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Discussion

Dynamics of Vertical Annular Liquid Jets[1]

M. A. Hoffman.[2] Liquid jets and water bells of various geometries have been the subject of basic research for over a century. However, the use of modern computational techniques for calculating the behavior of these types of liquid jets is relatively new and will have importance in a wide range of applications from high-speed ink-jet printers to spray coating of materials.

The particular application which motivated this study was that of a possible future fusion reactor design. The concept may seem rather exotic to many people outside the field of fusion, but a short explanation may help the reader to appreciate the potential importance of these liquid jet concepts.

The energy release in the first generation fusion reactors utilizing the deuterium-tritium fusion reaction is made up of the kinetic energy of the fusion products, a 14.1 MeV neutron and a 3.5 MeV alpha particle. Consequently, 80% of the fusion energy is in the high energy neutron which must be slowed down by the materials in the reactor vessel which surrounds the fusion plasma. In the process of slowing down these neutrons and converting their kinetic energy to thermal energy through the mechanism of collisions with the solid materials of the reactor vessel, these materials would suffer severe neutron damage which would require that they be replaced every few years. This is a possible solution to the design problem, but perhaps not the best one.

Researchers at the Lawrence Livermore National Laboratory in the Inertial Fusion Systems Study Group and their contractors have vigorously pursued alternative approaches employing liquid "walls" surrounding the fusion plasma. The liquid walls made up of liquid jets of various configurations, including the annular jet which is the subject of this paper, would be "self-healing" and hence not subject to the severe neutron damage of solid materials. The search for the best liquid jet configuration to accommodate the many severe design constraints of a fusion reactor has led to a resurgence of interest in liquid jet research. It is to be hoped that the publication of this research will stimulate other fluid mechanics researchers to pursue basic research in this ancient but still vital field of liquid jets. The reader who wishes to pursue this subject further, may find the additional references listed below of interest.

Additional References

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Authors' Closure

The authors wish to thank Professor Hoffman for further illuminating the possible application of annular jets to inertial confinement fusion reactors. We share his hope that our research, together with the studies in the references he cites, will encourage further theoretical and experimental investigations in this area. From the analytical standpoint, we suggest that the next logical step is to implement a linearized stability theory in a numerical algorithm such as the ANNJET code. This would allow predictions of the dynamic response of annular jets to perturbations such as nozzle vibrations or turbulent fluctuations.

[1] By P. D. Esser and S. I. Abdel-Khalik, published in the March 1984 issue of the JOURNAL OF FLUIDS ENGINEERING, Vol. 106, No. 1, pp. 45–51.

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