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A Comparison of Characteristic Time Scale and Flame Area Evolution Combustion Models in Medium Speed Diesel Engines

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Abstract: In this paper, results are presented from CFD analyses using a three-zone extended coherent flame model (ECFM-3Z) that describes the evolution of the flame area to model the heat release and emission formation under large bore diesel engine conditions. The ECFM-3Z model divides the local gas mixture into three zones: the unmixed fuel, the unmixed air, and the mixed gases. The mixed gases, which are the product of mixing between the unmixed fuel and air, can be either unburnt, premixed, or burnt. In the premixed case, the calculated reaction rate is based on solving the flame area density equation whereas in the post-flame zone (burnt gases), it is described by an eddy breakup type model. These results are compared with those obtained with a turbulent mixing controlled characteristic time scale model that has been applied widely in previous engine studies. Ignition models are used with both combustion models to predict correct ignition timing at various engine loads. The RNG k-ε turbulence model and the WAVE drop breakup model have been employed in all the computations. The heat release rates obtained with the two combustion models are compared and the correctness of the mixing limited assumption is assessed. Preliminary results indicate that the characteristic time scale model may predict higher maximum gas phase temperatures. Possible reasons for this will be sought. The NO emissions predicted with both model types will be compared and possible differences analyzed. As NO chemistry is relatively slow compared to the main chemistry, the fast chemistry assumption may provide incorrect NO results. The soot formation will also be computed based on the Hiroyasu-Magnussen model as well as a model proposed by Mauss and coworkers. The engines to be modeled are two Waertsilae medium speed four-stroke engines with cylinder bores of 200mm and 460mm respectively.