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THE INFLUENCE OF CAVITATION PHENOMENON IN A DIESEL INJECTOR ON THE SPRAY CHARACTERISTICS AND COMBUSTION PROCESS OF A DI DIESEL ENGINE

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Abstract: The improvements in the fuel injection system of diesel engines can significantly reduce the emission of harmful pollutants. Cavitation phenomenon inside a diesel injector plays a critical role in primary spray breakup and development processes. In this paper, a CFD analysis of the influence of internal flow through various nozzle geometries on the global characteristics of the spray, including spray tip penetration, sauter mean diameter (SMD) and spray pattern are discussed in a heavy-duty DI diesel engine. Cylindrical nozzles with different nozzle inlet R/D ratios and nozzle hole, L/D ratios are used in order to observe the individual effects of these geometrical parameters. With respect to the liquid-phase, spray calculations are done based on a statistical method referred to as the Discrete Droplet Method (DDM). The results show that the lower R/D ratio or the sharper nozzle inlet leads to lower spray tip penetration length, larger spray angle and smaller droplet sizes due to stronger cavitation phenomena in the nozzle hole. Interestingly, soot emissions for a rounded-edged nozzle are much higher compared to a sharp-edged nozzle with the same rate-of-injection. Inversely, round edge inlet nozzle produces lower NOx emission in compared to sharp edge inlet nozzle.

Keywords: Fuel injection, Cavitation, Spray characteristics, Combustion, Emissions.

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Introduction

In a diesel engine, the design of fuel injection nozzle is an important factor for the improvement of the combustion performance and reduction of emissions because nozzle geometry influences the spray characteristics and air–fuel mixing in the engine.

Cavitation is one of the most important factors that influence nozzle flow characteristics, which is generated from the liquid to bubble in the low static pressure flow regions when the pressure is less than the saturated pressure (Nurick, 1976). There are some works in the literature, which is focused on influence of cavitation on the discharge coefficient, internal flow, air-fuel mixing and spray characteristics in the nozzle of injector. Lefebvre (1989) was investigated the spray development concerning to the effect of nozzle geometry and injector operating conditions, and the experimental and computational studies were developed based on this review by many of researchers (Han et al. (1997); Cousin and Nuglisch (2001); Gavaises and Arcoumanis (2001); Halder et al. (2002)). Payri et al. (2004) reported that