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Developing Low Gasoline Particulate Emission Engines Through Improved Fuel Delivery

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ABSTRACT

Particulate emissions are of growing concern due to health impacts. Many urban areas around the world currently have particulate matter levels exceeding the World Health Organisation safe limits. Gasoline engines, especially when equipped with direct injection systems, contribute to this pollution. In recognition of this fact European limits on particulate mass and number are being introduced. A number of ways to meet these new stringent limits have been under investigation. The focus of this paper is on particulate emissions reduction through improvements in fuel delivery.

This investigation is part of the author's ongoing particulate research and development that includes optical engine spray and combustion visualisation, CFD method development, engine and vehicle testing with the aim to move particulate emission development upstream in the development process. As part of this work, a spark eroded and a laser drilled injector were fully characterised in a spray vessel under key engine running conditions. Injector nozzle geometries and mass flow data were also measured in great detail.

This paper demonstrates using both steady state and transient engine testing that very significant improvements in particulate emissions can be made. Control strategies enabling multiple injections of smaller volumes of fuel per injection are the most promising technology. The MAHLE Flexible ECU (MFE) combined with injector testing allowed early stage development and demonstrated these effects for a number of key engine operating conditions. Most notably it was found that particulate matter emissions could be reduced by 80-90% during the catalyst light off phase. A new approach was developed (MASTER) to simultaneously assess the effects of calibration changes on all emissions to increase testing efficiency and hence get to more optimised solutions faster. This approach was successfully tested on a production engine comparing two injectors achieving 82% reduction in particulate number emissions during the first 200seconds of the NEDC relative to the EU5b baseline.

Finally it was found that both fuel properties and injector deposits can have a significant effect on particulate emissions.