DYNAMIC BEHAVIOR OF LIQUID SHEET WITH CO-FLOWING GAS

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Introduction:

The dynamic and breakup of liquid sheets and jets in a gaseous medium are of considerable technical importance in connection with atomization and combustion engineering, spray coating, fire fighting and curtain coating. In particular, the study on the disintegration of thin liquid sheet in a gas flow is very important to increase the knowledge for the improvement of the two-fluid atomizer and other related devices of engineering applications. There are many industrial processes where liquid spray is widely used in the system and an important factor for producing quality products. The purpose of liquid breakup in a spray is to increase the liquid surface area for efficient heat and mass transfer. The spatial distribution or dispersion of the droplets affects the mixing of the fuel with the oxidant, which influences combustion efficiency and the flame length. Though a number of investigators contributed their works on this subject, the underlying physics of liquid disintegration from jets and sheets is still unrevealed and the breakup mechanism has not been fully understood. Therefore, it demands more investigations on liquid breakup problem, particularly, on the breakup of a moving sheet, which is also of importance in many of the practical application mentioned above.

Objectives with Specific aims:

- ✓ To investigated the mechanism of capillary wave on the liquid sheet.
- ✓ To study the effect of co-flowing gas on the liquid sheet surface.
- ✓ To reveal the physics of liquid sheet breakup
- ✓ To study the effect of Gas Weber number on the dynamic behavior of the liquid sheet

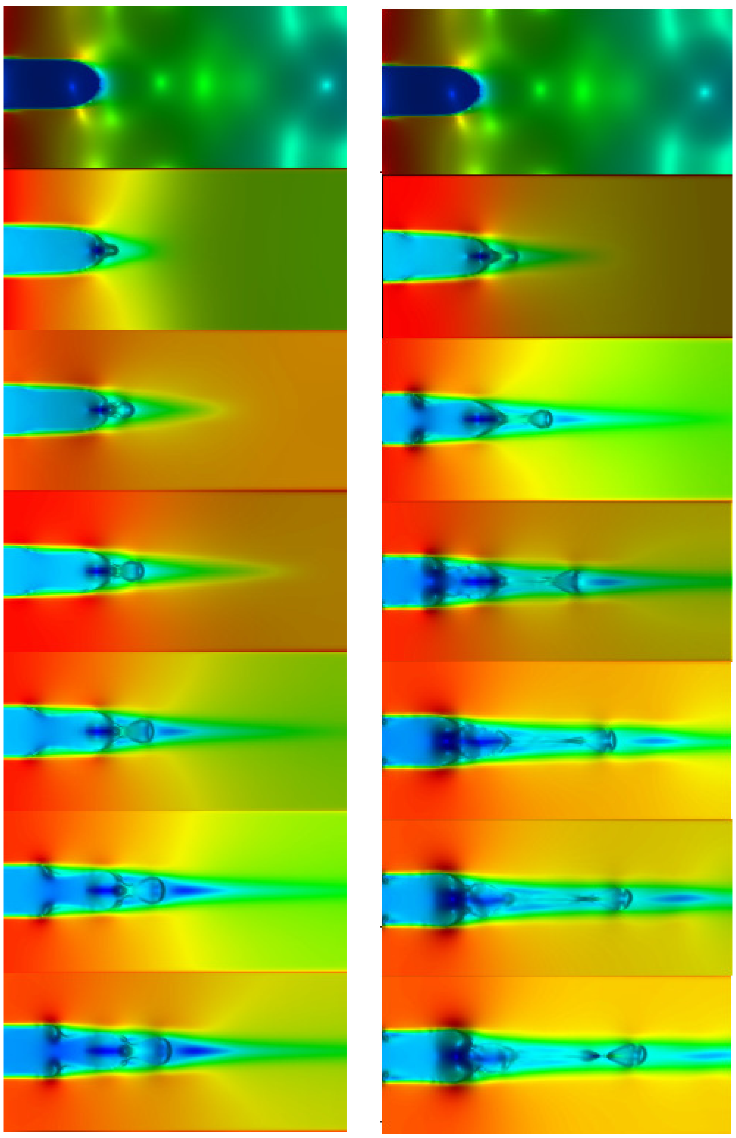
This investigation will give a good idea on the performance of liquid film coating technique and polymer processing.

Methodology:

A numerical analysis is performed on moving liquid sheet in a gaseous medium of much higher velocity compared with the liquid sheet to investigate the mechanism of capillary wave on the liquid sheet. The effect of co-flowing gas on the liquid sheet surface and the effect of Gas Weber number on the dynamical behavior of the liquid sheet will also be included in the analysis. For numerical simulation, volume of fluid (VOF) method based on a simplified treatment of the Navier-Stroke equation with a fixed, regular, uniform grid is used to solve the problem. Piecewise Linear Interface Calculation (PLIC) is implemented for the advection of the liquid interface. The treatment of surface tension consists of artificially smoothing the discontinuity present at the interface by Continuum Surface Force (CSF) manner. In the present work the surface tension force is estimated by a volume force which gives the correct surface tension. The volume force is calculated with the area integral over the portion of the interface lying within the small volume of integration. An experiment is performed on the breaking length of a liquid sheet to compare the simulation result with the data. The numerical model will then be used to investigate the characteristic of capillary waves and the detailed dynamics of breakup process for a moving sheet in a quiescent and viscous moving gas medium.

Effect of Gas Weber Number on Breakup of Liquid Sheet:

A two-dimensional numerical investigation is carried out with liquid of SF_6 and co-flowing gas of N_2. Through out the calculation, at the inlet boundary the uniform gas velocity is imposed on top and bottom of the liquid sheet and constant gas pressure is considered for all boundaries of calculation domain. For liquid sheet, at inlet boundary the constant pressure is used. To investigate the effect of Gas Weber number on the liquid sheet breakup mechanism the Weber number of gas is varied from 10 to 1000 by keeping constant liquid Weber number, W_{el} =1. The figure shows the breakup process for Gas Weber number of 10 and 19. It can be shown that the critical value of Gas Weber number is 14, i.e. below of this value no droplet or breakup of liquid sheet can occur. Therefore, the figure shows that for Gas Weber number of 19 breakup is occurring whereas for Gas Weber number of 10 only the shape of a drop is forming but no droplet is occurred. However, investigations are going on to reveal a complete understanding on liquid sheet breakup mechanism.



(a) (b)

Fig: Pressure contour for the Gas Weber Number: (a) 10 (b) 19.

Project is approved by the resolution of the CASR (Committee for Advanced Studies and Research) meeting no. 212 agendum no. 83 held on August 25, 2008.