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REVIEW ARTICLE

Study of hybrid fuel injectors for aircraft engines

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Abstract

This project is based on the fuel injectors initially; a multi-hole injector is designed and then the single-hole injector is attached and converted to a hybrid injector, which is the hybrid combination of multi-hole and single-hole injector which could be controlled electrically. All these processes are done with software. Solid works is used for designing and ANSYS is used for analysis of the 3D model. The mass flow rate, pressure and velocity through the inlet and outlet is better when compared to other nozzles. This hybrid fuel injector has the added advantage of good atomization, providing better nozzle combustion. Then, the nozzle is used to operate a range of fuels, including JETA, kerosene, gasoline, diesel, and cryogenic fuel. Using the nozzle, each fuel exhibits various properties in terms of pressure and velocity. The designs are subjected to fluid flow simulation using ANSYS. Particularly, the liquid fuel are injected with very high pressure and velocity in order to atomize the fuel to form a homogeneous combustion. The present design is done for low viscous fuels.

Keywords: Fuel injectors, ANSYS, Nozzle, Viscous.

Introduction

A multi-hole nozzle has many outlet openings, whereas a single-hole nozzle only has one outlet opening through which fluid can flow. Depending on the design and application, a multi-hole nozzle's number of holes might change. When compared to a single-hole nozzle, the fundamental benefit of employing a multi-hole nozzle is that it enables a more uniform dispersion of fluid flow. This can be especially helpful in situations like fuel injection in engines, where a more uniform spray pattern can increase combustion efficiency and lower emissions. On the other hand, a single-hole nozzle might be preferred in some situations where a highly concentrated, fast-moving jet of fluid is needed. A hybrid fuel injector is a particular kind of fuel injector that can run on two distinct fuels at once. It is frequently employed in hybrid automobiles, which run on both fuel and electricity. One set of nozzles on the hybrid fuel injector is usually used for gasoline and the other for electric fuel. The injector's nozzles are placed carefully to deliver fuel to the engine at the proper time and in the appropriate amounts. The engine control module (ECM), which watches the vehicle's working conditions and modifies the fuel flow as necessary, operates the hybrid fuel injector. The injector feeds fuel into the engine when the car is in gasoline mode. The injector, however, feeds the motor with electric fuel when the cars is in electric mode. In comparison to conventional fuel injectors, the hybrid fuel injector is intended to offer greater fuel efficiency and lower emissions. Additionally, it enables seamless transitions between gasoline and electric power for hybrid cars, resulting in a smooth and effective operation. The hybrid fuel injector is a crucial part of hybrid vehicle technology, enabling higher fuel efficiency and lessening transportation's effect on the environment.

As a result, the idea of an injection system for gasoline engines is not novel. An ongoing amount of continuous metered fuel used in automobile engines. In order to make the engines work smoothly, the gasoline injection device. The injector receives the fuel from the pimp and is released as a finely atomized mist into the air stream instead of carburetion, which combines fuel and airflow. Observable differences between the carburetor and the device for injecting gasoline. The throttle valve's location regulates the flow of into the intake manifold with the combination.

Literature Survey

"Fuel atomization for next-generation gas turbine combustors" by M. A. Benjamin was published in Atomization and Sprays journal in 2000. The article discusses the

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importance of fuel atomization in gas turbine combustors and explores the various techniques that can be used for effective atomization. The author explains that efficient atomization is crucial for achieving complete combustion in gas turbines, which can lead to lower emissions and improved fuel efficiency. The article describes the different fuel atomization methods, including pressure swirl nozzles, airblast atomizers, and pre-filming atomizers. It also discusses the challenges associated with fuel atomization, such as droplet size distribution, spray angle, and the impact of fuel properties on atomization. The author suggests that optimizing fuel atomization can significantly improve gas turbine performance, including reduced emissions and improved fuel flexibility.

