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Effects of Surrounding Gas Pressure and Temperature on Auto-Ignition of an Ethanol-Diethyl Ether Blended-Fuel Spray in a Vessel

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This study deals with the development of controlled auto-ignition technology for high performance compression ignition DI alcohol engines. Although research trends for recent technologies of power units have changed from internal combustion engines to battery and motors, ignition, combustion, and emission characteristics of biofuels such as bioethanol, butanol in high performance diesel engines have been still focused on as one of the options for the enhancement of renewable/sustainable/carbon-neutral energy utilization. Recently, ignition, combustion, and emission characteristics of alcohol-diesel blended fuels in conventional diesel engines have been intensively investigated and reported [1,2]. In order to develop such diesel engines fueled by alcohol-diesel blends, correct understanding of auto-ignition of an alcohol spray is required. However, a few fundamental studies [3,4] on the physical and chemical mechanisms of auto-ignition of an alcohol spray are found in these couples of decades. Auto-ignition of a fuel spray depends on fuel properties and surrounding gas conditions such as pressure, temperature, and Oxygen concentration. In our past experimental studies [5], therefore, surrounding gas pressure and temperature dependence of the spray auto-ignition phenomena in a vessel (electrical heating Constant Volume Combustion Chamber: CVCC) has been investigated for Ethanol (E) and Diethyl-ether (D) blended fuels with changing its blend ratio, and we have reported the auto-ignition quality of tested ED fuels in a form of the 3D-mapping/surface data of ignition delay versus surrounding gas pressure and temperature. However, the physical and chemical mechanisms of spray mixture formation process up to auto-ignition of ED blended fuels have not been revealed yet. Therefore, we performed numerical analysis to make clear the required surrounding gas conditions to realize stable auto-ignition of an ED-blended-fuel spray. One of the commercial CFD codes; CONVERGE was used in computational calculation with the considerations of fluid compressibility, turbulence, atomization, evaporation and detailed chemical reactions. Computational examination for auto-ignition quality of ED blended fuels was performed under the condition of constant Oxygen concentration in mass fraction of ambient air (23%). Results of numerical analysis showed good agreement with experimental data as the higher surrounding gas pressure and temperature, the shorter ignition delay. The characteristics of auto-ignition phenomena of an ED-blended-fuel-spray are discussed in this paper from physical and chemical aspects.

References

[1] Zhang, X., Li, T., He, R., and Chen, R. Study on the Physicochemical Properties and Spray and Combustion Characteristics of 1-Butanol/Diesel Fuel Blends in a Constant-Volume Combustion Chamber, Journal of Energy & Fuels, Vol. 33, 2019, pp. 10218-10227
[2] Li, Z., Mi, S., Zhang, Y., Zhu, J., Qian, Y., Zhu, L., and Lu, X. A comparative study on alcohol-diesel blended fuels in a common rail diesel engine: Combined effects of carbon numbers, oxygen content, and molecular structure. Journal of POWER AND ENERGY, Vol. 236(1) 2022, pp. 124-136
[3] Siebers, D. L. and Edwards,C. F., Auto-Ignition of Methanol and Ethanol Sprays under Diesel Engine Conditions. SAE Technical Paper,1987 SAE-870588
[4] Saitoh, H., and Uchida, K., On the Main Factors Governing Auto-Ignition Phenomenon of Alcohol Spray –A Study from the viewpoint of fuel properties–. SAE Int. J. Fuels and Lubricants, Vol.2(1),2009, pp.911-920.
[5] Saitoh, H., and Uchida, K., Surrounding Gas Pressure and Temperature Dependence of the Spray Auto-ignition Phenomenon for Ethanol-Diethyl Ether Blended Fuels. Journal of Research and Applications in Mechanical Engineering, 2016, Vol.4, No.1, pp.79-86.