Influence of fuel mixture on spray formation in diesel processes

T. Vogel[*°], M. Lutz°, M. Wensing, A. Leipertz[*°†]
[*] Lehrstuhl für Technische Thermodynamik, Department of Chemical Engineering
Universität Erlangen-Nürnberg
Am Weichselgarten 8, 91058 Erlangen, Germany
° Esytec Energie- und Systemtechnik GmbH
Am Weichselgarten 6, 91058 Erlangen, Germany
[†] Erlangen Graduate School of Advanced Optical Technologies
Universität Erlangen-Nürnberg
Paul-Gordan-Str. 6, 91052 Erlangen, Germany

Abstract

In this measurement series the spray behavior of different fuels available on the market and canola oil was carried out. It was clearly visible that high boiling components, like fatty acid methyl ester, the canola oil itself or gas to liquid additives, increase the maximum penetration depth of the liquid fuel phase

Introduction

The mixture formation and the injection strategy in direct injecting diesel engines influences significantly the combustion process and thus the power generation, noise development, exhaust emission and efficiency of the engine. Earlier investigations of gasoline fuels carried out, that even small fractions of high boiling components have major effect on the spray characteristic and the evaporation behavior [Zigan]. For diesel fuels the high boilers fraction in bio-diesel fuels is increased compared to the mineral oil fuel. European law provides a blend of the bio diesel cut up to 10% until the year 2020. Thus, a significant alteration of the spray- and evaporation behavior can be expected.

Materials and Methods

A detailed analysis of the spray formation and evaporation of several different bio diesel fuels was carried out. The fuels investigated are miscellaneous first generation bio-diesel fuels like FAME-Diesel. Furthermore, pure plant oils have been used.

Measurements were performed in an optical accessible heated high pressure cell, allowing to separately change ambient pressure and temperature conditions up to 100 bars and 1000 K. A modern Piezo-actuated injector was pressurized up to 2000 bars. The temperature of the injector and the fuels tested were adjusted to a constant level. Ten different fuels have been investigated while ambient pressure, ambient temperature and injection pressure were varied.

Mie scattering (integral illumination) was used to acquire the differences in liquid fuel propagation and evaporation. The very high amount of image data collected was handled by using an automated image processing system providing penetration length, cone angle and spray area for the different fuels and various conditions in comparison. The parameters influencing the spray were controlled precisely and therefore, the experiments were reproducible on a high level. In order to get a direct relation to the engine conditions different precalculated engine load points were applied.

Results and Discussion

In a first comparison pure plant oils and diesel blend with a high content of plant oil as well as a reference diesel were investigated. In pure plant oil the fraction of high boilers is dominant. It was found that this fraction continues to dominate the spray characteristics of diesel oil blends down to a 50% volume fraction of plant oil, so that only marginal differences in comparison to pure plant oil can be found. In contrast to mineral oil diesel, that figures out constant penetration depth after 500µs after start of injection due to evaporation, the penetration of these sprays still increases 1 ms after start of injection. Figure 1 point out the penetration depth over time for three different fuels.

In a second comparison commercially available standard diesels containing lower bio-diesel fractions were compared to the CEC reference fuel without FAME-components. The influence of the bio-components was found in a slight to moderate increase of the penetration length. A significant change in the spray propagation

* Corresponding author: vogel@esytec.de

was found for premium diesel qualities with added GtL components which showed a distinct increase of the maximum penetration length. Figure 2 compares the frequency distribution of canola oil, CEC reference fuel and premium diesel with GtL components at the same point in time.

The results figure out that low volatile fuel components, which were found to have big impact on the spray formation and evaporation process under SI engine conditions, show generally the same effect in case of diesel injection processes and under realistic diesel engine conditions. As bio-components for diesel fuel that are currently used and discussed mainly or to a relevant part consist of low volatile components, these components will alter the spray formation and evaporation process in diesel engines. Therefore, bio-fuel components may contribute to a further increase of injections pressures in diesel injection to compensate for the increased break-up length and reduced evaporation.

[1] Zigan, L., Schmitz, I., Flügel, A., Wensing, M., Leipertz, A., *Conference on Injection Systems for IC Engines*, IMECHE, London, UK, 13.–14. May 2009, pp. 193-202.

[2] Lutz, M., Zigan, L., Flügel, A., Lindner, R., Wensing, M., Leipertz, A., *Ninth Congress on Engine Combustion Processes, Current Problems and modern Techniques*, Munich, Germany, 19. – 20. March 2009, BEV, Berichte zur Energie- und Verfahrenstechnik, Volume 9 (2009), pp. 309-320.

