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Optical and Numerical Investigation of the Combustion Process in a Single Cylinder Medium Speed Diesel Engine

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Abstract: Strict emission regulations and the need of higher efficiency of future diesel engines require an optimized combustion process. For getting a better understanding of the combustion process optical investigations represent a powerful tool and they are already widely used within the development process of passenger car and truck engines. For medium speed diesel engines however, optical investigations are still not common due to costs of optical test engines and technical practicability.

Within the IP-Hercules ss project MAN Diesel SE in cooperation with the “Institut fuer Kolbenmaschinen” (IfKM) at the Technical University of Karlsruhe realized optical in-situ investigations of the combustion process on an MAN Diesel SE 32/44 CR single cylinder medium speed diesel engine. For the optical investigations a special optical cylinder head was developed with several optical accesses for an endoscope and also laser illumination. Endoscopic investigations were chosen because an emphasis was placed on minimum modifications to the combustion chamber. The deflection of spray and combustion due to the optical instrumentation had to be minimized in order obtain results fully representative of the standard engine as well.

The first optical investigations aimed on soot luminescence. For that purpose special injectors were designed for separating a single flame plume and spray cone respectively. Pressure and temperature conditions at start of injection were adjusted by modified charge air conditions. Different marine fuels were used for the tests. The images of the combustion process were recorded with an endoscope and a high speed camera.

For comparing optical images and CFD combustion simulation results, selected engine operating points were simulated with a modified version of the CFD code KIVA3V-Release2 containing additional sub-models developed both at the Engine Research Center of the University of Wisconsin - Madison (ERC) and at MAN Diesel. The purpose of the comparison was to validate the CFD models with in-situ measurements inside the combustion chamber.

First results show that endoscopic in-situ investigations of the combustion process can give feasible data for validating CFD combustion simulation models. The used CFD-models are capable of predicting standard measurement data of medium speed diesel engines like cylinder pressure, heat release rate or NOx emissions without adjustment of model parameters. The comparisons of spatially resolved data show that the used CFD models are capable of predicting important trends, but that they are not yet accurate enough for getting exact agreement with the optical images. Nevertheless, the observed deviations between spatially resolved details represent valuable information about how to further optimize the CFD models with a focus on medium speed diesel engines.