Developments in Hydrogen-Fueled Engines for Automobiles and Aircraft

David Ermakov-Spektor, Mentor: Sastry Pamidi

Center of Advanced Power Systems (CAPS), Florida State University

Background

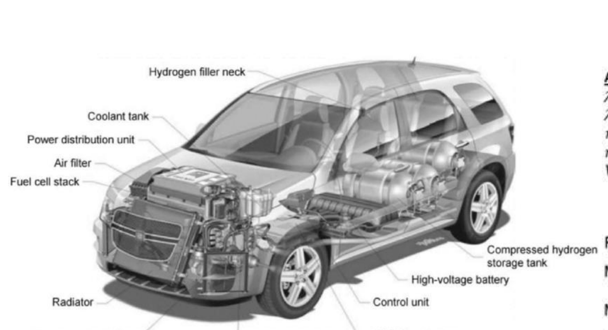
Green Hydrogen or zero-emission hydrogen fuel-based technologies within the past 7 years have found important infrastructure built up. There are delivery trucks and 18-wheel trucks transitioning to running on hydrogen fuel cells. This is in addition to the latest development of green hydrogen powered aircraft & engines. This research is to analyze the development of these green hydrogen fueled engines and their developments in design and changes in infrastructure within the engines of these vehicles.

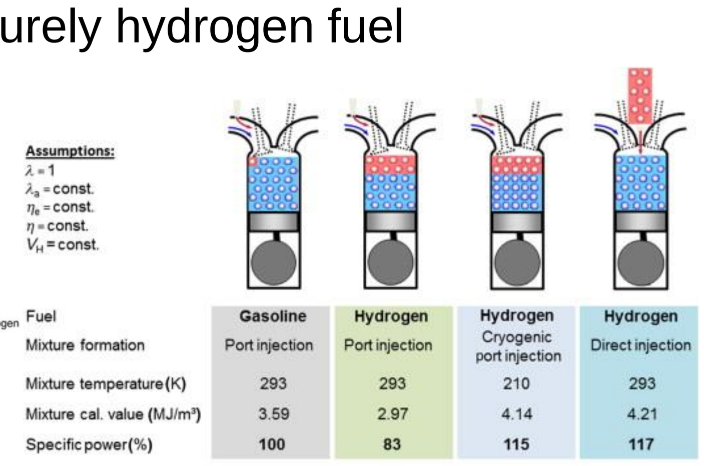
•Between 2022 and 2023 recent models as portrayed have been approved, before this point:
Introduction of hydrogen fuel cells in the ~1842
•Amazon and USPS trucks default usage of hydrogen fuel cell technology in 2017 and 2018
•Development of recent airplane models focused around 2022 and 2023 usage of liquid hydrogen featuring superconductors and a turbine + Engine setup for hydrogen fuel injecting

•Usage of hydrogen technology in Europe through busses and airplanes.

Methods

Our methods were comparing the effectiveness of new hydrogen burning engines and their cost, efficiency, emissions, mileage, compositions and having additional videos/graphics highlighting the difference in function of diesel/gasoline engines and hydrogen-air burning engines. (there will be graphics to highlight this with 1 graphic focusing on the energy density and efficiency of hydrogen engines, this will be followed by a referenced graphic of the inner-working engine cylinders). Afterwards, measuring efficiency in a different manner, this takes 4 different fuel types: 1. a gasoline engine as our control group, 2. hydrogen-air mixture, 3. Cryo-compressed hydrogen-air mixture, 4. Purely hydrogen fuel





Fuel	Gasoline	Hydrogen	Hydrogen	Hydrogen
Mixture formation	Port injection	Port injection	Cryogenic port injection	Direct injection
Mixture temperature (K)	293	293	210	293
Mixture cal. value (MJ/m^3)	3.59	2.97	4.14	4.21
Specific power (%)	100	83	115	117

Figure [1]: A GM HydroGen4 2007 model used for example of storage **Figure [2]:** Energy density across various forms of Hydrogen Fuel

Results

The results found that since hydrogen has a lower volumetric energy density as a fuel than gasoline, more volume displacement (in this context: fuel injection) would be required, showing that cryo-compressed hydrogen fuel and direct injection of liquid hydrogen is a favorable richness of fuel for matching to a control group of gasoline fuel combustion engines. Within different conducted studies, it is shown that hydrogen carries power under cryo-compressed injection at a favorable rate (MJ/m^3) to that of a gasoline engine.

