MAN engine test facility– from lab to large scale laser diagnostics

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Two-stroke diesel engines are used for propulsion on larger freight ships due to their unrivalled efficiency and reliability. Refinement of such large-bore two-stroke Diesel engines with reduced pollutant emissions and improved performance will require novel engine designs, just as for the smaller engines. Currently development is also directed towards optimising operation on new fuels for the marine market, including LNG, LPG, ethane and methanol.

For such a development advanced optical imaging tools are desirable, both for testing new engineering designs and for validating computational models used in such work. Main propulsion marine engines often feature bore diameters of 0.5 up to 1 meter, and stroke lengths of 1.5 to over 3 meters. Optical diagnostics in such an engine poses a number of challenges (size, vibrations, thermal loads, luminosity and safety) which differ to those of smaller sized engines. We have developed two main approaches for achieving optical access to the combustion chamber on one of the cylinders of our 4-cylinder test engine situated at MAN in Copenhagen. The first uses borescopes and the second an optical cover fitted with flexible optical ports with 40 mm diameter free view. With borescopes high-speed imaging of ignition and flame development can be made, as well as IR thermography. The optical cover allows laser diagnostic techniques such as Mie scattering, PIV, and thermographic phosphors to be applied.

A number of examples of the application of optical techniques for marine engine development will be presented. Simultaneous laser illumination and flame emission imaging has been used for studying diesel jet injection, propagation and ignition. Multiple high-speed cameras have been used for imaging of the flame from several views simultaneously, allowing a time-resolved mapping of flame location and geometry within the cylinder – using both diesel and LNG as fuels. Finally flow and cavitation inside fuel injectors has been studied in transparent 1:1 models using micro-PIV and diffuse background illumination, in order to increase understanding of fuel injection phenomena.

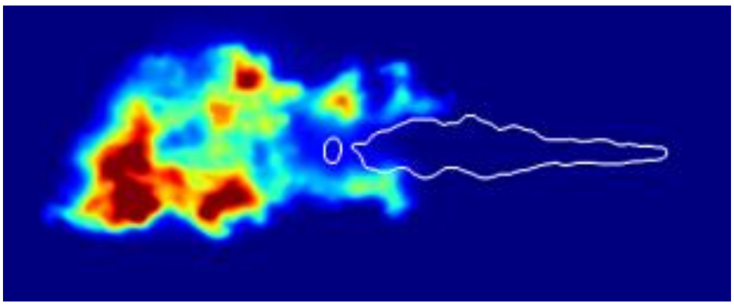

Figure 1. Liquid part of diesel jet (white outline) and surrounding flame shortly after ignition.