FOCUS ON IMAGING

In Application

Imaging of Ammonia in IC-Engines

FluidMaster BOS system

Introduction

Ammonia, traditionally known for its role in agriculture and industry, is emerging as a promising alternative fuel in the maritime sector, particularly for large engines powering ships.

With increasing concerns about air pollution, sustainability, and greenhouse gas emissions, the maritime industry is exploring cleaner fuel options to reduce its environmental footprint.

Ammonia stands out due to its potential to significantly lower emissions of CO_2 and other pollutants compared to conventional marine fuels. Additionally, its global availability and ease of production make it an attractive candidate for widespread adoption.

Furthermore, utilizing ammonia as a fuel can contribute to enhancing combustion efficiency, thereby improving overall engine performance.
However, challenges such as safe handling, storage, and distribution need to be addressed to ensure the seamless integration of ammonia as a viable marine fuel.

As efforts to decarbonize the shipping sector intensify, the importance of leveraging alternative fuels like ammonia becomes increasingly evident in achieving sustainability goals and mitigating the impacts of maritime transportation on the environment.

The geometric distribution of gaseous fuels, like ammonia, when blowing them into combustion chambers or intake manifolds with injection valves is an elementary parameter for valve designing, optimizing combustion processes and validating numerical simulations.

The typical methods for spray visualizing of liquid fuels (Mie scattering or shadow imaging) are not suitable for gaseous fuels. Other laser-based techniques need an additional seeding of the flow and a high technical effort.

The Karlsruhe "Institut für Kolbenmaschinen" (IFKM) in cooperation with LaVision applied the simple to use **Background Oriented Schlieren** (**BOS**) technique at a pressure chamber to visualize the injection of ammonia with a commercial gas injection valve.

Figure 1 shows the used high-speed camera and the tempered pressure cell with the gas injector mounted at the top. The illuminated special BOS-pattern is placed at the rear side of the chamber.

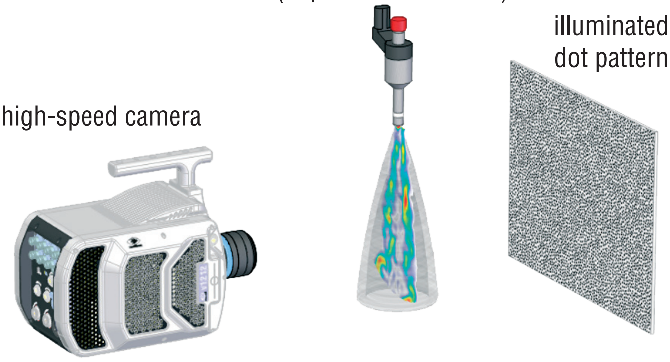

Figure 1: Sketch of experimental setup with high-speed camera and pressure chamber

Background Oriented Schlieren technique

BOS is a digital Schlieren technique and works on detecting changes in the refractive index of media. Thus, making it possible to effectively visualize ammonia in contrast to the rest of the engine's charge.

The main advantage of BOS is the simplicity of the implementation. All that is required are a digital camera and the BOS pattern printed on a screen. Figure 1 shows this principal setup for characterizing gas injection valves. Additional illumination of the pattern helps to increase the contrast of the recorded images, especially for time-resolved high-speed imaging.

LaVisionUK Ltd
2 Minton Place / Victoria Road
Bicester, Oxon / OX26 6QB / United Kingdom
E-Mail: sales@lavision.com / www.lavisionuk.com
Phone: +44-(0)-870-997-6532 / Fax: +44-(0)-870-762-6252

LaVision GmbH
Anna-Vandenhoeck-Ring 19
37081 Göttingen / Germany
E-Mail: info@lavision.com / www.lavision.com
Tel. +49-(0)551-9004-0 / Fax +49-(0)551-9004-100

LaVision Inc.
211 W. Michigan Ave. / Suite 100
Ypsilanti, MI 48197 / USA
E-mail: sales@lavisioninc.com / www.lavisioninc.com
Phone: (734) 485 - 0913 / Fax: (240) 465 - 4306

