DESIGN AND DEVELOPMENT OF HYDROGEN BASED DUAL FUEL SI ENGINE

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Introduction:

Engines are machines that convert fuel chemical energy into mechanical energy. Spark and compression ignition engines are indispensable for goods transport, and defense applications. The current automobile industry is gradually moving away from traditional fossil fuels due to fuel shortage and pollutant characteristics. Also, the life of existing SI and CI engines can be increased as they are compatible for the dual fuel systems to accept secondary fuels. The use of hydrogen as a fuel in particular is reported to improve the performance and reduce the emissions from the engines. Due to these factors, efforts are being made to implement more sustainable and eco-friendly alternatives. These alternatives include natural fuels like bio-alcohols (ethanol, methanol), hydrogen fuel, biodiesel, vegetable oil, and other biomass sources.

Among these hydrogen fuel has a better combustibility rate when compared to normal fossil fuels (Koryagin and Vorobeva, 2015). Fossil fuels are currently the primary energy source but shortly due to the depletion of fossil fuels, hydrogen fuel may be added to fossil fuels as a supplement for traditional SI and CI engines. Different methods of hydrogen utilization have been proposed; they include Hydrogen Fuel Cells, Dual Fuel Combustion utilizing Hydrogen, and Hydrogen as Direct Fuel. The current project utilizes dual-fuel combustion using hydrogen as a secondary fuel and petrol as a primary fuel. The combination of traditional fossil fuels like petrol, and hydrogen can reduce carbon and NOx emissions. Due to cleaner combustion, the engine is expected to perform better and produce lower emission rates than an engine using petrol or diesel combustion.

Objectives:

The following five objectives are followed to achieve the aim of the project:

1. To conduct literature survey on hydrogen-based engines
2. To arrive at suitable design concepts for the introduction of hydrogen gas into the engine
3. To arrive at design specifications of the selected concept
4. To retrofit an SI engine to accept dual fuel
5. To test the performance improvement of the retrofit engine

Methodology:

Literature related to properties and use of hydrogen as fuel for internal combustion from existing journals, research articles and internet sources were studied before starting the project. The literature survey served as a base for the understanding of hydrogen, its properties and different ways of using it in engines and existing concepts and experimental results to see its viability.

With the knowledge gained through literature survey various concepts for hydrogen introduction into the engine were developed. Following two concepts were developed:

Concept 1: Direct Hydrogen Gas Injection into the Engine

In this concept, ECU controlled Hydrogen injectors are required to inject hydrogen to the engine, fundamentally, the ECU controls the injection of the hydrogen and the timing of the spark to ignite it. These require a number of sensors to measure such variables and apply them to logic in the programming of the ECU to determine how to correctly inject the hydrogen gas.

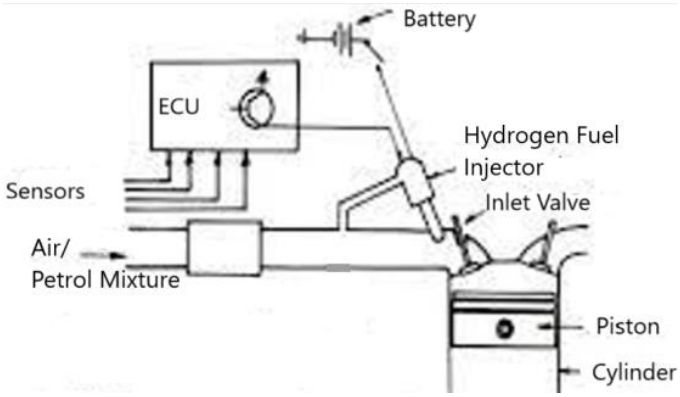


Figure 1- Concept1

Concept 2: Addition of Hydrogen gas and Air from carburetor

In this concept existing carburetor system is modified to accept hydrogen at the air inlet such that the mixture of air and hydrogen is added to the combustion chamber. Air and hydrogen are mixed in the manifold that is fixed to the air inlet of the carburetor. Hydrogen addition is controlled using Flow valve control and pressure control valve. Figure shows the schematic of the hydrogen inlet assembly. Safety components such as fire arrestors and non-return valve are used to avoid accidental release of hydrogen to the atmosphere.

