Abstract

Experiments on a laboratory scale louvered cylindrical funnel has been done to measure the air suction rate in to the funnel as a function of various input parameters such as; louver's opening area, diameter of funnel and protrusion length of the nozzle in to the funnel. Numerical simulations have also been done by solving the conservation equations of mass and momentum for the louvered funnel (exactly of the same size and shape as has been used in the experiment) with a surrounding computational domain so that suction can take place at the louver entry. The resulting equations have been solved numerically using finite volume technique in an unstructured grid employing eddy viscosity based two equation k-ε turbulence model of Fluent 6.3. It has been found from the experiment and the CFD computation that there exists an optimum funnel diameter for which the mass ingress into the funnel is highest and also there exists an optimum protrusion length of the nozzle which entrains maximum air flow into the funnel. For isothermal air suction the mass ingress in to the funnel does not depend on the inclination of the funnel

Then the above CFD methodology has been extended to a real funnel of naval or merchant ship (density is a function of temperature and the energy equation being solved) where the jet is a hot gas and there exists a density difference between the jet fluid and the atmospheric air. It has been found from the computation that there exists an optimum nozzle protrusion length in to the funnel and optimum funnel diameter (irrespective of the nozzle fluid temperature) for which the suction of air is found to be highest. It was found that an inverted frustum with a value of $r_1/r_2 = 0.8$ could suck the maximum amount of air compared to a cylindrical funnel of same volume. The cylindrical sucking funnel has interestingly a much shorter entrance length compared to a simple pipe flow with uniform flow at the entrance having the same Re number. It was found that for $Gr/Re^2 \leq 0.4$ the funnel inclination had no effect on the rate of mass suction. As the value of Gr/Re^2 increased beyond 1 the influence of funnel inclination on rate of mass suction was found to be significant.

A general correlation was developed to predict the entrance length for a sucking pipe as a function of different input parameters. Also general correlations could be developed to predict the mass suction rate in to the funnel and the temperature of the plume at the exit of the funnel as a function of different pertinent input parameters which are of significant importance to the shipping industry.

Key Words: Funnel, Louvers, jet suction, ejecting nozzle, entrance length, ship