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OPTIMIZATION RESEARCH FOR A HIGH PRESSURE COMMON RAIL DIESEL ENGINE BASED ON SIMULATION

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ABSTRACT−A TP (Temperature Phase) model is presented to carry out optimization calculation for a high-pressure common rail diesel engine. Temperature is the most important parameter in the TP model. For the lower branch (when temperature T < 850 K) of the S-shaped curve (auto-ignition phase), a 6-step ad-hoc model with adjusted rate constants of n-heptane is used, referred to steady state assumption. Steady state assumption is based on the observation that, due to very fast chemical processes in combustion problems, many chemical species and reactions are in a quasi-steady state or partial equilibrium. When a species is assumed to be in the steady state, the corresponding differential equation can be replaced by an algebraic relation, which reduces the computational costs. For the middle branch (850 K ≤ T < 1100 K) of the S-shaped curve, a 4-step model is used to calculate the unstable phase. For the upper branch (T ≥ 1100 K) of the S-shaped curve, one-step model is used because the one-step model has widely been used in descriptions of flame stability where it essentially serves as a model that produces a thin flame with strong temperature sensitivity. When zone temperature T<1500 K, only the soot precursors –PAHs (Polycyclic aromatic hydrocarbons) is created and there is no soot emission. When zone temperature T ≥ 1500 K, PAHs and soot source terms (particle inception, surface growth, oxidation, coagulation) are calculated. The TP model is then applied in multidimensional simulations to carry out optimizing, which reduces experiment cost. The results of cylinder pressures, the corresponding heat release rates, NOx and soot with variation of injection time at constant rail pressure, variation of EGR-rate at constant rail pressure and variation of rail pressure at constant EGR-rate between simulation and experimental data are analyzed. The results indicate that the TP model can carry out optimization and CFD (computational fluid dynamics) and can be a tool to calculate for a high-pressure common rail diesel engine.

KEY WORDS : High-pressure common rail diesel engine, Polycyclic aromatic hydrocarbons (PAHs), Temperature phase model, Optimization calculation

1. INTRODUCTION

At present, it is difficult in China to manufacture a conventional distributed pump diesel engine without after-treatment to EURO-II to EURO-III environmental standards. Matching the optimism combustion system for a high-pressure common rail diesel engine is very important and necessary work to improve fuel efficiency and emissions. The development of the combustion system, i.e. combustion chamber geometry, fuel injection system, and air management system was in the past a rather pragmatic practice largely based on experience. Fang *et al*. (2008) used an optically accessible single-cylinder high speed direct-injection (HSDI) diesel engine, equipped with a Bosch common rail injection system, to study low temperature Modulated Kinetics (MK) combustion with a retarded single main injection. They employed high-speed liquid fuel Mie-scattering to investigate the liquid distribution and evolution. By carefully setting up the optics, they obtained three-dimensional images of fuel spray from both the bottom of the piston and the side window and measured NOx emissions in the exhaust pipe. They identified the influence of injection pressure, EGR rate, and injection timing on the combustion modes based on experiment. Kim *et al.* (2008) investigated the effects of injection conditions and swirl on D.I. diesel combustion using a transparent engine system. They conducted a combustion analysis and steady flow test to measure the heat release rate due to cylinder pressure and the swirl ratio. In addition, they obtained spray and diffusion flame images using a high speed camera and captured the LII and LIS images using an ICCD camera to investigate the soot distribution in the cylinder. These experiments give lots of real data and a convincing basis for engine design. However, new technologies related to fuel injection have dramatically increased the range over which the parameters affecting the performance of an engine can be varied, making such an approach intractable when attempting to reach future stringent

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