IJRESM
International Journal of Research in Engineering, Science and Management
Volume-1, Issue-11, November-2018
www.ijresm.com | ISSN (Online): 2581-5792

A Review on CFD Modelling and Analysis of Dual Fuel (Diesel + Methanol) Combustion Engine with Various Blend Grade Using ANSYS (Fluent)

Pravesh Tedia[1], Shahnawaz Ansari[2]
[1]*M. Tech. Scholar, Department of Mechanical Engineering, Oriental College of Technology, Bhopal, India*
[2]*Assistant Professor, Department of Mechanical Engineering, Oriental College of Technology, Bhopal, India*

***Abstract*: In order to develop design guidelines for optimum operations of internal combustion engines fuel with alternative fuels, comprehensive understanding combustion behavior and the pollutant formation inside the cylinder are needed. The first part of this study aimed to numerically study the combustion performance in a CI engine fuel (Diesel) with Ethanol and Methanol. Advanced simulations were performed using multi-dimensional software Fluent coupled with CHEMKIN. Formation rates of nitrogen oxides (NOx) within the engine were accurately predicted using the extended chemkin mechanism. Multi fuel combustion is not a mature technology when compared to CI and SI combustion. Because of this it is expected that not all challenges and limitations have been encountered and documented, much less fully understood. The objective of this project is to identify, investigate and attempt to overcome known and unknown limits to dual fuel operation. Alternative fuels have been getting more attention as concerns escalate over exhaust pollutant emissions produced by internal combustion engines, higher fuel costs, and the depletion of crude oil. Various solutions have been proposed, including utilizing alternative fuels as a dedicated fuel in spark ignited engines, diesel pilot ignition engines, gas turbines, and dual fuel and bi-fuel engines.**

***Keywords*: Dual fuel engine, Diesel, Methanol, Emissions, CI engine, CFD, and Fluent etc.**

1. Introduction

Under section 1.8 of the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Measurement Determination)) a blended fuel is a fuel that is a blend of fossil and biogenic carbon fuels. For example, E10 is a blend of gasoline (fossil fuel) and up to 10 per cent ethanol (biogenic carbon fuel). The NGER Measurement Determination defines 'biogenic carbon fuel' as energy that is: Derived from plant and animal material, such as wood from forests, residues from agriculture and forestry processes and industrial, human or animal wastes, and not embedded in the earth, like coal oil or natural gas. Examples of biogenic carbon fuels under the NGER legislation are listed in items 10–16 and 28–30 of Schedule 1 of the National Greenhouse and Energy Reporting Regulations 2008 (NGER Regulations). The NGER legislation does not define fossil fuels. However, taking the ordinary meaning of the term, a fossil fuel is a carbon-based fuel from fossil hydrocarbon deposits, including coal, oil and natural gas. The problem with crude oil depletion has arisen in the last years. There has been intensive research to find out alternatives to fossil fuels. Alternative fuels are derived from resources other than petroleum. When these fuels are used in internal combustion engines, they produce less air pollution compared to gasoline and most of them are more economically beneficial compared to oil. Last but not least, they are renewable. The most common fuels that are used as alternative fuels are natural gas, propane, ethanol, methanol and hydrogen. Lots of works have been written on engines operating with these fuels individually; but a small number of publications have compared some of these fuels together in the same engine [1]-[4]. The idea of adding low contents of ethanol or methanol to gasoline is not new, extending back at least to the 1970s, when oil supplies were reduced and a search for alternative energy carriers began in order to replace gasoline and diesel fuel. Initially, methanol and ethanol were considered the most attractive alcohols to be added to gasoline. Methanol and ethanol can be produced from natural products or waste materials, unlike gasoline which is a non-renewable energy resource [5], [6]. One of the important features is that the ethanol and methanol can be used directly without requiring any major changes in the structure of the engine. Among the various alcohols, ethanol and methanol are known as the most suitable fuels for spark ignited (SI) engines. The use of fuel additives is very important because many of these additives can be added to fuel in order to improve its efficiency and its performance. Some of the most important additives to improve fuel performance are oxygen containing organic compounds (oxygenates). Several oxygenates have been used as fuel additives, such as methanol, ethanol, tertiary butyl alcohol land methyl tertiary butyl ether [7]. The use of oxygenated fuel additives provides more oxygen in the combustion chamber and has a great potential to reduce emissions from SI engines.