"Viscosity and surface tension effects in pressure swirl atomization" was published in the journal Atomization and Sprays in 1995. The authors of the article are V. Dorfner, J. Domnick, F. Durst, and R. Kohler. The article discusses the effects of viscosity and surface tension on pressure swirl atomization, which is a common method of atomizing liquid fuels in combustion processes. The authors present experimental data and analysis to show how these properties, including droplet size and spray angle, influence atomization. It begins with a review of the basic principles of pressure swirl atomization and the role of fluid properties in the process. The authors then describe their experimental setup, which involved measuring droplet size and spray angle for various fuels with different viscosity and surface tension values.

"Internal and near-nozzle flow of a pressure-swirl atomizer under varied fuel temperature" was published in the journal Atomization and Sprays in 2007. The authors of the article are S. Moon, C. Bae, E. F. Abo-Serie, and J. Choi. The article presents a study on a pressure-swirl atomizer's internal and near-nozzle flow characteristics under varied fuel temperatures. The authors performed a series of experiments using a transparent pressure-swirl atomizer and a high-speed camera to capture flow field images. Using a laser diffraction particle analyzer, they also measured the spray's droplet size and velocity distribution. The article provides a detailed description of the experimental setup and methodology used in the study. The authors also present the results of their experiments, which show that the internal and near-nozzle flow of the pressure-swirl atomizer is significantly affected by the fuel temperature. Specifically, the authors found that the spray cone angle, droplet size, and velocity distribution were all affected by changes in the fuel temperature.

"Modeling and Simulation for Design and Testing of Direct Injection Gaseous Fuel Systems for medium speed Engines" was published in the SAE International Journal in 2011. The authors of the article are Vilmar Aesoy and Eilif Pedersen. The article presents a study on designing and testing direct injection gaseous fuel systems for medium-speed engines. The authors developed a computational model to simulate the fuel system's performance under different operating conditions. They also conducted experimental tests to validate the model and evaluate the fuel system's performance. The article provides a detailed description of the computational model and the experimental setup used in the study. The authors also present the results of their simulations and experiments, which show that the direct injection gaseous fuel system can provide significant engine performance improvements, especially in fuel efficiency and emissions reduction.

"Optical patternation of a multi-orifice spray nozzle" by Lim, Sivanthanu, published in Atomization and Sprays in 2005, describes a study on the spray characteristics of a multi-orifice nozzle using optical techniques. The study used a high-speed camera and a laser-based visualization technique to investigate a multi-orifice nozzle's spray patterns and droplet size distribution. The nozzle had five orifices with different diameters, and the liquid used was water. The results showed that the orifice size and spray pressure influenced the spray pattern and droplet size distribution. The smaller orifices produced finer droplets, while the larger orifices produced coarser droplets. The spray angle was also found to increase with increasing orifice diameter. The study also investigated the effect of liquid flow rate and viscosity on the spray characteristics. It was found that the spray angle increased with increasing liquid flow rate and decreased with increasing viscosity. Overall, the study provides insights into the spray characteristics of multi-orifice nozzles and can be useful in optimizing spray systems for various applications, such as in agriculture, industry, and medicine.

Types of Injector Nozzles

The existing system for A hybrid fuel injector is a particular fuel injector that burns gasoline, ethanol, or another alternative fuel. The current hybrid fuel injector system typically uses a fuel system that can hold both gasoline and ethanol. Among the components of the fuel system are a gasoline tank, fuel lines, fuel injectors, and a fuel pump. The fuel tank contains an ethanol and gasoline mixture that is normally combined at an 85% gasoline to 15% ethanol ratio (E85). The fuel is drawn from the tank by the fuel pump, then it travels through the fuel lines to the fuel injectors (Figures 1 and 2).

According to the engine's needs, the fuel injectors are made to supply the right amount of fuel. In most cases, the engine's computer operates the injectors. Using sensors to track the engine's performance, the computer then modifies the fuel injection. A hybrid fuel injector system can, in comparison to a gasoline-only system, offer increased fuel efficiency and lower emissions. Corn, sugar cane, and cellulosic materials can all be used as feedstocks to make ethanol, a renewable fuel source. Ethanol has the ability to lower greenhouse gas emissions and lessen reliance on fossil fuels when used as a fuel.

