International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-2S2, January 2019

# Challenges and Solutions for using Liquid Fuels in Aviation Industry

**Mohammadsalman Warimani, Muhammad Hanafi Azami, S. A. Khan**

***Abstract:*** ***Riding imperatives of twenty-first-century modern aviation are adequate fuel intake. Aircraft may be fueled via sustainable liquid fuels that make it more advantageous and exploitable in applications are described and as compared to the ones of different conventional fuels. In this review paper, different researches had been cited. As can be found from numerous researches, insertion of barriers is better to gain detonation speed. In the pulse detonation engine deflagration to detonation (DDT) transition procedure is observed to be a maximum crucial issue. Detonation initiation of multiphase flow is vital to the improvement of the pulsed detonation engine (PDE). Examination of multiphase flow detonability shows that mixing and stoichiometry are essential to a success DDT. In the present paper, a detailed assessment of different experimental studies and computational analysis addressing liquid fuels in pulse detonation engines discussed. The effect of various parameters at the improvement of propulsion overall performance of pulse detonation engine has been provided in detail in this review paper.***

***Keywords: Liquid fuels, DDT, PDE.***

## I. INTRODUCTION

The detonation of liquid fuel blends can be followed back to the mid-1960 when trial work by Webber and Cramer showed up in writing, as completed a theoretical investigation by Williams. Throughout the years, work has proceeded, with specific consideration being centered around such issues as fuel droplet size effect and shearing effect and detonation shearing and ignition[1]. Only liquid propellants possess the fundamental stuffs to accomplish admittance to planetary. Robert Goddard is indorsed with the main flight of a liquid-fueled rocket in 1926. Numerous different skyrockets were produced for defense solicitations amid the year 1940s, for example, liquid filled missiles which were rocket-assisted for takeoff. In the Russian studies, a variety of gaseous and liquid fuels were successfully detonated in an annular combustor, and minimum critical dimensions of the chamber were reported. A liquid rocket detonation engine for improved performance, compactness, lower feeding pressure, and thrust vectoring [2]. There is current critical enthusiasm for cryogenic fluid methane, which has a higher specific impulse yet less density than kerosene[3]. As in the missile 1st-stage promoter circumstance, the lower compactness of hydrogen makes fluid hydrocarbons reasonable as petroleum[3]. The issues that vital be persisted and the advancement till today that has been accomplished in the utilization of fluid jp-10 in pulsation ignition engine managed portrayal of the atomizers utilized and effectively starting explosions in $JP10/O_2$ blends with globule diameter transcendently underneath 10 µ [4]. The perception is once more prepared that in two-phase current, the petroleum must be overall evaporated beforehand a ample response be able to happen[4].

## II. OPPORTUNITIES TO USE LIQUID FUELS FOR PDE

Liquid fuels are favored in practical applications wherein the volume is restricted[5]. Liquid hydrocarbons, in all probability, will remain a vital factor in fulfilling our energy needs. Further, liquid fuels are exceptionally well applicable for use within the transportation region. Even though the technology for acquiring liquid fuels from non-petroleum feedstock exists, the modern-day availability and production of alternative liquid fuels continues to be restrained but is projected to increase within the near future [6]. Seong-Young Lee et al. Selected Ethylene (C2H4) because of the fuel, because of its properly documented detonation qualities with air and due to the fact, it is a common decomposition factor of large hydrocarbon species usual of liquid fuels. For the baseline single-shot detonation experiments, ethylene and air propellants at an equivalence ratio of 1.2 have been used because it is far surprisingly easy to attain detonation combustion due to the propellant aggregate's minimal cell size[7]. The consideration of determining the pulsed mass flow rate measurement of gas is more stringent as compared to that of a liquid [8]. Heating the first aggregate helps each through easing the detonation initiation process in addition to aiding inside the detonation propagation with the aid of introducing a few pre vaporizations and reducing the droplet size [4]. Because of the limitation of the engine size and weight in pulse detonation engines, liquid fuel is required [9]. Researchers in the world are giving more important to liquid fuels in many applications specifically for liquid fuels for air breathing engines. Benefits of using liquid hydrocarbon fuels compared with gaseous fuels, liquid fuels having more energy density, easily carriable, good storability, and safe. Detonation enhancement techniques are researched for above mentioned reasons[10].

**Manuscript published on 30 January 2019.**
***** Correspondence Author (s)
**Mohammadsalman Warimani** Department of Mechanical Engineering, Faculty of Engineering, IIUM, Kuala Lumpur, Malaysia.
**Muhammad Hanafi Azami** Department of Mechanical Engineering, Faculty of Engineering, IIUM, Kuala Lumpur, Malaysia.
**S. A. Khan** Department of Mechanical Engineering, Faculty of Engineering, IIUM, Kuala Lumpur, Malaysia.

These strategies incorporate shchelkin spirals and orifice plate as DDT devices. For more natural detonation flash vaporization , predator, and also high energy ignition technics are used [10].

