Two-dimensional impinging jets of ideal fluid issuing from an asymmetric nozzle

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ABSTRACT

Two-dimensional impinging jets of ideal fluid issuing from an asymmetric nozzle are considered. The jet issuing from the orifice of an asymmetric nozzle forms contact surfaces between the fluid and surrounding air. They are called free boundaries. The governing equation of the jet problem is harmonic but the fact that the geometries of free boundary are unknown a priori makes the problem highly non-linear. Using the boundary integral equation method and the sensitivity analysis, we develop an efficient iterative numerical method to solve the problem. In numerical results, the force exerted on the wall by the pressure and numerical calculations of diverse examples are shown.

MAIN ISSUE

The jet issuing from a symmetric nozzle impinges against the wall and then flows away along the wall in two ways. The jet issuing from the nozzle orifice yields a boundary between the air and the fluid. We call it the free boundary of jet. It is not known a priori because it should be a part of the solution.

Many researchers have studied about the free boundary problems. In 1868, Helmholtz and Kirchhoff have introduced the theory of free streamline and solved it by complex analysis. Birkhoff et al.(1957)[1], Gurevich(1965)[2] and Woods(1961)[3] solve this free boundary problem by using hodograph method. Dias et al(1987)[4] have developed method for two-dimensional ideal jets issuing from the polygonal containers by Schwarz-Christoffel techniques. Peng and Parker(1997)[5] obtain the solution of jet flowing against an arbitrary curved wall by using the complex-variable and transform techniques. Merzougui et al.(2007)[6] model the 2D channel flow against the inclined wall by considering surface tension effect.

Using the layer potentials, we formulate the problem in terms of the boundary integral equations. And we derive the variational integral equations through perturbing the free boundary a little to obtain the solution of the jets problem. Using the derived integral equations, we propose an efficient algorithm to find the gradient toward the solutions from an assumed free boundary. Particularly, our algorithm can deal with the entire computational domain instead of truncated one by considering the far-field behavior of solutions. In numerical results, the force exerted on the wall by the excess pressure is investigated according to the impinging angle of the jet on the wall and the convergence of numerical solutions is shown. Fig. 1 shows the isobaric curves of excess pressure.

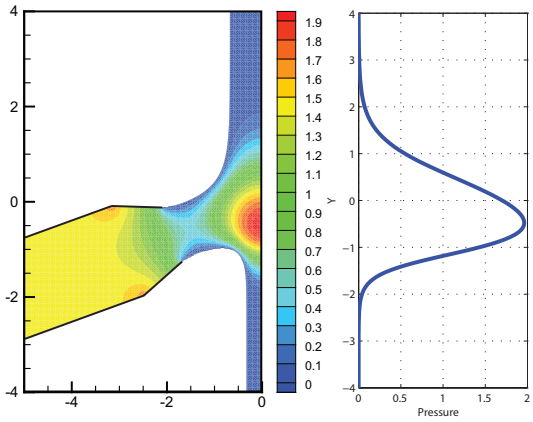

Figure 1. Isobaric plot of the excess pressure of the jet flow in case of the angled nozzle.

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