Conversely, recent testing with hydrogen combustion engines have found that the efficiency of Hydrogen's heat transfer is siphoned by the production of NOx due to a hydrogen engine's higher ignition temperature and engine temperature while burned, (585 degrees Celsius for Hydrogen engines compared to 518 degrees Celsius), this as problem has been combated by the timing and change in fuel injection rate. "High NOx emissions present a significant constraint on the power and efficiency enhancement of direct-injection hydrogen engines." With other models of hydrogen engines discussion of using a 3-level reduction of NOx by a 3-step catalytic converter to reduce the emissions of potential NOx.

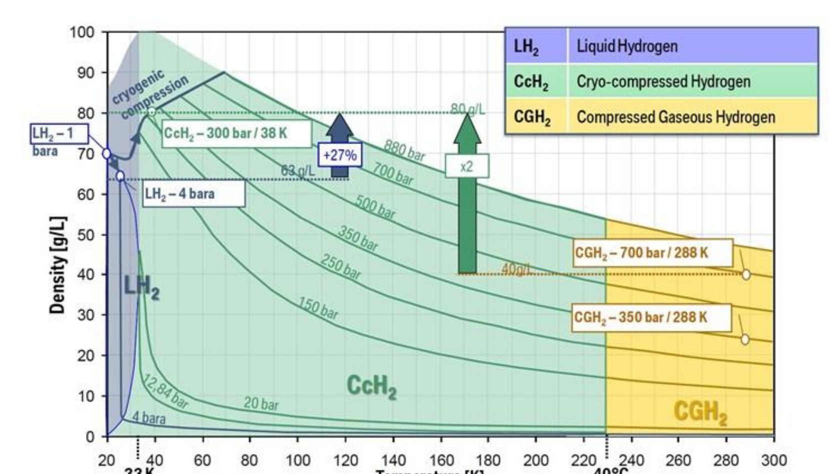


Figure [3]: Volumetric Density of Liquid Hydrogen Cryo-Compressed Hydrogen, and Compressed Hydrogen