On the combustion characteristics, the auto-ignition temperature and flash point of ethanol and methanol are higher than those of gasoline, which makes it safer for transportation and storage. The latent heat of evaporation of ethanol is between three and five times higher than that of gasoline; this makes the temperature of the intake manifold much lower, and increases the volumetric efficiency. The heating value of ethanol is lower than that of the gasoline. Therefore, we need 1.6 times more alcohol fuel to achieve the same energy output. The stoichiometric AFR (air–fuel ratio) of ethanol is about 2/3 that of the gasoline, so the required amount of air for complete combustion is lesser for alcohol [8]. Ethanol has some advantages over gasoline, such as the reduction of CO, unburned HC emissions and better anti-knock characteristics [9]. Methanol and ethanol have much higher octane number than gasoline [10]. This allows engines to have much higher compression ratios, thus increasing thermal efficiency [11]. Methanol can be produced from natural gas at no great cost, and is quite easy to blend with gasoline, so this alcohol was seen as an attractive additive. However, when methanol was used in practice, it became clear that precautions had to be taken when handling it and that methanol is aggressive to some materials, such as plastic components and even metals in the fuel system [12]. There is plenty of literature to various blends of ethanol, methanol and gasoline. Palmer [13] studied the effect of using various blend rates of ethanol–gasoline fuels in engine tests. Results indicated that 10% ethanol addition increases the engine power output by 5%, and the octane number can be increased by 5% for each 10% ethanol added. He indicated that 10% of ethanol addition to gasoline could reduce the concentration of CO emissions up to 30%. Bata et al. [14] studied different blend rates of ethanol–gasoline fuels in engines, and found that the ethanol could reduce the CO and UHC emissions to some degree. The reduction of CO emissions are apparently caused by the wide flammability and oxygenated characteristic of ethanol. Kim et al. [15] estimated that the potential for ethanol production is equivalent to about 32% of the total gasoline consumption Worldwide, when used in 85% ethanol in gasoline for a midsize passenger vehicle. Shanghais et al. [16] used a three-cylinder SI engine with different blends of methanol (10%, 15%, 20%, 25% and 30%) in gasoline under full load condition. Results indicated that engine power and torque decreased, while the brake thermal efficiency improved with the methanol blends increase in the fuel blend. Bilgin and Sezer investigated the influence of methanol addition to gasoline on the engine performance. They reported that the maximum brake mean effective pressure (bmep) was obtained from M5 fuel blend. Altunetal. Studied the effect of 5% and 10% ethanol and methanol blending in unleaded gasoline on engine performance and exhaust emission. Results indicated that M10 and E10 blended fuels demonstrated the best result in exhaust emission. The HC emission of M10 and E10 are reduced by 13% and 15% and the CO emissions by 10, 6% and 9, 8%, respectively. Increased CO_2 emission for M10 and E10 compared with unleaded gasoline was observed. The ethanol and methanol addition to unleaded gasoline demonstrated an increase of BSFC (brake specific fuel consumption) and a decrease of break thermal efficiency in comparison to unleaded gasoline.

2. Review of literature

M. Mofijur [1] Ever increasing drift of energy consumption due to growth of population, transportation and luxurious lifestyle has motivated researchers to carry out research on biofuel as a sustainable alternative fuel for diesel engine. Biofuel such as biodiesel and ethanol, produced from renewable feedstocks, are the most appropriate alternative of petroleum fuels. However, direct using of ethanol in diesel fuel face some technical problem especially in cold weather, due to low cetane number, lower flash point and poor solubility. Biodiesel can be blended with both ethanol and diesel fuel and biodiesel–alcohol–diesel blends can be used in diesel engines. The aim of this review paper is to discuss the effect of mixed blends of biodiesel alcohol and diesel on engine performance and emission parameters of a diesel engine. Most of the researchers reported that adding ethanol into biodiesel-diesel blend in diesel engines significantly reduce HC, PM, NOx and smoke emissions but slightly increase fuel consumption. The study concluded that biodiesel-diesel-ethanol blend can be used as a substitute of petro-diesel fuel to reduce dependency on fossil fuel as well as the exhaust emissions of the engine.

Chunhua Zhang et.al [2] The diesel-LNG (liquefied natural gas) dual-fuel combustion mode was conducted on a high-pressure common-rail six-cylinder diesel engine to find an assistant parameter to assess the brake thermal efficiency (ge) and nitrogen oxides (NOx) emission of the diesel-LNG dual-fuel engine. The results show that the diesel injection timing has a prominent impact on the centroid angle of combustion duration (α) which is closely related to ge and NOx emission. At low and medium loads, when a is near to top dead center (TDC) and is after TDC, the ge and NOx emission are higher. Nevertheless, when α is before TDC, the result of NOx emission is opposite. Therefore, for optimal ge and NOx emission at low and medium loads, it would be the best way altering diesel injection timing to retard a to ATDC and ensuring a in 1–2 ˚CA ATDC. Aman Hira [3]. This paper is based on experimental investigation of performance and emissions of CI engine. Due to exponential growth in industrialization the demand for conventional automotive fuels is also increased sharply which adversely affects not only the economy but also the environment. This makes the search for an alternative fuel more important today. In this research the blends of ethanol & biodiesel with diesel in varying proportions are used. The performance& emission levels has been investigated under the various parameters like Brake Thermal efficiency, BSFC, BSEC, Smoke density, HC, CO & exhaust temperature. The experimental results show that the BE20 fuel gives the best performance in comparison to conventional diesel fuel along with fairly reduced exhaust emission.

