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THE UNIVERSITY OF MICHIGAN

College of Engineering

Department of Nuclear Engineering

Laboratory for Fluid Flow and Heat Transport Phenomena

Report No. 08466-PR-2

Progress Report
on
Asymmetrical Bubble Collapse Studies

Robert Cheesewright

Frederick G. Hammitt

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PROGRESS REPORT

1. ARO-D PROPOSAL NUMBER: 6310 - Eng

2. PERIOD COVERED BY REPORT: 4/1/67 to 9/30/67

3. TITLE OF PROPOSAL: Asymmetric Bubble Collapse Studies

4. CONTRACT OR GRANT NUMBER: DAH 67 c 0007

5. NAME OF INSTITUTION: University of Michigan

6. AUTHOR(S) OF REPORT: Robert Cheesewright & Frederick G. Hammitt

7. LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED UNDER ARO-D SPONSORSHIP DURING THIS PERIOD, INCLUDING JOURNAL REFERENCES:

   References 2 and 3 on the attached sheet. Reference 2 has also been submitted to the Accoustical Society of America for publication.

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD:

   1. F. G. Hammitt, Principal Investigator
   2. James F. Lafferty, Visiting Associate Professor of Mechanical Engineering, University of Kentucky
   3. Robert Cheesewright, Visiting Assistant Professor (University of London, England)
   4. Charles L. Kling Doctoral Candidate
   5. Terry M. Mitchell " "
   6. Osman S. M. Ahmed " "

   No degrees were awarded during this period as a result of work under this contract

BRIEF OUTLINE OF RESEARCH FINDINGS

This project involves experimental and theoretical studies of the collapse of cavitation bubbles under the influence of various asymmetries such as the presence of a large pressure gradient or the proximity of a solid wall. The work described in the first progress report (1) has been continued and extended to include high speed photography of the asymmetric collapse of ultrasonically-induced cavitation bubbles (2). Although this work, which was also partially supported by NSF grant no. GK 730, has made use of an existing camera having a limited framing rate (26,000 frames/s), it has served to demonstrate two important features of the collapse phenomenon. Firstly, the collapse time of bubbles collapsing in an asymmetric mode (toroidal) is significantly greater than that for the symmetrical Rayleigh type of collapse. Secondly, in a bubble field containing a number of bubbles, considerable asymmetry is introduced by the effect of the collapse of one bubble on adjacent bubbles.

The spark camera referred to in (1) has been assembled and tested satisfactorily (3). Its full performance cannot, however, be utilized until a new two-dimensional venturi having optically flat sides is available. Construction of this venturi is in hand.

The theoretical aspects of this investigation have proceeded with the development of computer codes for the numerical solution of the collapse problem using the MAC (Marker and Cell) technique. A comprehensive test of this technique on the classical spherical collapse problem (Rayleigh Collapse), to which the analytical solution is well known, has revealed a number of important results (3). The most significant of these is concerned with the possibility of obtaining significant reductions in computer time and storage requirements by the careful positioning of a few marker particles in the input specification of the problem, as compared to the uniform distribution normally adopted. Work is currently underway on the application of the code to the asymmetric problem.

The subsidiary investigation dealing with the correlation between the pulse height spectrum as seen by a high response-rate pressure transducer in a cavitating venturi and the observed pitting on a test specimen, has been extended to include also a correlation with the size and density spectrum of nuclei present in the water tunnel upstream of the cavitating venturi. The significance of this extension of the work lies in its connection with the introduction of asymmetry into the collapse of one bubble due to the proximity of other bubbles.

References

1. Frederick G. Hammitt and J. F. Lafferty, "Asymmetric Bubble Collapse Studies", University of Michigan Progress Report 08466-PR-1, April, 1967.

2. H. G. Olson and F. G. Hammitt, "High Speed Photographic Studies of Ultrasonically-Induced Cavitation", University of Michigan Technical Report 08466-1-T, July, 1967 (also listed as 07738-6-T because of joint sponsorship by NSF and ARO-D).

3. T. M. Mitchell, C. L. Kling, R. Cheesewright and F. G. Hammitt, "Numerical and Photographic Studies of Asymmetric Bubble Collapse", University of Michigan Technical Report 08466-2-T, July, 1967(also listed as 07738-5-T because of joint sponsorship by NSF and ARO-D).