Ilass 2013

Influence of nozzle hole eccentricity on spray morphology

Andreas Schmid\textsuperscript{1}, Beat von Rotz\textsuperscript{1}, Reiner Schulz\textsuperscript{1}, Kai Herrmann\textsuperscript{1}, German Weisser\textsuperscript{1},
Rolf Bombach\textsuperscript{2}

1: Wärtsilä Switzerland Ltd., Winterthur, Switzerland
2: Paul Scherrer Institute, Villigen PSI, Switzerland

Abstract

Large marine two-stroke diesel engines have an injector geometry, which differs substantially from the configurations used in most other diesel engine applications, as the injector orifices are distributed in a highly non-symmetric fashion. In order to experimentally assess the impact of key features of such orifice arrangements on spray morphology, orifice eccentricity relative to the injector axis in particular, a dedicated test setup has been realised, including the development and application of tailor-made data processing routines. The high-speed camera recordings of the Mie-scattering data obtained simultaneously for two perpendicular views of single sample sprays have been analysed in terms of spray tip penetration and spray angle as well as with respect to the orientation of the spray. These analyses confirm the complex three-dimensional structure of sprays at such conditions: They are in fact far from rotationally symmetric – specifically when high levels of eccentricity apply – and the actual orientation of their axis in such cases clearly deviates from the nominal one, normally assumed to be in line with the orifice axis. These deflections are in the range of \(10^\circ\) and they apply not only in the direction of the eccentricity but also perpendicular to it. Additional effects arise from the geometric configuration of the central bore of the injector, upstream of the orifice, and when varying the injection pressure. In the case of high eccentricity, moreover, a clear pattern can be discerned in the initial evolution of the spray deflection: Starting from a slight deflection in the direction of the eccentricity, the spray axis moves first to its nominal direction and then gradually changes orientation again towards the level of stabilisation.

Introduction

In contrast to other diesel engine applications, large two-stroke marine diesel engines are equipped with at least two injectors, which are protruding from the side of the cylinder head into the combustion chamber. The fuel is injected into a cylinder charge characterised by significant swirl levels, via typically five orifices per injector. As a consequence, the injectors are highly non-symmetric, in contrast to the designs typically used in all other types of diesel engines. Figure 1 shows a sample design of the tip of such injector.

In order to achieve an optimum distribution of the fuel in the combustion chamber, the individual orifices are normally sized differently and covering only a relatively small range of angles on a plane perpendicular to the axis of the injector. This small range of angles of the orifices requires the suitable selection of their arrangement without unnecessarily prolonging the injector tip as this would result in excessive heating of the (uncooled) injectors, thus reducing their lifetime. On the other hand, fundamental mechanical stability requirements dictate a minimum distance between the orifices. In order to meet those requirements, the design of individual orifices involves non-negligible levels of eccentricity of the orifice axis relative to the injector axis.

Figure 1 Sample design of typical fuel injector tip (left), cross-section through orifice region (right).