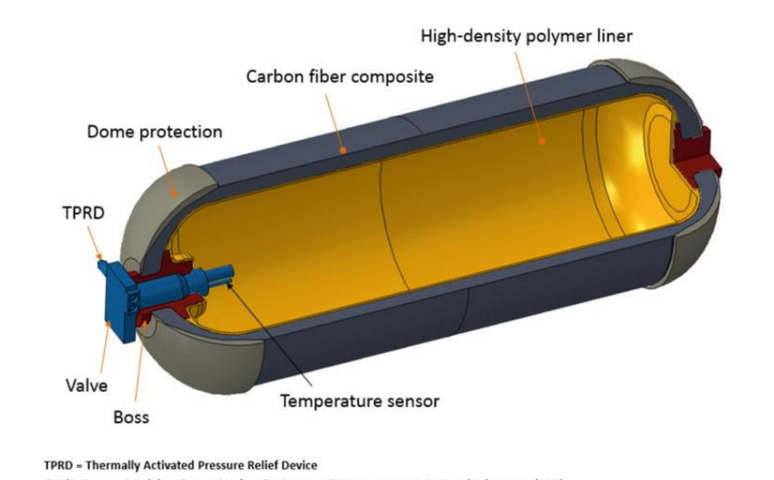


Figure [4]: Models for Pressurized Hydrogen Storage Cylinder

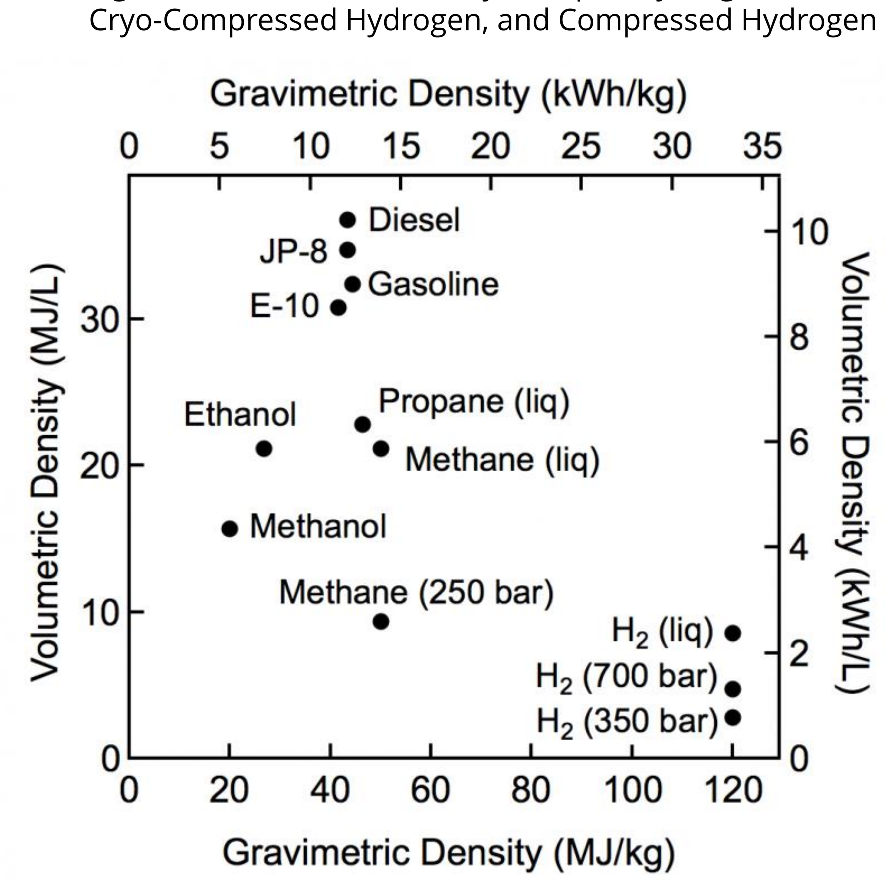


Figure [5]: Comparison of Specific Energy of Hydrogen varieties vs Volumetric & Mass density relative to other fuels.

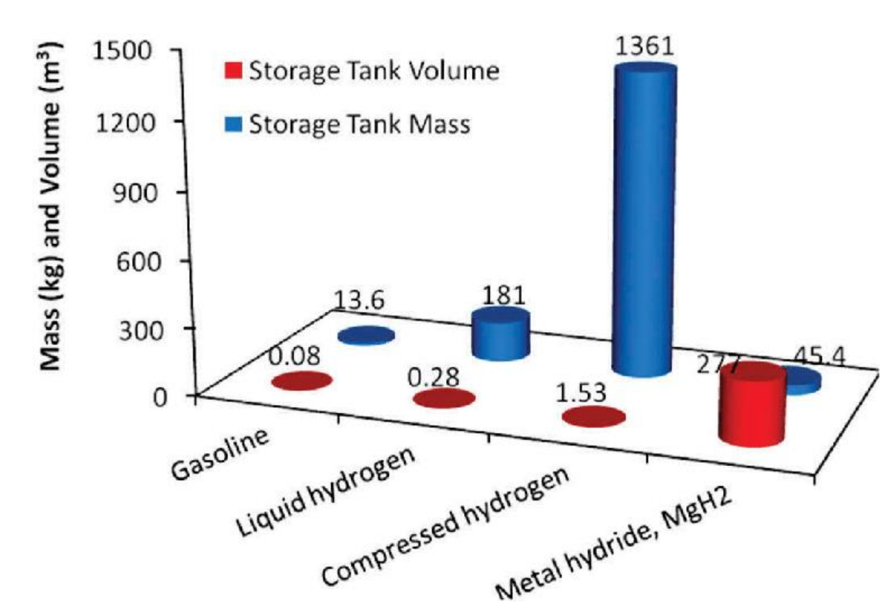


Figure [6]: Contained hydrogen storage with respect to volume-mass

[1]: A GM HydroGen4 2007 model (Harrop and Das n.d)
[2]: Figure from citation, work by Sebastian Verhelst et al
[3]: From energy.gov report by EERE
[4]: Process modeling group, Nuclear Engineering Division, Argonne National Laboratory (ANL)
[5]: From energy.gov report by EERE
[6]: Contained hydrogen storage with respect to volume-mass (Petkov, Veziroğlu, and Of Citationn.d).

Discussion

- Hydrogen engines are attractive as infrastructure for hydrogen becomes more available, the accessibility and usage of cryo-compressed hydrogen storage will become a realistic alternative that reduces the number of emissions and by prospective reports, may cut down on 4% of emissions created by automobiles as this technology becomes better implemented.
- The main problem with hydrogen fuel being the next larger alternative to gasoline and natural gas is storage of this hydrogen; hydrogen refueling centers are required to ensure that the hydrogen in the tank over a longer duration remains cryo-compressed and efficient.
- The production of NOx is something that is actively being addressed and worked upon
- Cryo-compressed for many corporations is the most cost-efficient option and competes at similar power efficiency to that of gasoline engines.
- Concurrently, in the state of California and throughout Europe, hydrogen-fueled transit in the form of mail trucks and busses are using hydrogen within their vehicles. The production and cost-efficiency of hydrogen is prospectively optimistic.

References

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For other references, please use the QR code to the left.