2011-24-0009

Numerical Investigation on the Spray Characteristics and Combustion Process in a DI Diesel Engine at Reduced Temperature Combustion Condition

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ABSTRACT

In this paper, reduced temperature combustion has been investigated at high load condition of a direct injection diesel engine. A three dimensional CFD model for flow field, spray, spray-wall interactions, combustion and emissions formation processes have been used to carry out the computations. The combined effect of EGR temperature and EGR rate is analyzed to choose by consideration of engine performance. Then, the effect of injection timing and injection pressure is investigated to the improvement of mixture formation at high engine load condition. It reveals that combustion temperature is dramatically decreased by the increase of cold EGR to 25% rate. This characteristic influences on the increase of the liquid spray penetration and the decrease of indicated mean effective pressure (IMEP) and NOx emission associated with the increase of soot emission. Advance injection timing and high injection pressure together with applying 25% EGR lead to simultaneous reduction in NOx and soot formation compared with the base engine condition.

INTRODUCTION

Direct-injection diesel engines have proved to be an efficient option in heavy-duty applications like transportation or power generation. However, due to the natural conditions of high pressure and temperature in the combustion process, diesel engines emit considerable amounts of pollutants, especially nitrogen oxides (NOx) and soot [1]. International regulations ratified in recent years have imposed more stringent limits on pollutant emissions in internal combustion engines. To comply with these regulations with the common rail injection system which is widely used in recently developed engines, several new fuel injection strategies on conventional diesel combustion have been investigated in direct injection diesel engines.

Variable injection timing is a possible way to meet increasingly restrictive emissions' requirements for direct injection diesel engines. Jafarmadar and Zehni [2] investigated the effect of injection timing and split injection parameters on combustion and emissions of a DI diesel engine via Fire CFD code. The results indicated that 25% of total fuel injected in the second pulse, reduces the total soot and NOx emissions at 25°CA delay dwell between the pulses.

In order to further reduce both NOx and soot emissions, new diesel combustion concepts should be developed in conjunction with suitable injection strategies.

One concept of new diesel combustion is homogenous charge compression ignition (HCCI) based on the simultaneous ignition of a highly diluted premixed air-fuel mixture throughout the combustion chamber [3-5]. Close to homogenous conditions are obtained by very early fuel injection. This concept corresponds to combustion in an area with an equivalence ratio leaner than 1 and a temperature lower than 2200°K. HCCI combustion results in minimal soot and NOx emissions with only a slight decrease in fuel efficiency.