Experimental Study on Binary Droplet Evaporation at Elevated Pressure and Temperature

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The evaporation characteristics of single and multicomponent droplets hanging at the tip of a quartz fiber are studied experimentally at the different environmental conditions under normal gravity. Heptane and Hexadecane are selected as two fuels with different evaporation rates and boiling temperatures. At the first step, the evaporation of single component droplet of both fuels has been examined separately. At the next step the evaporation of a blend of 50 percent volume mixture of these two fuels, as a binary droplet, has been studied. The temperature and pressure range is selected between 400 and 700 °C, and 0.1 and 2.5 MPa, respectively. High temperature environment has been provided by a falling electrical furnace. The initial diameter of droplet was in range of 1.1 and 1.3 mm. The evaporation process was recorded by a high-speed CCD camera. The results of binary droplet evaporation show the three-staged evaporation. In the first stage the more volatile component evaporates. The droplet temperature rises after an almost non-evaporating period and in the third stage a quasi-linear evaporation takes place. The evaporation of the binary droplet at low pressure is accompanied with bubble formation and droplet fragmentation and leads to incomplete microexplosion. The bubble formation and droplet distortion does not appear at high environment pressure.

Nomenclature

\[ C_v \] = evaporation pressure rate
\[ d \] = droplet diameter
\[ d_0 \] = initial diameter of droplet

1. Introduction

VAPORIZATION of a liquid fuel droplet at high pressure and high temperature environments 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. The study of evaporation of a single droplet is necessary for characterizing and understanding the spray vaporization and combustion. In many applications droplets consist of a mixture of two or more pure liquids. The multi-component droplets may consist of several species with completely different physical and chemical properties. The degree of volatility, boiling temperature, evaporation latent heat, surface tension, and heat capacity of each component play an important role in the interior thermo-fluid dynamic of droplet. There are various complications that occur during vaporization of multicomponent liquid droplet. Different components vaporize at different rates, creating concentration gradients within droplet and causing mass diffusion. Also evaporation of component with relatively low boiling temperature produces vapor and forms vapor bubbles and causing temperature and concentration gradient inside of droplet. In some cases pressure build up in bubbles leads to complete or incomplete explosion of droplet.

The evaporation characteristics of multicomponent droplet have been studied, \(^1\) analytically and experimentally. Concentration and thermodynamic properties of species play very significant role in evaporation of binary or multicomponent droplets. The evaporation of the more volatile component, due to its lower boiling temperature,

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