (often used for the tank in both methods) to become brittle, thus becoming a safety concern. Other disadvantages to storing hydrogen as a liquid include it having a boil off rate (evaporative loss) of about 1% per day which further decreases the efficiency as well as the loss of power which would need to be used to keep the hydrogen cool enough (Ross, 2006, sec. 2)). For the above reasons much of the research and development is being put in to developing alternative storage solutions. One such storage solution is the use of hydrogen containing molecules. Cousins and Zhang (2019) states that storing H₂ molecules as part of another larger molecule and breaking the bonds before use so that the hydrogen can be used as a fuel is a current way of storing H₂. This has the bonus of having a large storage capability; however, they also state that this process used large amounts heat in order to

break the bond of the H_2 , leading to a decrease in its overall efficiency. These larger molecules also tend to be quite reactive causing safety concerns with this method. (Cousins and Zhang, 2019)

2.3 Hydrogen Fuel Cells in Practise

Hydrogen as a fuel source can be used in several different ways. The main two ways of using it in a vehicle are by internal combustion or by using it within a fuel cell to create electricity. Blitek and Mieszko (2019) suggest that the main way in which hydrogen power could be used in vehicles is with the use of a fuel cell to convert the chemical energy of the hydrogen into electrical energy. A fuel cell is made of four main components. On the outside there are two flow fields either side of the fuel cell, then there is the anode, then an electrolyte in the middle, which can be made of many different materials to change the characteristics of the fuel cell; finally, there is the cathode. Blitek and Mieszko (2019) go on to explain that by splitting the particle of hydrogen, the chemical energy stored in the hydrogen is released as electrical energy and used to power the motors and cars systems. They also go on to explain that in the case of hydrogen, within the anode the hydrogen is split into positive hydrogen protons and negatively charged electrons. The electrolyte in the middle serves only to allow the protons to flow through it which causes the negative electrons to flow around the circuit you want to power to reach the cathode. In the cathode the particles react together to form into water as a waste product. (Blitek and Mieszko, 2011, p. 6)

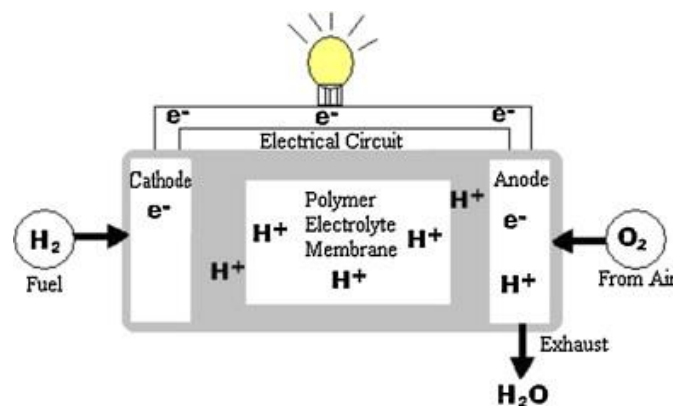


Figure 1 Operating principle of a fuel cell (Mekhilef, Saidur and Safari, 2012)

2.4 Hydrogen Production

The production of hydrogen is very important to the future of H_2 vehicles as at current, it is one of main obstacles standing in the way of hydrogen being the accepted alternative fuel. Hydrogen is not naturally present on its own, meaning it must be refined from other sources. Nikolaidis and Poullikkas, (2017) state that the current main method of producing hydrogen is refining it from fossil fuels by hydrocarbon reforming and pyrolysis, this method contributes to most of the world's supply of hydrogen. Research shows that the hydrogen produced is refined from 48% natural gas, 30% heavy oils and 18% from coal. This means that although FCV's produce no emissions, the hydrogen they run on is refined from fossil fuels, which undermines the goal of hydrogen being renewable. Another method outlined by Nikolaidis and Poullikkas, (2017) is H_2 production via splitting water using electrolysis. Electrolysis is known to be the best way to produce H_2 from water and is done by using an anode and a cathode in an electrolyte which as electrical current run through, it causes the water to be split into hydrogen molecules at the cathode and oxygen molecules at the anode. The hydrogen is then collected. (Nikolaidis and Poullikkas, 2017) states as electrolysis require electricity to extract hydrogen, the source of that power can greatly affect how eco-friendly using hydrogen

can be. If a fossil fuel is used to create hydrogen, it will not be as environmentally friendly as extracting it using renewable energy. "If the required energy input is provided from renewable energy sources, the hydrogen produced will be the cleanest energy carrier that could be used by mankind." (Nikolaidis and Poullikkas, 2017).

3 Results and Discussion

From the research conducted in this report H₂ is being taken seriously in the automotive industry as a possible alternative to fossil fuels. A reason for this is that compared to current fuels, hydrogen power, using fuel cells, produces no emissions at all and it is possible to produce the H₂ used to be produced in a renewable way and without producing and greenhouse gases (GHG's). this would make it possible for vehicles to run totally emission free using totally emission free fuel. This however isn't true at this time as the vast majority of the H₂ we produce is refined from fossil fuels meaning current FCV usage is far from the zero-emission concept that is possible. Another obstacle for FCVs to overcome is the onboard storage issues with the current technology used. This is a major hurdle as it negatively impacts the viability of FCV as current storage methods are either potentially unsafe, power intensive effecting the efficiency of the vehicle or don't have a very good storage capability meaning low effective range and poor storage efficiency. This proves to be a large flaw in the future of FCVs until a better and safer solution is developed.

4 Conclusion

To conclude, the future of H₂ as an alternative fuel source shows a lot of promise as a clean, safe and renewable option. There are a lot of positives regarding how effective FCVs can function and how they can integrate into the automotive industry, however there are major flaws such as the production and storage which need to be solved, as well as infrastructure implementation first. H₂ vehicles, like many other industries, is limited mainly by the global production of energy and primarily how much of it is produced in an eco-friendly way. As stated above, if more of the worlds H₂ production was done through water splitting electrolysis, and if the energy used to produce the hydrogen was generated without the burning of fossil fuels, then FCVs would be the most environmentally friendly vehicles we can use. However, until energy is produced from more renewable sources on a wider scale, FCV will not fill their full potential as transport for the future.

5 References

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