The angle at which the hydrogen is introduced was based on fluid flow simulations.

Fluid flow simulations was carried out for 90^{o} and 45^{0} angle of hydrogen introduction.

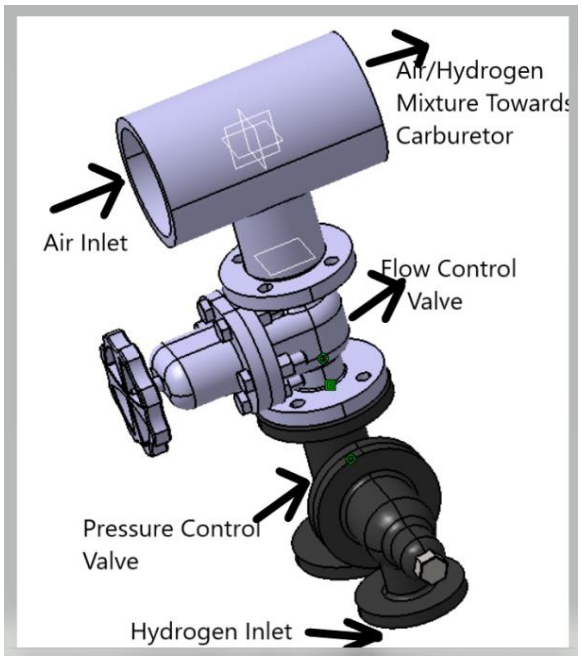


Figure2 - Concept 2

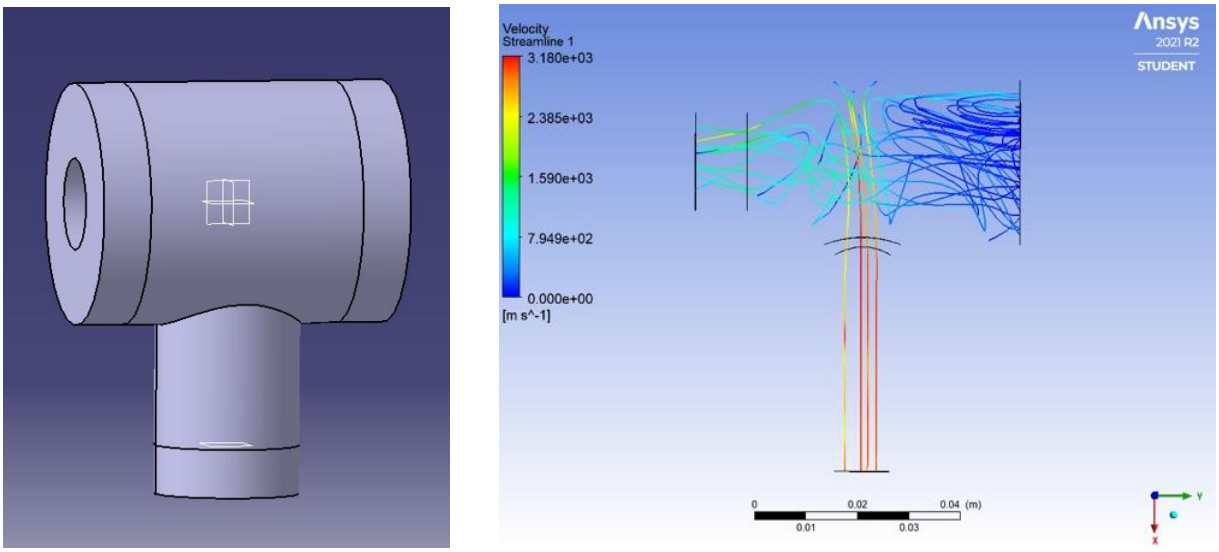


Figure 3 – 90º angle H2 introduction

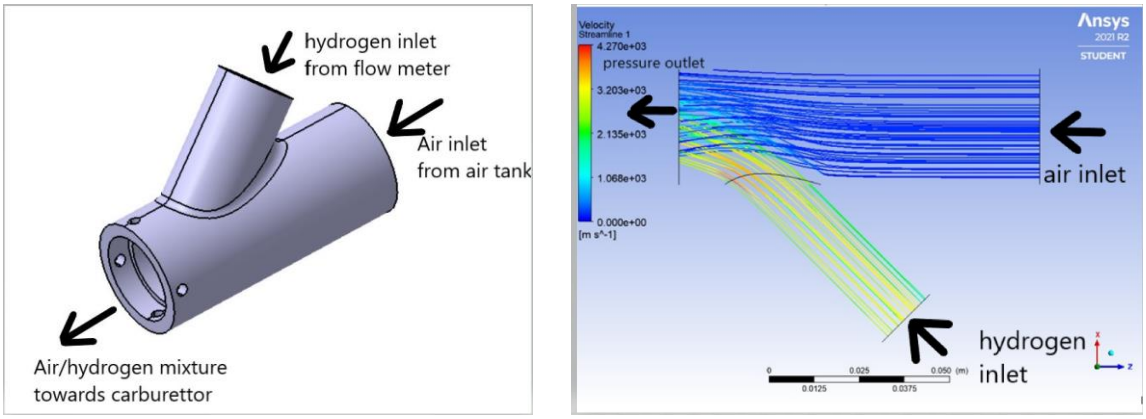
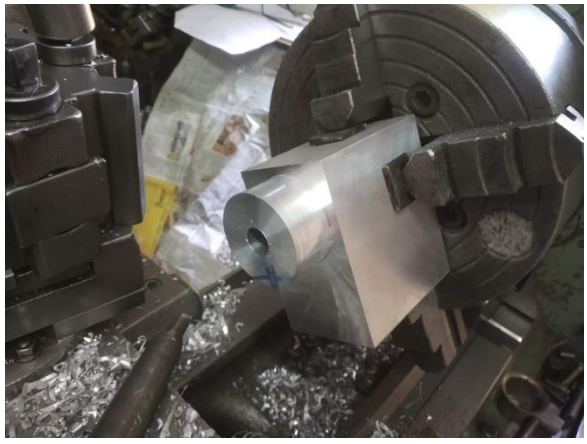


Figure 4 – 45º angle H2 introduction

Figure 3 shows the intake manifold in which the hydrogen is introduced at 90º to the air inlet along with the velocity streamlines and figure 4 shows the intake manifold in which the hydrogen is introduced at 45º to the air inlet along with the velocity stream lines. It is clearly seen that when H2 is introduced at 90º there is significantly more turbulence and back flow of hydrogen when compared to when H2 is introduced at 45º. Based on these conclusions the intake manifold with 45º H2 inlet was selected.



Fabrication:

Aluminium Material was used since it is a light material and is unreactive against Air or Hydrogen at Normal Temperatures. CNC machining was carried out for the fabrication of the intake manifold

Conclusion:

This project introduces dual fuel injection technology into the field of automobile industry, this technology can be adopted to existing engine too and a kit or a component that plays as an interface between two fuel sources. It reduces the primary fuel consumption (fossil fuels), by utilizing alternate fuels. Hydrogen and petrol can be used as two fuel sources. In the engine test runs it is evident that Brake thermal Efficiency was better and gasoline consumption was low for the same power output. Using Hydrogen as dual fuel can reduce the carbon footprint of existing petrol SI Engines. In terms of emissions NOx, CO2, Co emissions were significantly lower to when compared to SI Petrol Engine. Implementing the retrofit component saves old engine component from being discarded.

Scope for future work:

Similar methodology can be used in cars and heavy vehicles where the high cost of hydrogen will be more sustainable with its improved efficiency.

Further experiments should be conducted to check the structural integrity of the engines over long runs with hydrogen combustion.