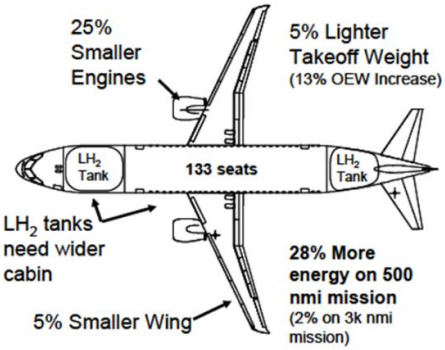


**Figure.1. Liquid hydrogen-powered airplane [11].**

Figure 1. Shows benefit of liquid hydrogen in the aircraft. The aircraft engines are usually sized to power the aircraft throughout the heaviest a part of its challenge (takeoff), it is far viable to downsize the liquid hydrogen airplane's engines to supply approximately 25 percent less thrust, thereby allowing smaller, lighter weight engines for use. It is viable to downsize the wing slightly because it still needs to bring the additional weight of the fuel tanks for the duration of the plane's slow technique to the airport. Due to these tanks, the airplane Will want about percentage more energy on a standard 500 nautical-mile mission. For longer intervals, the lightweight properties of the fuel start to conquer the drawbacks of the heavy tanks. On a 3,000-nautical-miles assignment, the aircraft will only use 2 percent extra energy than a jet-fueled plane[11]. Longer range airplanes could most likely experience a fuel savings gain of the usage of liquid hydrogen over jet-a fuel [11].

## III. EFFECT OF VAPORIZATION AND MIXING ON LIQUID FUELS

Flash vaporization system will overcome challenges in detonating liquid fuels. The method is to convey liquefied petroleum with its predilections ability to store, and extraordinary thickness. However, to present the petroleum as a gas into the ignition conduit. Problems like long start stage and extraordinary dynamism requirement of liquefied petroleum will be solved by Flash vaporization system [10]. Mixing of fuel and oxidizer is essential to obtain entirely advanced detonations because insufficient blending will fail in transition to detonation. When liquid fuels are added, atomization and vaporization ought to be taken into consideration in addition to mixing with the oxidizer. If the spray droplets are sufficient high-quality ignitions spreading at around the equivalent gas-phase ignition speed in a diversity of fuel–oxygen combinations, for that reason, efforts related to fast vaporization and mixing which has a significant effect on high-frequency operations[5]. Flash vaporization system used to vaporize liquid fuels before mixing with the oxidizer. Therefore, multiphase effects may be neglected. The flash vaporization system stores high-pressure (40 bar) and high-temperature (above 395 k) fuel in a furnace[5]. K. Wang et al. [5]. Successfully investigated steady-state flash vaporization of JP-8 has been demonstrated with test times of up to 20 min. Experimentally demonstrated the heating of Jet propellant 8 (JP-8) to steady-state supercritical conditions with fuel injection temperature over 760 k. Successful detonation of flash-vaporized JP-8 in the air over a variety of fuel temperatures and fuel to- air ratios obtained without oxygen enhancement or a pre-detonator. Because the fuel vaporization and mixing became advanced, the lean operating ignition limit changed into reduced from an equivalence ratio of 1.08 with ambient temperature fuel to 0.89 with the 555-k fuel. Various liquid fuels like JP-8, JP-7, JP-10, RP-1, JP-900, and S-8 was examined. Besides for, there may be a reduction in deflagration to ignition changeover time by up to 15 %, a lesser in space in the range up to 30 %, a development intimate the fruitful ignition proportion by up to 180 % by increasing fuel injection temperatures[5].One issue is to control the fuel temperature at a suitable level to avert choking, else which may block fuel injectors or deposit on tube wall, effecting heat exchanger. Also, regardless of whether the fuel is completely vaporized the fuel distribution inside the detonation tube significantly affects performance [5].

## IV. RESULTS BY USING LIQUID FUELS IN PDE

Ignition chamber dimension is significant and may be as cm in liquid, and it is of the order mm in gaseous fuels in oxygen[10]. With fluid petroleum, difficulties like atomization, drop disintegration, fractional vaporization, and imperfect fuel-air mingling considered additionally. Parameters inclusive of drop magnitude and dispersal will play a prime role[4]. Thoughtfulness can be low when the fuel is within the liquid phase. The power required to provoke detonation of low-sensitivity propellants, along with the fuel-air aggregate and liquid-phase aggregate is more. For initiation of a detonation wave using power sources commonly, a deflagration-to-detonation transition (DDT) process is usually employed. However, a low-sensitivity combustible mixture requires a long distance and time for the DDT procedure, which results in decreases in operating frequency and thermal efficiency [12]. In spite of research on liquid fuels over 50 years but still detonation of liquid fuels is a complicated problem[10].Atomization process takes more time by utilizing liquid fuels. And also, more time required for fill and purge. Liquid fuels having many problems like longer ignition time than gaseous fuels, huge initiation power required. And also in case of direct initiation if initiation energy is not more then it takes long deflagration to detonation time[10]. Liquid fueled pulse detonation engines (PDE) are bulkier due to the presence of chambers for the preheating and mixing of fuel and air. Preheating done with the aid of transferring heat from the primary PDE frame. Shchelkin spirals within the primary combustion chamber can cause a lack of thrust. Moreover, fuel-air combinations, in particular, aerosol combos of liquid fuels, have longer DDT run up lengths and times [13].


