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Effects of Ambient Density and High Injection Pressure on the Flow Characteristics of Biodiesel Spray

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Abstracts. Fuel spray and mixture formation are playing as an important criteria in displaying a fuel's combustion and emission characteristics since it has an instantaneous impact on the creation of an air fuel combination. The purpose of this study is to compare the effects of three different Crude Palm Oil (CPO) biodiesel blends, B5, B10, and B15, with different ambient density on nozzle flow and spray characteristics, computational fluid dynamics (CFD) were used to determine the nozzle flow and spray characteristics for different injection pressure of biodiesel spray to ambient variant conditions on mixture formation. Injection of biodiesel into the RCM constant volume chamber was considered in the simulation. While maintaining constant values for the other parameters, the boundary condition is adjusted at a different ambient parameter. Under the presence of in-cylinder flow, the impact of fuel type, injection pressure, and ambient variables on spray behaviour, such as spray penetration, has been explored. It was projected that high injection pressures would be more essential for the biodiesel fuels to develop their break-up. The effects of these various parameters are examined in terms of spray characteristics and opposed with the results of the experiment.

Keywords: High Injection Pressure, Biodiesel, Spray Injector

INTRODUCTION

Fuel spray is important in displaying a fuel's combustion and emission characteristics since it has an instantaneous impact on the creation of an air fuel combination [1-5]. The purpose of this study was to use CFD simulation to assess the effects of different ambient conditions and injection pressures of biodiesel spray. The spray influence of the nozzle was also investigated. The simulation results are utilised to examine the behaviour of fluid flow inside the orifice, as well as spray parameters like nozzle flow and spray penetration [6-9]. CFD simulation is one of the alternatives for assessing uncertainties that experimental research were unable to do due to cost and time restrictions. This simulation work used computational fluid dynamics (CFD) and ANSYS VERSION 16.1 Fluent software to analyse spray properties [10-15]]. Nishida's research group at the University of Hiroshima conducted numerous trials using a variety of ultrahigh injection pressures, micro-hole nozzles, spray wall impingement configurations, and diesel and alternative diesel fuels [16-18]. According to Nishida's research, the combination of 300 MPa injection pressure and 0.08 mm nozzle-hole diameter produced the greatest results in terms of turbulent mixture processing and lean mixture production. Previous studies, for example, [19-20], spray injection parameters have been shown to have a considerable influence on the

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processes of evaporation, mixture formation, ignition, combustion, and pollutant generation in diesel engines. It was also demonstrated that nozzle geometry influenced spray characteristics and mixture formation. The mechanisms of turbulent flow, fuel atomization, and the interaction of fuel and air in a diesel engine remain unknown. A lot of researchers are now investigating flow and fuel qualities using currently available methodologies and technologies. This research simulates the interactions between fuel and air in a diesel engine using a constant volume chamber for a rapid compression machine (RCM).

GEOMETRY OF INJECTOR AND SPRAY CHAMBER

The cross section of the injector and cahmber and physical of blended biodiesel fuel are shown in Figure 1 and Table 2, respectively. As shown an Figure 1, the cross-sectional image highlight the injector and analysis area which the areas to be analyzed using the Computational Fluid Dynamics (CFD). A complete injector has six nozzle was performed with angle of 15 degree between each hole. It is observed that all dimensions are in millimeters and the design of injector shown that is only focus on the injector head and spray chamber.

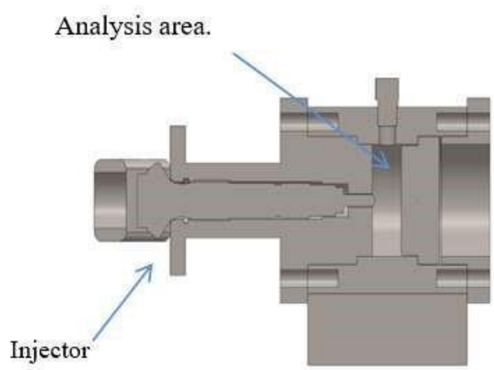

FIGURE 1. Nozzle injector in constant volume chamber: entire and cross-sectional models.

TABLE 1. Physical properties of blended biodiesel fuel

Fuel	Fuel Properties			
	Density (g/cm^3)	Kinematic Viscosity (cP)	Water Content (ppm)	Flashpoint (^{O}C)
DIESEL	0.8337	3.0	79.9	80.0
B5	0.8370	3.0	120.1	91.5
B10	0.8376	2.9	158.6	92.0
B15	0.8404	3.0	219.0	93.5

THE INFLUENCE OF HIGH INJECTION PRESSURE ON THE FLOW CHARACTERISTICS OF A BIODIESEL SPRAY INJECTOR

A transient multiphase simulation was used using the volume of the fluid model. The model's solid wall was observed as the domain's basic boundary condition for this fluid movement. pressure is applied, the domain, fluid velocity, pressure, and temperature are all known. Also, conductivity for coconut palm oil and air is varied. The effect of injection pressure on flow characteristics was studied at 19 m/s base swirl for injection pressures of 100 MPa, 130 MPa, 160 MPa, and 190 MPa. The pressure output at 4 MPa corresponds to an ambient density of 16.6 kg/m3, and the equivalency ratio of 0.37 was used as the baseline condition. The remaining parameters of B5 fuel are kept constant, with the exception of the variable injection pressure, as the initial ambient temperature T, 850 K, and biodiesel was injected by a 6-hole injector with a hole width of 0.129mm. Throughout the simulation process, the boundary condition for three different nozzle geometries parameter cases is assumed to be similar.

