Spray analysis of an internal steam-assisted atomizer for multiple geometries of the fuel injector, mixing chamber and nozzle

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Abstract

Steam-assisted atomizers are widely used in thermal power plants fed by heavy fuel. In the present study, a generic internal steam-assisted atomizer formed by an assembly of three different pieces, a central nozzle for liquid fuel injection, a mixing chamber for steam addition and a nozzle for spray injection has been designed. The fuel and steam supplies feed the mixing chamber through a central fuel injector intersected by four radial steam jets distributed around the mixing chamber. This two-phase fluid mixture leaves the mixing chamber through five small injection holes regularly distributed around the atomizer nozzle with an angle of 52.5° with respect to the atomizer axis. The system was developed to conduct parametric analyses of the resulting spray structure for different geometrical configurations of the atomizer, steam and fuel injection pressures. The analysis is conducted here for a central fuel injector with a hole diameter of 0.10 mm, a mixing chamber with steam hole diameters equal to 0.10 mm and a spray hole diameter of 0.25 mm. The atomizer is embedded in a regulated experimental setup with controlled mass flow rate, temperature and inlet gauge pressure for both steam and fuel flows. Steam is supplied with an evaporator that provides a maximum water mass flow rate of 2 g/min, evaporated by a 500 W thermal resistance. The steam flow is overheated at 453 K and can be delivered at a pressure up to 5 bar. A pressurized tank and a Coriolis mass flow rate controller are used to deliver a maximum fuel flow rate of 14 g/min at 13 bar. The whole test rig is kept at constant temperature. The gas to liquid mass flow rates ratio GLR is varied in these experiments between 0.02 to 0.15 as in typical industrial applications. The analysis is conducted here for a surrogate fuel with dodecane. Two different types of experiments are conducted to characterize the spray. The spray is first examined using back light emission with a CCD camera. A Particle Doppler Anemometer PDA is used to characterize the influence of GLR on the droplet size distribution in a selected number of geometrical cases at different axial positions downstream the nozzle exit. Measurements are compared to classical correlations found in the literature.

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