Towards More Complete NO Emission Prediction by CFD in Marine Diesel Engines

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Abstract

Diesel engines are known to be cost-effective, efficient power producers with a high durability and availability. During the past decades diesel engines have developed dramatically in terms of fuel economy, power efficiency, and emission characteristics. A specific NO emission factor in the range 5-10 g/kWh can easily be obtained with the current engine-based low-NO_x technology, and about 2 g/kWh with the selective catalytic NO_x reduction (SCR). These factors represent a NO_x reduction of about 30-50% and 90%, respectively, as compared to corresponding uncontrolled NO_x level. However, it is evident that even more stringent emission regulations will be implemented and/or voluntarily proposed for diesel engines in the near future. Consequently, there is a continuous need for development of fuel-economical diesel engines with even lower emissions (NO_x, PM, etc.).

To address these challenges the CFD-based diesel engine analysis offers many advantages and complements the possibilities offered by modern experimental techniques. The present paper describes work-in-progress aimed at developing CFD to more accurate and complete. The main focus has been on the prediction of NO emission with a new model that incorporates NO formation by both the thermal and the N_2O-intermediate path.

A medium-speed, four-stroke direct-injection marine diesel engine (bore=200mm, stroke=800mm) has been simulated at two different load conditions by the commercial CFD code, STAR-CD version 3.20. In the simulations, most of the submodels used for fuel behaviour, heat transfer, flow and turbulence and combustion are standard models as included in STAR CD. The predictions by the new NO model are compared to those by alternative NO models like the Zeldovich NO and the Extended Zeldovich NO, and to available NO emission measurements.

Based on the simulation results, the importance NO formation paths is discussed. Further, the potential for NO reduction by soot and unburned hydrocarbons is illustrated.