Comparing the Cycle-to-Cycle Variations of Pulsing Spray Characteristics by Means of Ensemble Image and Probability Presence Image Analysis Techniques

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Abstract

This paper presents an investigation to reveal the cycle-to-cycle variations of pulsing spray characteristics of Spark-Ignition Direct-Injection (SIDI) fuel injectors. The objective is to quantify the spray's cycle-to-cycle variation such that further insight of the operating principles in the fuel injection system could be developed to enhance the combustion efficiency and reduce emissions of SIDI engines. The experiments were carried out using a multi-hole SIDI fuel injector under an extended range of test conditions in a spray chamber. Using a strobe light as an illumination source, images of the spray structure were taken by a CCD camera. The analysis approach of the cycle-to-cycle variation was based on constructing two types of images, namely, 1) Ensemble Image, and 2) Probability Presence Image (PPI). The analysis of the ensemble image and PPI reveals that both approaches can be used to extract the variations of the spray structure. While an ensemble image is useful for determining the quantitative variation of the spray characteristics, such as the penetration and spray angle, in terms of average, maximum and minimum limits, a PPI provides a new way to examine the spray variation in terms of a probability defined for the presence of the liquid region. Not only a PPI is able to illustrate the magnitude of cycle-to-cycle variation in penetration and spray angle values quantitatively, it also displays the variations qualitatively in a two-dimensional manner in terms of the liquid presence probability.

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