Jeongwoo Lee et.al [4] Reactivity controlled compression ignition (RCCI) is one of representative dual-fuel combustion concepts for low NOx, soot emissions and high thermal efficiency. Overall lean and highly premixed auto-ignition combustion make low combustion temperature and the reduction of heat transfer loss. Although premixed compression ignition (PCI) combustion using a single fuel, i.e., diesel, also shows low emissions and higher thermal efficiency, combustion characteristics of RCCI (dual-fuel PCI) are different from single-fuel PCI due to reactivity gradient from two different fuel characteristics as well as local equivalence ratio due to the fuel distribution. Therefore, it is necessary to know the influence of above two factors on the dual-fuel combustion characteristics for better understanding of dual-fuel combustion and its effective utilization. In this research, the characteristics of dual-fuel combustion are evaluated comparing to single-fuel combustion. Also, dual-fuel combustion modes are classified according to the analysis of heat release rate (HRR) shapes. Major factors in the classification of dual-fuel combustion modes are the degree of fuel reactivity gradient and the local equivalence ratio in the cylinder. Thus, the diesel injection timing, diesel and port injected gasoline fuel ratios and the overall equivalence ratio were selected as the main variables to characterize each dual-fuel combustion mode. The result emphasizes that the dual fuel combustion could be classified as three types by HRR shapes, and it was mainly affected by reactivity gradient and overall equivalence ratio. M. Srinivas naik [5]. The fuel which is used in Internal Combustion engines meant for transportation applications will satisfy all the requirements of cost effectiveness, maximum thermal efficiency, excellent engine performance, and still remain clean enough to protect the environment. Alcohol fuels such as methanol (CH_3OH), Ethanol (C_2H_5OH) are favorable for IC Engines because of their high octane rating, burning velocities, and wider flammability limits. Alcohols can be considered as attractive alternative fuels because they can be obtained from both natural and manufactured sources. The air quality deterioration is a vital issue that needs to be seriously monitored and limited. The transportation system is a major air pollution contributor due to the exhaust emissions such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxide (NOx), carbon dioxide (CO_2), and particulate matter (PM). Extensive research and development is difficult to justify until the fuels are accepted as viable for large numbers of engines. Liquid fuels are preferred for Internal Combustion Engines because they are easy to store and have reasonably good calorific value. The main alternative is the alcohol. Methanol and ethanol are two kinds of alcohols that seem most promising fuels and will likely play an increasingly important role in the future. In this review, the physical and the combustion characteristics of alcohols have been discussed briefly after comparing with the diesel. The production methods of alcohols have been discussed. The safety aspects of alcohols have also been discussed. Carmelina Abagnale et.al [6] the effect of different fuel ratios on the performance and emission levels of a common rail diesel engine supplied with natural gas and diesel oil. Dual fuel operation is characterized by a diesel pilot injection to start combustion in an intake port premixed NG/air mixture. The combined numerical – experimental study of the dual fuel diesel engine that is carried out in this paper aims at the evaluation of the CFD potential to predict the main features of this particular engine operation. The experimental investigations represent a tool for validating such a potential and for highlighting, at the same time, the major problems that arise from the actual engine operation with different NG / diesel oil fuel ratios.

3. Objectives of the study

The purpose of this study is to seek out the proportion of NOx after the combustion of Dual fuels. From this study our main interest is which can facilitate to reduce the formation of air pollution and acidic rain and lots of alternative harmful effects. computational fluid dynamics may be a widely used tool in optimizing fossil fuel burners, for example, emission problems and also the method of combustion of fossil fuel to sight the NOX formation like mass fraction of NO, NO_2 and N_2O. In order to save lots of procedure time, the flow is sculptured with an axis-Symmetrical formulation in fluent Ansys 14.5. In current study we will investigate the proper mixing of chemical species and the combustion of dual fuel (Diesel +Methanol) with various blend grade like M5, M10, M15, M20 and M25. Present study we use one conventional and other is Alternate fuels due to challenges in power sector. A cylindrical combustor burning (Diesel + Methanol) in air is studied using the eddy-dissipation model in ANSYS (Fluent). Our main objective of the study is to analyze the dual fuel combustion model with both type of mixing method Premixed and non-premixed type of combustion and compared on the basic of emissions (COx & NOx) and combustion efficiency.