Hybrid Fuel Injectors

A hybrid fuel injector is a type of fuel injector that combines elements of both multi-hole injection and single-whole injection systems (Figure 3). Before entering the engine cylinder, fuel is injected into the intake manifold or multi-hole where it mixes with air. In contrast, a single entire system injects gasoline directly into the engine's combustion chamber.

By using a single injector to give fuel to the intake manifold or multiple injectors to deliver a second, precise fuel spray straight into the combustion chamber, a hybrid fuel injector tries to combine the advantages of both methods. By giving the fuel-air mixture better control and lowering the amount of combustion, a hybrid injector can increase fuel efficiency, power output, and emissions.

Design Specification

Methods Used for this Study

Journals, magazines, publications, reports, books, dailies, periodicals, articles, research papers, websites, company publications, manuals, booklets, and other available sources such as online portals are used to acquire secondary data.

Results and Discussions

Design of fuel injector nozzle with combination of single and multi-hole and designed using solid works software and analysis is done using ANSYS software. The velocity is obtained up to 5.719e + 03 and pressure as 2.024e + 07 and mass flow in inlet as 2.041 and in outlet 2.9493 and net value is 2.4243 (Figure 4, Table 1).

Figure 1: Single hole nozzle

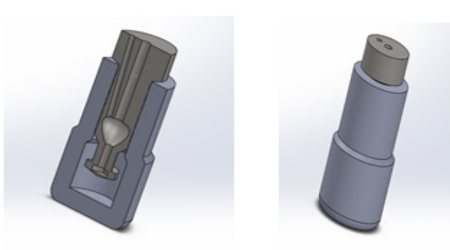

Figure 2: Multi hole nozzle

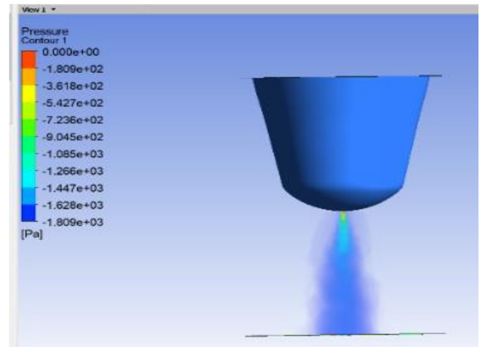

Figure 3: Analysis of multi injector

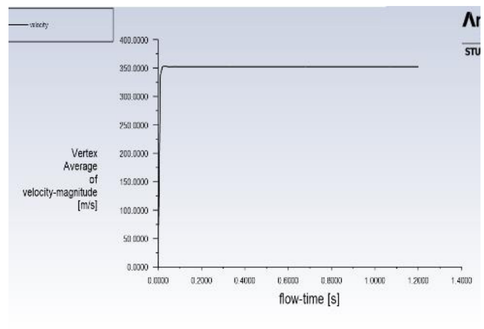

Figure 4: Flow time graph

Table 1: Tabulation for different fuel characteristics

S. No	*Fuel type*	*Velocity*	*Pressure*
1	Gasoline	1.529e + 01	1.904e + 05
2	Diesel	3.545e + 06	1.489e + 01
3	Jet A	2.504e + 00	1.036e + 05
4	Kerosene	1.482e + 01	2.154e + 05

Conclusion

In conclusion, the design and analysis of a hybrid fuel injector nozzle is critical to developing a successful hybrid fuel injection system. The nozzle must be carefully designed to work with gasoline and electric power sources and switch between the two seamlessly. Analysis is essential to ensure that the nozzle is operating efficiently and that the system delivers the desired performance level. Using computer simulations and modelling tools can help evaluate various design options and predict the system's behavior under different operating conditions. A well-designed hybrid fuel injector nozzle can significantly improve fuel efficiency and reduce emissions while providing the power and range required for longer trips. Furthermore, a successful hybrid fuel injection system can offer drivers the benefits of both gasoline and electric power sources, making it an attractive option for environmentally conscious consumers.

Future Work

This design is now an analysis for future enhancement, but it will be converted as the model of combining single and multi-hole nozzle.

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