THE UNIVERSITY OF MICHIGAN

College of Engineering

Department of Mechanical Engineering

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Report No. UMICH 03371-13-I

LIQUID IMPACT BEHAVIOR OF VARIOUS ELASTOMERIC MATERIALS

(Summary for ASTM Symposium, June, 1973)

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Liquid droplet impact at high velocities upon materials is of importance in several applications, i.e., low pressure stages of large steam (or other vapor) turbines where moisture droplets form and impact rotating blading; high-speed military and civil aircraft where rain erosion of components such as radome surfaces is an important problem; cavitation damage where the damage mechanism appears to include a major contribution from microjet impact induced by asymmetrical influences such as an adjacent wall, pressure and/or velocity gradients, etc. In recent years much theoretical and experimental work has been done upon liquid droplet and/or jet impingement upon material surfaces, including some from this laboratory. However, most of this work, involving the details of the collision process, has been concentrated upon impacts upon rigid surfaces, rather than upon surfaces for which substantial deformation takes place during the impact, thus importantly influencing the collision process itself. The present paper reports upon photographic and theoretical studies of the impact process upon elastomeric materials.

High-speed motion picture sequences taken at 0.66 million frames per second of short liquid jets of 1.2 mm diameter and velocity of 500 MPH (223 m/s) upon 14 elastomeric materials* and plexiglass will be presented in the paper. The water slugs result from our automatic water gun device (1), and resemble closely those produced by the type of momentum change device pioneered by Brunton (2, e.g.). Since the jets have an approximately hemispherical

*Supplied by B. F. Goodrich Company

leading edge, the resultant flow and pressure upon the target during the initial part of the impact is very similar to that obtained from a spherical drop of the same diameter. Previous theoretical work (2, e.g.), including our own recent numerical studies (3,4,5, e.g.) show that this is the case, and also that only the very initial part of the impact is likely to be important to the damage process.

The high-speed photographs indicate the large differences in splash patterns resulting from the different materials. These can be correlated with the erosion resistance of the same materials as measured with the same automated water gun device. These results will be included in the paper. In addition, quantitative data on the axial and radial velocities resulting from the impacts upon the various materials will be presented and correlated with the observed type of splash pattern. It is hoped that this information may help to understand the relation between mechanical properties of the materials and erosion resistance, and may perhaps allow the eventual prediction of erosion resistance from splash patterns which can be observed fairly easily with suitable photographic equipment.

To further assist the understanding of the detailed mechanism of damage upon droplet or jet impact upon elastomeric materials, we have performed numerical calculations showing surface deformation for such materials as well as velocities and pressures along the surface (5) during impact with spherical droplets. These preliminary results using a some what restricted mathematical model, will be included in the paper.

Since it is generally agreed today that cavitation damage includes a strong contribution from liquid microjet impact, but that detailed differences certainly exist between jet impact per se and cavitation damage mechanisms, including that of scale, it is useful to compare the cavitation and jet impact damage resistance of a group of materials. This has been done for the present material group, using a relatively standard vibratory cavitation test to be compared with the water gun tests, and also with tests from the Goodrich propellor arm facility. The detailed results will be presented in the paper, but for this particular group of materials it was found that often an almost inverse relationship exists between liquid impact and cavitation damage resistance.

Finally the paper will present a correlation of both impact and cavitation damage resistance with the mechanical properties of Shore hardness and tensile strength. Shore hardness was found to be reasonably successful in this respect, particularly for cavitation resistance.

Acknowledgments

Financial support for this work was provided primarily by the B. F. Goodrich Company. Special thanks are due to Mr. Michael Hall who provided the broad technical direction for the work from the side of B. F. Goodrich. In addition, financial support for the numerical impact studies was derived from NSF Grant GK 730.

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