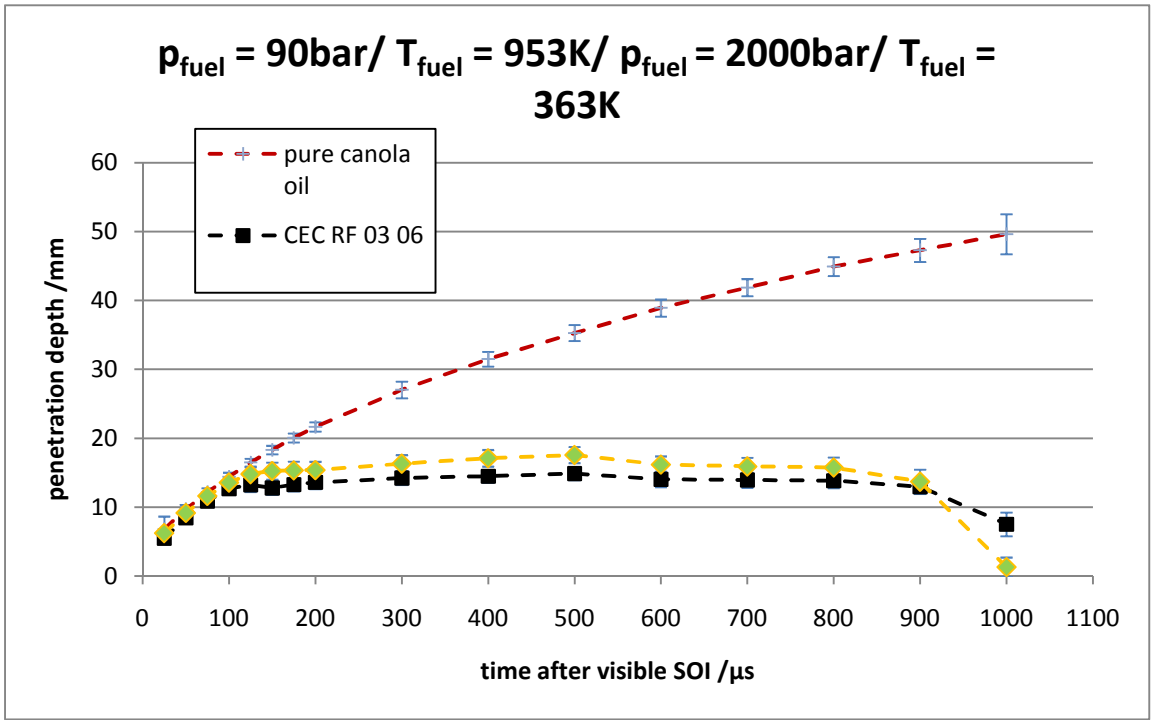

Figure 1: penetration depth of canola oil, reference fuel and diesel fuels with Gtl at a high motor load point

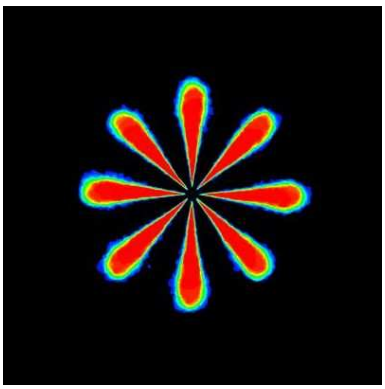

Figure 2: canola oil at 400 µs

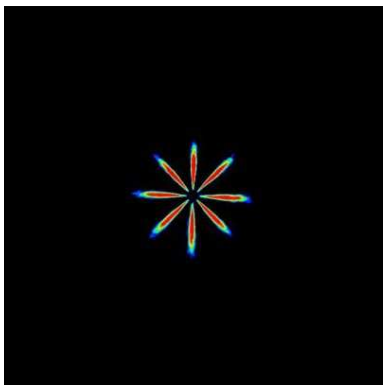

Figure 3: CEC RF at 400 µs

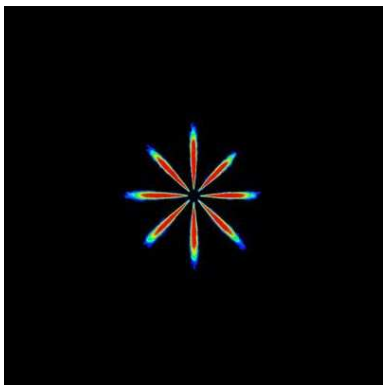

Figure 4: diesel with GtL additives