# A RECTILINEAR DROPLET STREAM STUDY: DYNAMICAL AND THERMAL BEHAVIOR

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This paper proposes an experimental study on the dynamical and thermal behavior of a monodisperse ethanol droplet stream, injected in the different environment conditions : non reacting conditions, evaporating conditions and reacting conditions. A non intrusive measuring techniques are associated to measure the liquid and gas phase properties. The experimental results focused on the evolution of the drag coefficient and the evaporation rate between cold conditions and reactive conditions and for different droplet spacings.

### **Experimental Setup**

The present work deals with an experimental study of a monodisperse ethanol droplet stream injected upward from the injector. This system permits to control all the characteristics of the droplets : diameter, velocity and temperature. Moreover an electrostatic deflector has been designed to increase the droplet spacing up to 40 diameters.

## **Measuring Techniques**

Non intrusive techniques have been developed to measure simultaneously the droplet size, temperature and velocity. A laser beam is focused on the axis of the stream. An interference pattern is created in the forward direction and the first order rainbow appears in the backward direction. The distance between two maxima in the interference pattern gives the droplet size and the position of the rainbow depends on the droplet temperature. The droplet velocity is obtained by shadowgraphy and image processing.

The knowledge of the temperature fields around the droplets is also necessary to estimate the gas phase properties. A K-type thermocouple is used to measure the temperature in the thermal boundary layer in the case of droplet evaporation. For reacting condition, the Coherent anti-Stokes Raman Spectrometry (CARS) is applied to determine the temperature fields in the vicinity of the droplets for different droplet spacings.

#### **Drag Coefficient Under Non Reacting Conditions**

The stream was first studied under non reacting conditions. The droplets were injected at the ambient temperature. The classical expression of the drag coefficient for an isolated droplet determined by Clift did not take into account the interaction effects which have a great influence. Moreover the results of Mulholland and Zhu which integrate these effects do not agree with our experimental measurements. So we determined a new expression of the drag coefficient taking into account the interaction effects. This expression will improve the prediction of the droplet trajectories by CFD codes for non evaporating conditions.

#### **Evaporating Conditions**

The monodispersed droplet stream is injected in the natural convection thermal boundary layer of a vertical heated plate. The drag coefficient was studied under those conditions. The film conditions were applied to estimate the Reynolds and transfer number as suggested by Rensizbulut where the gas phase can be measured by K-type thermocouple. A new expression of the drag coefficient was also obtained for evaporating conditions in the case of the dense sprays. The droplet diameter evolution was also precisely studied to compare with the D<sup>2</sup> law of an isolated droplet. The interaction effects appear to influence strongly the vaporization of the droplet. So a correction factor  $\eta$  for the D<sup>2</sup> law, defined by Labowsky, has been established as a function of the droplet spacing :

$$\left(\frac{Dg}{Dgo}\right)^2 = 1 - \eta Kt$$

## **Reacting Conditions**

The stream was also ignited by an electrically heated coil and surrounded by a laminar diffusion flame. The drag coefficient was studied under those conditions. The reference conditions were used to estimate the Reynolds number as suggested by Yuen and Chen in the expression of the drag coefficient. The CARS measurements gave information about the gas phase temperature and in particularly the position of the flame for several droplet spacing. A new expression of the drag coefficient and a correction factor  $\eta$  for reacting conditions were obtained.