Experimental and Numerical Investigations of Jet Impingement Cooling of Piston for Controlling the Non-Tail Pipe Emissions

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The continuing increase of power densities has led to high thermal loading of heavy duty diesel engine pistons. Material constraints restrict the increase in thermal loading of piston. High piston temperature rise may lead to engine seizure because of piston warping. Pistons are cooled by oil jet impingement from the underside of the piston in heavy duty diesel engines. Impingement heat transfer has been used extensively because of the high rates of cooling it provides. The associated high heat transfer rate is due to the stagnating mass that impacts hot impingement surface at high speed. However, if the temperature at the underside of the piston, where the oil jet strikes the piston, is above the boiling point of the oil, it may contribute to the mist generation. This mist significantly contributes to non tail pipe emissions (non point source) in the form of unburnt hydrocarbons (UBHC's).

This investigation presents and discusses the results of a simulation study with numerical and experimental investigation of the heat transfer between the constant heat flux applied to flat plate as well as piston model and impinging jet. Boundary conditions are applied to flat plate and piston. Using the numerical modeling, heat transfer coefficient (h) at the underside of the piston is predicted. This predicted value of heat transfer coefficient significantly helps in selecting right oil grade, oil jet velocity, nozzle diameter and distance of the nozzle from the underside of the piston. It also helps predict whether the selected grade of oil will contribute to mist generation. Using numerical simulation (finite element method) temperature profiles are evaluated for varying heat flux to demonstrate the effect of oil jet cooling. An experimental setup for the validation of computational results has been developed for flat plate and production grade piston. Infrared camera is used to investigate and validate the temperature profiles. High speed camera is used to investigate the oil jet breakup, localized pool boiling and mist generation due to impinging jet on the hot plate and piston underside.