SPRAY COMBUSTION

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1. Introduction

In many applications, fuel is used in a liquid phase. Transportation and storage of a liquid fuel is much easier than a gaseous one. One can cite applications such as large boilers, Diesel engines, gas turbines or turbojets where fuels are hydrocarbons. The same situation occurs in rocket engines, but in that case it may be the oxidizer that is in the liquid phase : liquid oxygen and gaseous hydrogen for instance. Combustion of liquid sprays is a rather old subject, but still of interest due to the complexity of the physical phenomena concerned. It is still today a limitation for many modeling approaches. See for instance [1-3] for an extensive description.

The study of heterogeneous combustion comprises to main axis. The first one is the study of isolated droplet vaporization and combustion. Due to the simplicity of the geometry, isolated droplet is an interesting case. Many studies have been devoted to the case of isolated droplets either in spherical or cylindrical symmetry assumption. One can refer to [4, 5] for reviews on the subject. The case of hydrocarbons have been studied theoretically [6-8] and experimentally [9-12] . A complete review on the effect of a velocity difference between both phases may be found in [13] who defines different breakup modes as a function of Weber and Reynolds numbers. But these different studies are limited to isolated drops and limited drop interaction.

The second axis is the study of interacting droplets and sprays combustion. A smaller number of studies have been devoted to cases where the spray is dense and where droplets are strongly interacting. One can refer to [14] for a review or to [15-17] for approaches in simplified geometries such as counterflow flames. Other authors [18-21] have introduced and quantified the notion of group. In this approach, the spray combustion does not take place as isolated droplets, but as a reaction zone surrounding and interacting with a droplet cloud. In that case, it may be assumed that the role played by the two phase flow transport is weak, and that droplets only intervene in modifying the species transport. Several experimental studies [22-25] show that the phenomenon is more complex and that droplets are interacting with the flame structure, especially by the concentration fluctuations inducted by vaporization, and lead to flame shape different from purely gaseous flames. The experimental study of burning spray and interacting droplets is made more difficult by the necessity of complex optical diagnostic techniques. Modelisations have been proposed for this situation [26-28].

These two aspects (isolated drops behavior and spray combustion) are nevertheless complimentary because single droplet behavior is very useful for more complex systems understanding and is an unavoidable step in the modeling of sprays. The present notes are discussing both aspects.