Effect of Droplet Initial Diameter on Droplet Vaporization Regimes for Kerosene Fuel Droplet

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An experimental study was conducted to investigate the effect of droplet initial diameter on droplet heat up period and steady state vaporization regime. Experiments were done with various sized isolated suspended kerosene fuel droplets under normal gravity at various ambient pressure and temperature conditions. The experimental results revealed that the droplet initial diameter has effect both on initial transient period as well as on the steady state vaporization period. The droplet heating time was found to be increased with an increase in droplet initial diameter at all ambient temperature and pressure conditions. The evaporation rate constant was also found to be increased with an increase in droplet initial diameter particularly at high ambient temperature and pressure conditions.

Nomenclature

\[ K_v = \text{evaporation rate constant (mm}^3\text{/s)} \]
\[ d = \text{droplet diameter (mm)} \]
\[ d_0 = \text{initial diameter of droplet (mm)} \]

I. Introduction

Vaporization of liquid fuel droplets at high pressure and high temperature environment is one of the basic mechanisms in spray combustion for various applications such as industrial furnaces, gas turbines, diesel engines and liquid propellant rocket engines. Study of the evaporation of a single droplet is necessary for characterizing the spray vaporization and combustion. The overall rate of evaporation depends on the pressure, temperature, and transport properties of the surrounding gas; the temperature, volatility, and diameter of the drops in the spray; and the velocity of the drops relative to that of the surrounding gas. Hence, qualitative as well as quantitative information on the physical processes governing liquid spray atomization, vaporization and combustion is necessary in the design of combustion chambers for optimum performance.

There are large amounts of works on study of single droplet evaporation of various liquid fuels. Evaporation behavior of single component fuel droplet has been studied under several ambient conditions, analytically and experimentally. Some important review papers present the state of the art in single droplet evaporation and combustion ¹⁴. The effects of temperature and pressure on the vaporization of single droplet under normal and microgravity have been investigated experimentally ¹⁵. In many applications droplets consist of a mixture of two or more pure liquids. The multicomponent droplet may consist of several species with completely different physical and chemical properties. The degree of volatility, boiling temperature, latent heat of vaporization and heat capacity of each component play important role in the interior thermofluid dynamic of the droplet. The evaporation characteristics of the multicomponent droplets have been studied ¹⁶, analytically and experimentally.

In practical combustors, droplets of different sizes coexist because of droplets collision, disruption, coalescence and fragmentation. The ratio of the largest droplet diameter to the smallest one is approximately one hundred ¹⁷. The droplets of various sizes may exhibit different evaporation characteristics including different transient heating

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