World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:11, No:06, 2017

Heat Transfer and Trajectory Models for a Cloud of Spray over a Marine Vessel

Authors : S. R. Dehghani, G. F. Naterer, Y. S. Muzychka

Abstract : Wave-impact sea spray creates many droplets which form a spray cloud traveling over marine objects same as marine vessels and offshore structures. In cold climates such as Arctic reigns, sea spray icing, which is ice accretion on cold substrates, is strongly dependent on the wave-impact sea spray. The rate of cooling of droplets affects the process of icing that can yield to dry or wet ice accretion. Trajectories of droplets determine the potential places for ice accretion. Combining two models of trajectories and heat transfer for droplets can predict the risk of ice accretion reasonably. The majority of the cooling of droplets is because of droplet evaporations. In this study, a combined model using trajectory and heat transfer evaluate the situation of a cloud of spray from the generation to impingement. The model uses some known geometry and initial information from the previous case studies. The 3D model is solved numerically using a standard numerical scheme. Droplets are generated in various size ranges from 7 mm to 0.07 mm which is a suggested range for sea spray icing. The initial temperature of droplets is considered to be the sea water temperature. Wind velocities are assumed same as that of the field observations. Evaluations are conducted using some important heading angles and wind velocities. The characteristic of size-velocity dependence is used to establish a relation between initial sizes and velocities of droplets. Time intervals are chosen properly to maintain a stable and fast numerical solution. A statistical process is conducted to evaluate the probability of expected occurrences. The medium size droplets can reach the highest heights. Very small and very large droplets are limited to lower heights. Results show that higher initial velocities create the most expanded cloud of spray. Wind velocities affect the extent of the spray cloud. The rate of droplet cooling at the start of spray formation is higher than the rest of the process. This is because of higher relative velocities and also higher temperature differences. The amount of water delivery and overall temperature for some sample surfaces over a marine vessel are calculated. Comparing results and some field observations show that the model works accurately. This model is suggested as a primary model for ice accretion on marine vessels.

Keywords : evaporation, sea spray, marine icing, numerical solution, trajectory
Conference Title : ICFMHTT 2017 : International Conference on Fluid Mechanics, Heat Transfer and Thermodynamics
Conference Location : Toronto, Canada
Conference Dates : June 15-16, 2017