4. Problem formulation

The cylindrical combustor considered in Present study is shown in Figure 1. The flame considered is a turbulent diffusion flame. A small nozzle in the centre of the combustor introduces (Diesel + Methanol) at 80 m/s. Ambient air enters the combustor coaxially at 0.5 m/s .The overall equivalence ratio is approximately 0.76 (approximately 28% excess air).The high-speed methane jet initially expands with little interference from the outer wall and entrains and mixes with the low-speed air. The Reynolds number based on the dual fuel jet diameter is approximately 5.7x10 -3 mm.

5. Proposed methodology

- Preprocessing of the CAD geometry
- Numerical modeling or discretization is to be done in Ansys (ICEM CFD) and Defining the cell zone for fluid
- Defining the boundary condition

- Model selection for the validation of the processes
- Comparison of cases
- Various input parameter in the processes of periodic flow

6. Proposed results

- Temperature distribution
- Pressure distribution
- Velocity profiles
- Temperature distribution at different position
- Temperature profiles on specified iso-surfaces
- Mass fraction of various emission

7. Conclusion

This paper concludes that the review on CFD Modelling and Analysis of Dual Fuel (Diesel + Methanol) Combustion Engine with various blend grade using ANSYS (Fluent)

References

[1] M. Mofijur, "Recent Developments on Internal Combustion Engine Performance and Emissions Fuelled With Biodiesel-Diesel-Ethanol Blends," Procedia Engineering 105 (2015) 658 – 664.

[2] Kamaltdinov V. G, "Modeling the combustion process of a powerful diesel engine," Procedia Engineering 129 (2015) 488 – 494.

[3] Aman Hira, "Performance & Emission Characteristics Of Ci Engine Using Blends Of Ethanol And Biodiesel With Diesel," International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 5, July – 2012.

[4] Murugan Sivalingam "Validation of some engine combustion and emission parameters of a bioethanol fuelled DI diesel engine using theoretical modelling," Alexandria Engineering Journal (2015) 54, 993–1002.

[5] M. Srinivasnaik, "Alcohols as Alternative Fuels for Diesel Engines: A Review," International Journal for Research in Applied Science & Engineering Technology (IJRASET) Volume 3 Issue VI, June 2015.

[6] Haozhong Huang, "The potentials for improving combustion performance and emissions in diesel engines by fueling n butanol/diesel/PODE3-4 blends," Energy Procedia 105 (2017) 914 – 920, Science Direct, The 8th International Conference on Applied Energy – ICAE2016

[7] Scott L. Springer Experimental Evaluation of Alternative Fuels for Internal Combustion Engines Session ETD 445 Proceedings of the 2013 Conference for Industry and Education Collaboration.

[8] Midhat Talibi, "Combustion and exhaust emission characteristics, and in-cylinder gas composition, of hydrogen enriched biogas mixtures in a diesel engine Energy," 124 (2017) 397-412.

[9] Kamaltdinov V. G. "Modeling the combustion process of a powerful diesel engine," Procedia Engineering 129 (2015) 488 – 494.

[10] Murugan Sivalingam, "Validation of some engine combustion and emission parameters of a bioethanol fuelled DI diesel engine using theoretical modelling," Alexandria Engineering Journal (2015) 54, 993–1002

[11] Himsar Ambarita, "Performance and emission characteristics of a small diesel enginerun in dual-fuel (diesel-biogas) mode," Case Studies in Thermal Engineering 10 (2017) 179–191.

[12] Ftwi Yohaness Hagos, "Effect of Air-fuel Ratio on the Combustion Characteristics of Syngas (H_2:CO) in Direct-injection Spark-ignition Engine," Energy Procedia 61 (2014) 2567 – 2571.

[13] Daniel Carder, "Emissions Control Challenges for Compression Ignition Engines," Procedia IUTAM 20 (2017) 103 – 1114th International Congress of Theoretical and Applied Mechanics.

[14] Sakda Thongchai, "Influence of Injection Strategy on a Compression Ignition Engine Fueled with Gasoline," Energy Procedia 105 (2017) 1757 –1763, The 8th International Conference on Applied Energy – ICAE2016.

[15] Vu Dinh NamStudy on Auto-Ignition Characteristics of Gasoline-Biodiesel Blend Fuel in a Rapid Compression Expansion Machine," Engineering Science and Technology, an International Journal 19 (2016) 438–443.

[16] P. Baskar, "Effects of oxygen enriched combustion on pollution and performance characteristics of a diesel engine," Engineering Science and Technology, an International Journal 19 (2016) 438–443.

\