Liquid Film Dynamic on the Spray Impingement Modelling

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Abstract

The dynamic of droplets impacting onto a dry or wet solid surface plays an important role in a wide variety of fields, such as in ink-jet printing technologies, spray painting and liquid-fuelled combustors. However, it has only been in the near decade that a major scientific effort has been pursued in order to acquire a comprehensive knowledge about the mechanisms underlying the spray impingement process. Yet, this complete physical understanding of the phenomena found during the spray/wall interaction is still lacking mainly due to the host of parameters that influence the outcome. One of those parameters, which curiously is often neglected in spray impingement models, is the liquid film accumulated on the wall due to the deposition of the impinging drops.

The present work aims at developing and integrating the liquid film formation in a multiphase computational model. This paper follows on from a set of previous studies [1-3] that seek to refine a flexible dispersion model in some aspects that would allow converging towards the best computational solution through the use of adapted and more suitable empirical correlations that fit specific configurations in order to preserve a close relation to the physical understanding of the phenomena involved in the spray impingement process with the presence of a crossflow. Therefore, the liquid film formation is developed by considering some basic principles (conservation of mass and volume between impinging and adhered parcels) but also an empirical correlation deduced from experimental data [4] for the average film thickness which allows a connection to the phenomenological experience that can easily be fitted to specific settings. This model is incorporated into the code originally proposed by Bai et al. [5] and the performance is recognized through the comparison between the numerical results – with and without the liquid film sub-model – and measurements for two crossflow rates. In addition, the integration of this newly developed computational extension with the spread/splash transition criterion used in this work is also evaluated by comparing the prediction results obtained using two different splashing thresholds: one that takes into account the effect of the film thickness on the disintegration criterion against another that does not.

Figure 1 illustrates the distribution of the relative liquid film thickness over half the impingement wall (a symmetry plane is considered at X=0). The injector is located 0.05m from the inlet with an inclination of 20º, in relation to the vertical plane, in the downstream sense. The figure shows that a thin liquid film forms along the surface but has a particular incidence in the region below the nozzle, which is where the maximum thickness is found. The reduction of the air flow velocity to 5 m/s leads to the thickening of the liquid film and the reduction of the number of the secondary droplets as also reported in the literature.

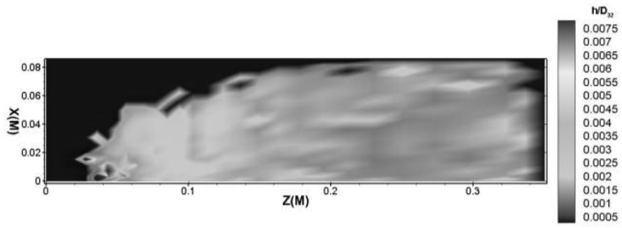

Figure 1: Distribution of the relative liquid film thickness over the impingement wall for a crossflow of 15 m/s.

The use of a transition criterion that does not take into account the effect of the liquid layer does not improve the simulation results. On the other hand, integrating the effect of the liquid film and the transition criterion that considers this effect on the splash threshold clearly enables the enhancement of the model performance.

References

[1]Silva, A., Barata, J., Rodrigues, C., "Influence of Spread/Splash Transition Criterion on the Spray Impingement Modelling", *ILASS-Europe 2011*, Estoril, Portugal, September, 2011.

[2]Rodrigues, C., Silva, A., and Barata, J., "Influence of the Energy Dissipation in the Spray Impingement Modeling", *50th AIAA Aerospace Sciences Meeting,* Nashville, Tennessee, January, 2012.

[3]Rodrigues, C., Barata, J., and Silva, A., "Dissipative Energy Loss and Influence of an Enhanced Near-Wall Treatment", *11th Int. Conference on Combustion and Energy Utilization*, pp. 1-16, 2012.

[4]Kalantari, D., and Tropea, C., "Spray impact onto flat and rigid walls: Empirical Characterization and Modelling", *International Journal of Multiphase Flow*, pp. 525-544 (2007).

[5]Bai, C.X., Rusche, H., and Gosman, A.D., "Modelling of Gasoline Spray Impingement", *Atomization and Sprays*, Vol. 12, No. 1-3, pp. 1-27 (2002).

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