NOZZLE FLOW SIMULATION

The flow of the spray nozzle is analysed by its velocity. The length of the spray nozzle injector is 0.64 mm. Figure 2 depicts a rising injection pressure graph created during the ignition delay. According to the graph, increased injection pressure causes an ignition delay and a longer physical process.

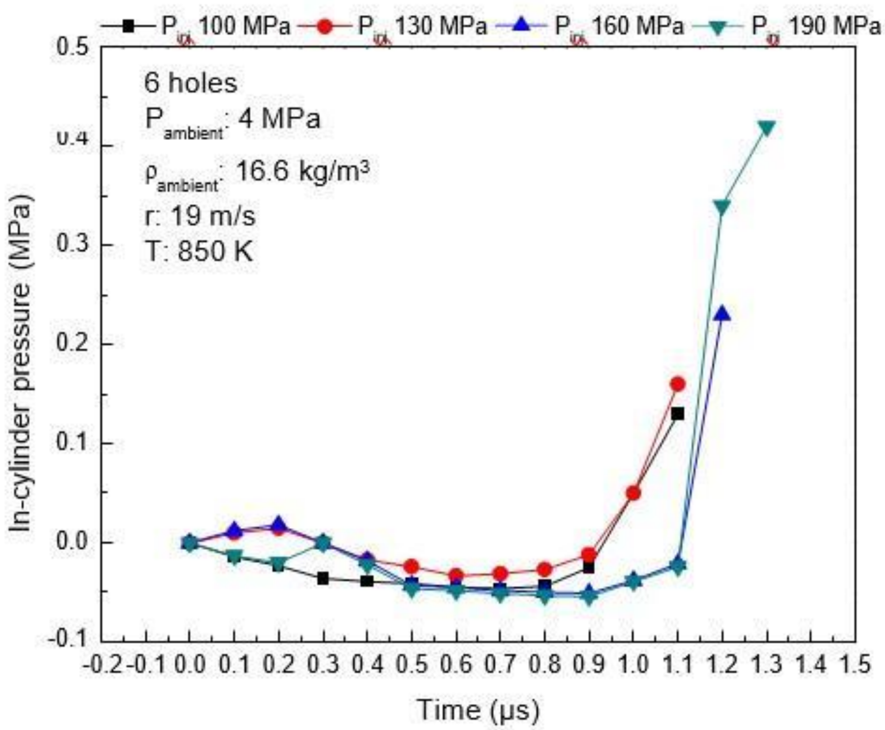

FIGURE 2. Histories of pressure during ignition delay

The Figure 3 shows the velocity image from the CFD analysis which indicate the cavitation bubble under injection pressure at 100 MPa(a), 130 MPa(b), 160 MPa(c) and 190 MPa(d). The result showed that the flow differences at different injection pressures, which are 100 MPa, 130 MPa, 160 MPa, and 190 MPa. The effect of implosions was investigated, and it was shown that cavitation bubbles inside nozzle holes rise as turbulence kinetic energy increases. However, the reflected implosion of cavitation bubbles generates additional spray breakdown and may result in finer droplets of fuel, which can accelerate fuel evaporation. According to the figures, the implosion of cavitation bubbles further breaks up the spray and may result in finer droplets of fuel, which can speed up the evaporation of fuel. According to the diagram, the spray behaviour in the combustion chamber influences the fuel-air combination.

