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Hydrogen Injection in Air Breathing Engines for Better Efficiency

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Introduction

Improvement in engine efficiency and power along with fewer emissions has been an area of research interest for engineers for quite some time now [1]. It has been proven in automotive engines, by experiments and various computational studies, that secondary fuel injection increases the engine performance [2,3]. To cater for less carbon emissions, hydrogen has shown promising results [2]. Since there has been extensive work on automotive engines in the above-mentioned research areas, it should be extended into the commercial aircraft engine designs. Therefore, to make the air breathing engines more efficient on fuel consumption and power generation, it is high time that air breathing engines are designed to inject small percentage of hydrogen to make the combustion more efficient. Some of the research is already been carried out in the power generation sector where dry low NO_x (DLN) hydrogen combustion has been investigated [4], which has also helped in the reduction of NO_x emissions. This research can also help reduce NO_x emissions as well as the carbon emissions and must be extensively investigated to analyze the effects of the blend on the emissions and engine performance. Numerical and computational studies have also been performed aimed at hypersonic vehicles with particular applications to scramjets [5] using hydrogen as a working fluid in the combustor. Due to the novel idea and proprietary nature of the studies performed in the area of air breathing engines, as well as defense applications, most papers for references have not been accessible to the author for further referencing.

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Methodology

The bigger problem to solve is to safely carry hydrogen onboard an aircraft. It could be solved by two ways; either by carrying liquid hydrogen (LH_2) as carried by rockets or carrying water on the aircraft. Both problems can be solved easily due to the lightweight materials now used to manufacture the latest aircraft. Since a very small amount of hydrogen is needed to inject into the air-fuel mixture (on the order of 1-3%), a small hydrogen tank will be sufficient. Investigation of various percentages of hydrogen injection with respect to engine rpm, power requirement and flight altitude along with the required temperature changes can provide optimum percentages of hydrogen needed for the particular setting and engine environment. The other solution could be to carry water in a water tank. The water in the tank goes through the process of electrolysis to produce hydrogen.

$$2\,H_2O(l) \rightarrow 2\,H_2(g) + O_2(g) \tag{1}$$

Either ways, it is not impossible to inculcate hydrogen as a secondary fuel into the combustion process on an air breathing engine. The benefits of hydrogen injection will be immense in terms of better combustion and thermal efficiencies as well as reduced carbon emissions. This will provide better fuel consumption and fuel economy leading to saving money by the airlines. At the same time, due to reduced emissions, it will environment friendly which is very relevant especially at a time when climate change is happening at a rapid pace. This technology can also be gelled up in the latest supersonic commercial aircraft development process as well.

Conclusion

Apart from the modifications suggested to the present air breathing engines, the new generation of air breathing engines can be designed with hydrogen injection nozzles designed inside the engine along with safe storage of hydrogen onboard an aircraft. All of this is possible with few modifications of the engine design. Since a larger amount of hydrogen has been safely carried by rockets and shuttles as a fuel during space flights, it should not be a problem to design a safe system to be carried on the aircrafts themselves. It is therefore recommended to work extensively on the experimental and computational studies to achieve this rather easy feat for the next generation of commercial flights which will help with lesser fuel consumption and carbon emissions. With US now joining the Paris climate agreement, this would become

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a better alternative for air breathing engines. The new age of air travel should benefit the aircraft companies and customers both in terms of cost of air travel as well as the time of flight to the destination.

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