Imaging of Ammonia in IC-Engines

FluidMaster BOS system

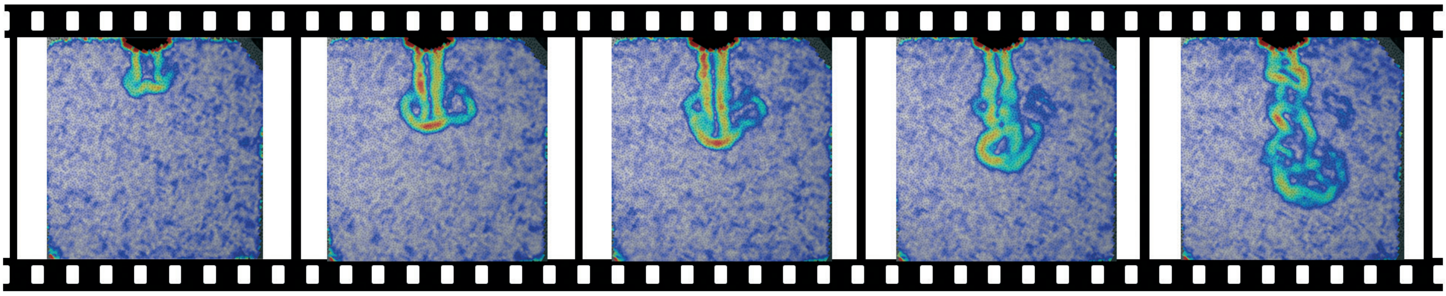

Figure 2: BOS-high-speed imaging of ammonia injection

Experiment

The experiment was carried out at the IFKM, where a high-speed camera was mounted in front of a heated pressure chamber with optical access at the front and rear. The gas injector was mounted at the top of the chamber. The illuminated BOS pattern was located at the rear of the chamber.

For simulating back pressure conditions the cell was pressurized with nitrogen (N_2). Single injection conditions were recorded with a frame rate of 10 kHz.

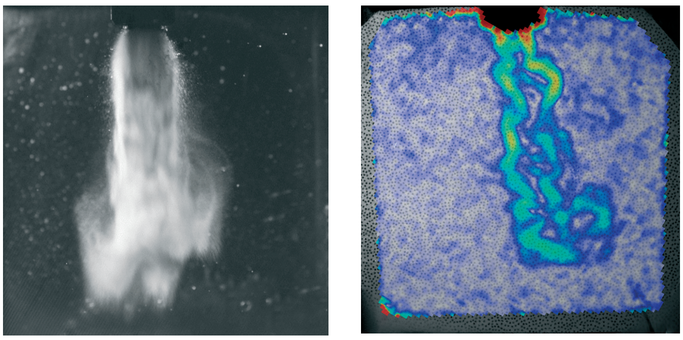

Figure 3: Left: raw picture of ammonia liquid injection, right: BOS image of ammonia injection (only gas phase)

Results

Using ammonia as fuel, the penetration behavior varies depending on the ambient conditions (chamber and injection pressure, chamber temperature).

So, penetration can take place as pure gaseous jet or as a liquid primary spray with a fast evaporation.

With this **BOS** measurement technique, component improvements for ammonia can be verified very efficiently and validation of simulation models is supported productively.

As part of a research project, detailed investigations of the ammonia spray behavior are currently taking place at the IFKM and will be published soon.

LaVisionUK Ltd
2 Minton Place / Victoria Road
Bicester, Oxon / OX26 6QB / United Kingdom
E-Mail: sales@lavision.com / www.lavisionuk.com
Phone: +44-(0)-870-997-6532 / Fax: +44-(0)-870-762-6252

LaVision GmbH
Anna-Vandenhoeck-Ring 19
37081 Göttingen / Germany
E-Mail: info@lavision.com / www.lavision.com
Tel. +49-(0)551-9004-0 / Fax +49-(0)551-9004-100

LaVision Inc.
211 W. Michigan Ave. / Suite 100
Ypsilanti, MI 48197 / USA
E-mail: sales@lavisioninc.com / www.lavisioninc.com
Phone: (734) 485 - 0913 / Fax: (240) 465 - 4306