Investigation of the Internal Dynamics of Diesel Nozzles by Time-Resolved Laser Doppler Vibrometry

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Abstract

Experimental and numerical data show that high frequency pressure fluctuations and vibrations exist inside modern diesel injectors. Even though nozzle vibrations may influence the shape and stability of sprays, no thorough spectral investigations have been reported and limited data are available. Experiments were performed to measure time-resolved vibration spectra of diesel injector nozzles using three dimensional laser vibrometry, needle lift sensor and fuel pressure transducer. The vibrometer, which measures the velocity of a vibrating object using the Doppler effect, was used to scan injector nozzle tips during the injection event. In order to allow a comparative investigation of the effect of nozzle type and orifice diameter, the nozzle library included custom-built single-orifice nozzles with VCO and minisac geometries. All nozzles were tested at injection pressures ranging from 60 to 140 MPa. A spectral peak was found around 7 kHz for all nozzles and every injection pressure. Further evidence of a similar frequency was obtained from the pressure sensor and injector needle lift sensor. This frequency is proposed to be caused by the injector's needle oscillation in the axial direction. Oscillations between 35 and 45 kHz where observed during the needle opening phase. For the 200 µm nozzle orifices, these oscillations were found to progressively extend into the steady state injection period as the injection pressure was increased. This was suggested to indicate the presence of quasi cyclic cavitation.

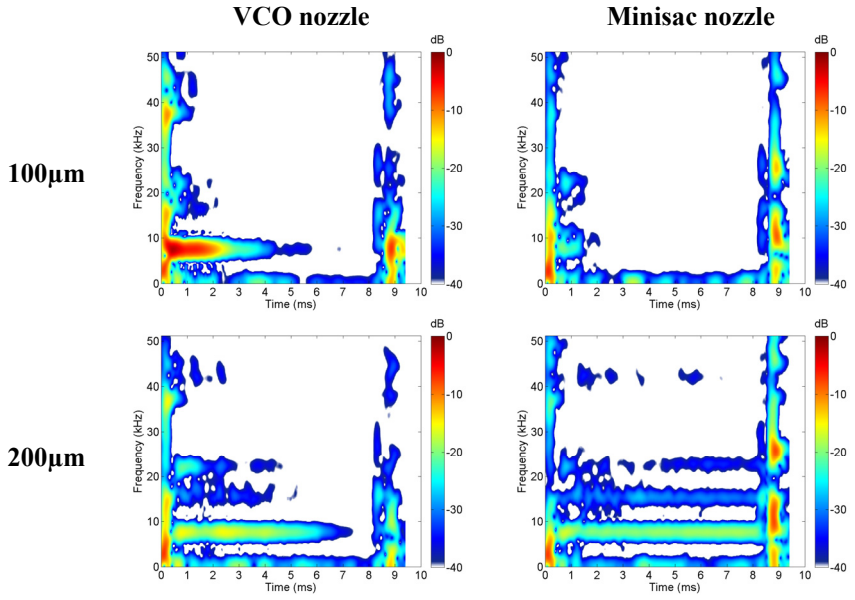

Figure 1. Spectrograms for single-hole VCO and minisac nozzles, with orifice diameters of 100 µm (top row) and 200 µm (bottom row) recorded for injections with 140 MPa pressure

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