Report on Euromechanics 265

Transient Effects in Cavitation and High Speed Liquid Impact
Robinson College, Cambridge
3rd-5th September 1990

Scientific Developments

The main emphasis of the meeting was on the fluid mechanical aspects of cavitation and jetting and the interaction of jets with material boundaries. The time scales involved in the early stages of liquid impact and in shock-induced cavity collapse require compressibility effects to be considered. Problems such as the impact of surface gravity waves against structures and ship slamming require the treatment of transient phenomena on the scale of surface wave propagation times. In addition to these basic scientific studies of fluid phenomena connections with important application areas, such as biomedical effects of cavity collapse, medical instrument design, and erosive effects in turbines and pipes, were discussed.

The role of compressibility in liquid impact and cavity collapse was looked at from several points of view. John Field and his group presented a large number of high-speed photographic sequencies, taken at micro-second framing intervals, of liquid impact and cavity collapse. Specific cavity collapse and impact configurations were created by the use of a gel technique, allowing the detailed study of critical aspects of the flow, such as shock escape in impact and jet formation in cavity collapse. The group also reported on a new device for the study of controlled multiple liquid impacts. A.A. Korobkin gave a mathematically rigorous discussion of the liquid impact problem in the acoustic limit. This work extended an earlier solution, due to Rochester, to and through the point of shock escape to the free surface jet formation. Finnström showed that Geometrical Shock Dynamics could be used to obtain a quasi-analytic solution of the gas motion in a cavity during the first stages of shock induced collapse. Lesser treated the collapse process using a one-dimensional model that could be completely solved to determine such parameters as collapse time and maximum cavity temperature. These results were seen to agree well with the experimental work on shock-induced collapse carried out by Bourne and Field. Enflo showed how the viscous structure of waves in liquids could be treated by the Burger's equation; in particular he considered cylindrical N waves, a configuration that has application in Lithotripter devices which were discussed in the presentations on applications. Lush reported on some extensions of his previous work involving liquid impact against a plastically deforming target.

As there are many problems in modeling boundary conditions and tensile stress effects in liquids undergoing rapid mechanical changes, a discussion was held on the properties of the liquid state. A chronology of developments in the area of the physics of the liquid state from the time of Laplace to the development of computer based molecular dynamics calculations in 1957 was given by Professor H.N.V. Temperley. Two highlights of the session, where Mørch's proposal of double electrical layer formation on curved surfaces as a source of cavity inception in fluids. Another was the demonstration of free radical formation by the study of sonoluminesence in acoustic cavitation by Walton.

Several experimental and analytical attempts to study the collapse of rotating cavities were reported. In part, these were proposed as an attempt to produce a simple model of vortex cavitation. These were only partially successful, but were of some interest to the participants. Avellan and his group, using the impressive facilities of their cavitation laboratory at E P F Lausanne presented a detailed and interesting study of shock formation due to cavitation collapse. Their results included both photographic evidence and flow data.

A number of important results involving the treatment of transients in incompressible fluids were reported. Peregrine and Cooker showed computer results that displayed how free surface waves approaching a breaker could produce large upward moving jets. Similar kinds of jetting were seen in a number of cavity collapse situations treated numerically by

Blake. It was generally agreed that full understanding of the mechanism behind the formation of these thin jets requires some additional work. Ockendon and his co-workers reported on a useful matched asymptotic solution for the entry of a body into liquid. This work, done as part of the PhD thesis of Wilson may have significant extensions that allow the solution of a number of otherwise intractable liquid entry problems. It was also shown by Greenhow that the problem of removing a body from liquid was quite different from the entry problem.

The discussion of a number of applications gave an opportunity to connect the theoretical and experimental work to specific technological problems. It was shown that much of the erosion studies from jet impact could explain damage side effects from lithotripters used for kidney stone removal. Leighton demonstrated how sonoluminesence showed when and where potentially dangerous free radicals could be produced.

The meeting closed with a panel discussion. The interchange was lively, focussing on interesting extensions of the jet impact problem and the somewhat mysterious ways in which thin jets form on free surfaces and in cavity collapse.

Conference Arrangements

The Colloquium was attended by 47 participants from fourteen countries. This included delegates from both Japan and China. The European countries included Denmark, Eire, France, Germany, Spain, Sweden, Switzerland, all parts of the United Kingdom, and the USSR.

Robinson College provided an excellent location for the conference. The new Umney Theatre at the college, which holds up to 120 people, provided an attractive and friendly atmosphere. The cost to delegates, including all fees and meals and lodging for four nights, was under £300. A conference reception was sponsored by Hadland Photonics Ltd. This company produce high speed cameras which find considerable use in the subject area of the conference. There was also a poster and equipment display. A visit was made to the Cavendish Laboratory to see relevant research on impact, cavitation, erosion and acoustics.

The general reaction to the conference by participants was very favourable, as indicated by a number of requests for a future meeting. It was also clear that a considerable number of collaborations will develop as a result of the meeting.

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Chairman Euromech 265

Professor Martin Lesser
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JEF/JGM/101290

December 10 1990

Professor Bengt Lundberg
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JEF/JGM/101290
10 December 1990

Dear Bengt

Thank you for your letter. The "Meeting Record" is enclosed. Further copies can be obtained from me.

The numbers - countries analysis is not all that simple.

41 are listed as delegates. There were 6 accompanying people giving a total Conference attendance of 47.

The 41 delegates come from **laboratories** in 10 countries. (1, Denmark; 24 England; 2 France; 3 Germany; 1 Japan; 1 Spain; 5 Sweden; 2 Switzerland; 1 USSR, 1 Wales).

However, on the basis of **nationality** the England number contains 1 Australian, 1 Chinese, 1 Eire; the Swedish number 1 American, 1 Chinese and possibly 1 Greek; the Switzerland number 1 Moroccan.

This would swell the number of countries to 16. I put 14 in my report as a compromise.

Regards.

Yours sincerely,

John Field