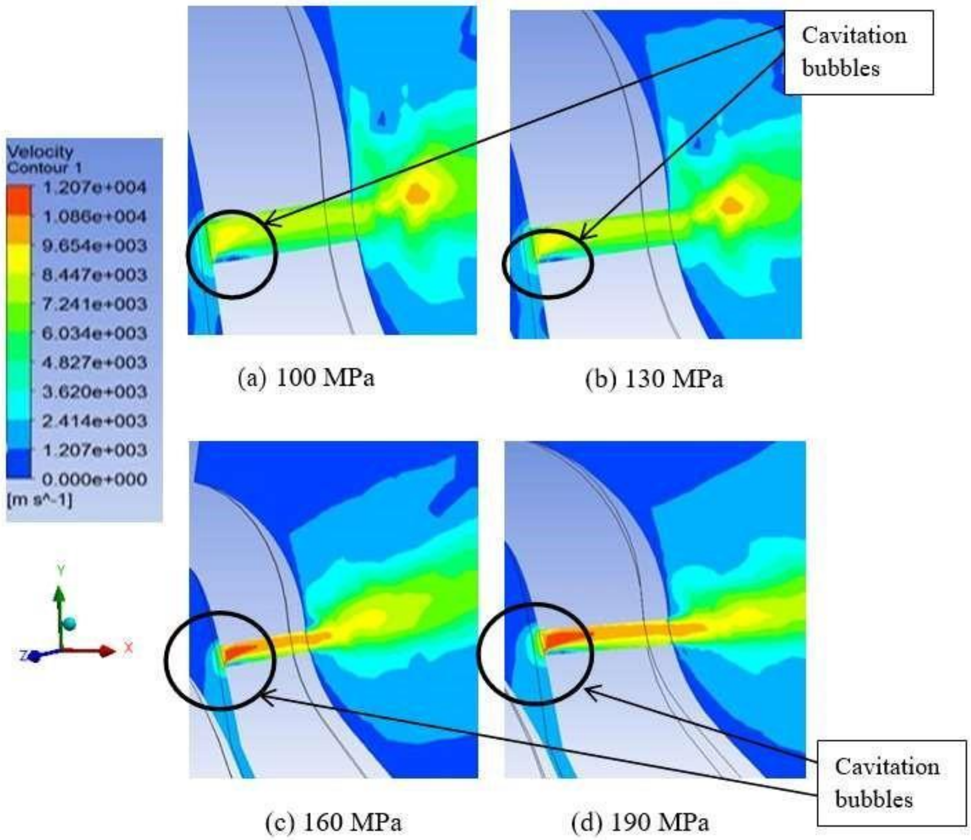

FIGURE 3. Injection pressure at 100 MPa(a), 130 MPa(b), 160 MPa(c) and 190 MPa(d)

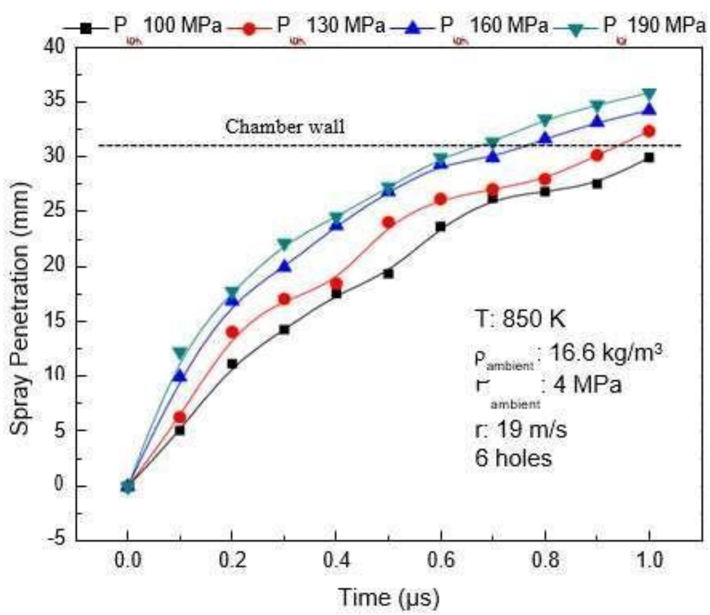

FIGURE 4. Spray penetration as the injection pressure varied

Figure 4 depicts the effect of spray tip penetration as injection pressure was modified. It is obvious that increasing the injection pressure promotes spray penetration along the wall region. Higher injection pressure is thought to allocate a large volume of fuel-air mixture and has been discovered to impact good spray atomization. The graph shows spray penetration across the wall chamber at 190 MPa injection pressure.

CONCLUSION

The effects of three different Crude Palm Oil (CPO) biodiesel blends, B5, B10, and B15, with different ambient density on nozzle flow and spray characteristics, computational fluid dynamics (CFD) were used to determine the nozzle flow and spray characteristics for different injection pressure of biodiesel spray to ambient variant conditions on mixture formation. Thus, the results obtained in this study are summarized as follows:

1. The effect of implosions was investigated, and it was shown that cavitation bubbles inside nozzle holes rise as turbulence kinetic energy increases. However, the reflected implosion of cavitation bubbles generates additional spray breakdown and may result in finer droplets of fuel, which can accelerate fuel evaporation.
2. Implosion of cavitation bubbles further breaks up the spray and may result in finer droplets of fuel, which can speed up the evaporation of fuel. According to the diagram, the spray behaviour in the combustion chamber influences the fuel-air combination.
3. Spray penetration increased as injection pressure increased. High injection pressures are used in biodiesel fuels to aid atomization.
4. The simulation of high injection pressure sprays of biodiesel fuels predicted that injection pressures of up to 190 MPa would be required to achieve improved atomization. In particular, high injection pressures were predicted to be more necessary for the biodiesel fuels to develop their breakup.

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