ever, at large port-to-tank diameter ratios, the formation of vortex is hindered as observed for initial quiescent conditions in the liquid. This appears justifiable due to nearly pipe flow conditions at the entrance to the drain port at the large port diameter ratios.

Shaping of Discharge Ports

Shaped ports can be configured to give a gradual reduction in diameter from the tank to the outlet of the drain port. Such shaped ports can be either in the form of a stepped port with the diameter reduction in successive steps or as a bellmouth. The bellmouth can have a circular shape and has been considered by Binnie and Hookings.[4] Figure 3 shows these shaped ports and their performance. In view of the successive reduction in diameters, these shaped ports bring about a small reduction in diameter as the flow enters and progresses in the drain port. This yields locally large values of port diameter ratios. Based on the results of experiments with cylindrical ports, a drastic reduction in air-vortex heights is to be anticipated with their use.

The air-vortex heights measured with the stepped, bellmouth, and cylindrical drain ports of the same exit diameter are compared in Fig. 3. These heights are measured at different times after stopping the stirrer that induces forced rotation of the liquid. The time between stopping of the stirrer and starting the draining is called settling time. A larger settling time denotes a lower level of rotational velocities in the column of liquid since with increasing settling time the rotational currents get dissipated. For times exceeding 5 min the liquid column becomes fully quiescent. It is seen that, with the stepped configuration of drain port, the vortex height becomes zero at very small settling times. The stepped port is therefore very effective in arresting vortex formation even when rotational motion is present in the liquid column. The bellmouth port also reduces the height of the maximum air vortex; however, it is not as effective as the stepped drain port. The cylindrical drain port gives the largest height of air vortex that persists even when all rotational flow velocities in the liquid column are dissipated.

When large rotational velocities are present in the liquid column (small values of settling time in Fig. 3), the shaped ports do not totally suppress the formation of air vortex as under initial quiescent conditions. A combination of vortex-arresting baffles that dissipate the rotational motion in the liquid and the shaped drain ports discussed here can therefore completely eliminate the formation of air vortex during the draining of liquids from tanks.

References

[1]Dergarabedian, P., "The Behaviour of Vortex Motion in an Emptying Container," *Proceedings of the 1960 Heat Transfer and Fluid Mechanics Institute,* Stanford Univ., Stanford, CA, 1960, pp 47–61.

[2]Granger, R. A., "Speed of Surge in a Bathtub Vortex," *Journal of Fluid Mechanics,* Vol. 34, Dec. 1968, pp. 651–656.

[3]Dodge, F. T., "Dynamic Behaviour of Liquids in Moving Containers with Application to Space Vehicle Technology," NASA SP-106, 1966.

[4]Binnie, A. M., and Hookings, G. A., "Laboratory Experiments on Whirlpools," *Proceedings of Royal Society of London, Series A, Mathematical and Physical Sciences,* Vol. 194, Sept. 1948, pp. 398–415.

Errata

Low Earth Orbit Simulation and Materials Characterization

R. A. Synowicki, Jeffrey S. Hale, and John A. Woollam
University of Nebraska at Lincoln, Lincoln, Nebraska 68588

[JSR Vol. 30, No. 1, pp. 116–119 (1993)]

In the original publication, two errors were inadvertently introduced in the title and author lines. They appear correctly above.

JOURNAL OF SPACECRAFT AND ROCKETS
Vol. 30, No. 6, November–December 1993

1993 *Journal of Spacecraft and Rockets* Index

How to Use the Index

In the Subject Index, pages 790–794, each technical paper is listed under a maximum of three appropriate headings. Note the number in boldface type following each paper title, and use that number to locate the paper in the Chronological Index. The Author Index, page 795, lists all authors associated with a given technical paper. The locating numbers are identical to those in the Subject Index.The Chronological Index, pages 796–799, lists all papers by their unique code numbers. This listing contains titles, authors and their affiliations, and volume, issue number, and page where the paper appeared. It also gives the AIAA paper number, if any, on which the article was based, as well as the "CP" or conference volume number if the paper was published in a bound collection of meetings papers. Comments, Replies, and Errata are listed directly beneath the paper to which they refer. If the paper to which they refer was published prior to 1993, that paper also will appear in both the Subject and Chronological Indexes. Authors of Comments also are listed in the Author Index.