Topic: On Experimental Study to Evaluate Evaporation Rate of Liquid Fuel Sprays

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ABSTRACT

The evaporation of a fuel spray is one of the very important processes controlling the efficiency of liquid fuel droplet combustion in engines and furnaces. A number of evaporation models of droplets in spray have been developed. However, few measurement data to quantify the evaporation of droplets in spray exists. In this thesis, experimental studies on the evaporation of an individual droplet and of line monodisperse droplets of liquid fuels have been advanced. The liquids used in this study are ethanol and distilled water.

The evaporation constant and the temperature of the droplets during evaporation are the pertinent parameters to be experimentally determined. For a single-suspended droplet of millimeter size, the imaging and the Airy –based rainbow techniques have been used to measure the time evolution of the size and the refractive index, from which the evaporation constant and the temperature of the droplets can be inferred. For the line droplets measurement, a new technique called one-dimensional rainbow technique (ORT), which is a modification of the classical global rainbow technique (GRT), is used. The ORT enables us to measure the changes of size of droplets along the line due to the evaporation at nanometric scale. The measurement data is then used to determine the evaporation constant of the droplets.

For the case of suspended water droplets, the evaporation constant and temperature obtained from the measurements are found to be dependent on the relative humidity and the temperature of the surrounding air, but independent of the size of the droplets. In this case, numerical simulation shows that the evaporation constant obtained from the measurement agrees very well with the D^2-model. The measured temperature of the droplet does not change during evaporation and being equal to the adiabatic saturation temperature of the surrounding moist air. For the ethanol, experiments under constant environmental temperature show that the regression of the D^2 with time is linear allowing one to determine the evaporation constant, being the slope of the regression line. The refractive index obtained from the rainbow measurement has the same behavior (but not the same value) as that of water, confirming that state properties of the evaporating process depend on the temperature and pressure of the ambient air.

The line droplets of ethanol are generated from an ultrasonic nozzle having initial diameter of 100-120 µm and being left to evaporate at the room temperature of 20^{o}C. The rainbow angles measured from the drops at different levels do not change, implying that all droplets along the line evaporate at a constant temperature. Over the 8 mm-line measurement length, the ethanol droplet diameter changes by 0.008 µm. With an approximated absolute drop diameter and the calculated droplet velocity, the plot of diameter squared versus time is performed, which shows the good linear regression and correlates well with the D^2-law of evaporation. The slope of the regression lines represents the evaporation constants and is found to be 0.008483±0.000513 mm^2/s.

Keywords: evaporation, d^2 law, rainbow, spray, droplet array, ethanol