*Published By:*
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Many problems, which includes reliable, rapid, and low-energy initiation of detonations, efficient supply systems for next injection of propellants, vaporization of liquid fuels and mixing with an oxidizer, thermal issues, restrict the operating frequency of a realistic PDE [5]. The pertinent multiphase concepts can be fairly intricate in their origination as two sets of transportation equalities are mandatory for both segments, and many combination expressions necessity is to be providing in the theory that interpretations for interphase interactions of mass, momentum, and energy. Supplementary norms necessity be completed to comprehend the model requirement alike stress and temperature steadiness. Even 1-D mockups are difficult and not upfront to compute. Extreme of the effort conceded out has been that of devising, stable solutions, and numeric. At hand are no dependable speculative outcomes for ignition constancy for this class of prototypes [14]. Another trouble with using fluid hydrocarbon petroleum is associated with ability condensation of the petroleum inside the ignition pipe because of the small filling temperature. Wintenberger et al. [15]. For the case taken into consideration here with jet propellant 10 (jp10), the filling high temperature stays under 300 k so long as Mach number < 2.3. The gas inserted will evaporate completely so stretched as its vapor pressure is excessive adequate at the temperature deliberated. It is viable that no longer all of the petroleum conforming to stoichiometric amount could be capable of vaporizing, and the engine may be run at a thinner configuration contingent on the flight circumstances considered[15]. Another primary difficulty is the potential to detonate liquid hydrocarbon fuels without the assistance of a pre-detonator [16].

## V. CONCLUSION

The above observe on pulse detonation engine in the light of thinking about various parameters consequences in a growing in deflagration to the ignition changeover method. Due to the above diverse advantages of the PDE further researches are going on in the world.

From all fuels tested using distinctive researchers, it may be concluded that,

Combination homogeneity changed into vital to a success detonation initiation. Failure to supply properly combined reactants with the right equivalence ratio will probably result in developing cellular length and resultant trouble in reaching DDT. Fuel heating changed into useful while detonating low-volatility fuels. High octane number and single-detail fuels had increased variability in effects.

## REFERENCES

1 S. Cheatham and K. Kailasanath, “Single-Cycle Performance of Idealized Liquid-Fueled Pulse Detonation Engines,” vol. 43, no. 6, 2005.
2 I. Introduction, “Recent Developments in the Research on Rotating-Detonation-Wave Engines,” no. January, pp. 1–24, 2017.
3 T. Edwards, “Liquid Fuels and Propellants for Aerospace Propulsion : 1903 – 2003,” *J. Propuls. POWER*, vol. 19, no. 6, pp. 1089–1107, 2003.
4 K. Kailasanath, “Aiaa 2003-4683,” no. July, pp. 1–11, 2003.
5 K. Wang and W. Fan, “Efforts on High-Frequency Pulse Detonation Engines,” vol. 33, no. 1, pp. 17–28, 2017.
6 K. Kumar and C. Sung, “A comparative experimental study of the autoignition characteristics of alternative and conventional jet *fuel*/oxidizer mixtures C,” Fuel, vol. 89, no. 10, pp. 2853–2863, 2010.
7 S. Lee *et al.*, “Deflagration to Detonation Transition Processes by Turbulence-Generating Obstacles in Pulse Detonation Engines,” vol. 20, no. 6, 2004.
8 D. D. Joshi and F. K. Lu, “Unsteady Thrust Measurement for Pulse Detonation Engines,” pp. 1–12.
9 Z. Wang, Z. Liang, Y. Zhang, and L. Zheng, “Direct-connected experimental investigation on a pulse detonation engine,” vol. 0, no. 0, pp. 1–9, 2016.
10 F. K. Lu, J. D. Carter, and D. R. Wilson, “Pulse Detonation Engine Demonstrator,” no. August, pp. 1–15, 2011.
11 D. Daggett, O. Hadaller, R. Hendricks, and R. Walther, “Alternative Fuels and Their Potential Impact on Aviation,” in *The 25th Congress of the International Council of the Aeronautical Sciences (ICAS)*, 3082BC, pp. 1–8.
12 M. Wakita, M. Tamura, A. Terasaka, K. Sajiki, and T. Totani, “Detonation Transition Around Cylindrical Reflector of Pulse Detonation Engine Initiator,” vol. 29, no. 4, 2013.
13 P. K. Panicker, “Development of a Compact Liquid Fueled Pulsed Detonation Engine with Predetonator,” no. January, pp. 1–13, 2007.
14 D. S. Stewart, “State of Detonation Stability Theory and Its Application to Propulsion,” vol. 22, no. 6, pp. 1230–1244, 2006.
15 E. Wintenberger and J. E. Shepherd, “AIR-BREATHING PULSE DETONATION ENGINES,” vol. 1, no. July, pp. 1–16, 2003.
16 J. D. Carter and F. K. Lu, “Experiences in Testing of a Large-Scale, Liquid-Fueled, Air-Breathing, Pulse Detonation Engine,” no. August, pp. 1–14, 2011.