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CLOSURE to discussion by K.S. Janaki Ram, S.R. Sasikanth, and  
B.C. Syamala Rao of "Interrupted Jet Water Gun Impact-Erosion  
Studies on Metallic Alloys," 1974 ASME Polyphase Flow Forum, by  
F.G. Hammitt, J.B. Hwang, Linh N. Do

by

F.G. Hammitt

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CLOSURE to Discussion by K. S. Janaki Ram, S.R. Sasikanth, and B. C. Syamala Rao of "Interrupted Jet Water Gun Impact-Erosion Studies on Metallic Alloys", 1974 ASME Polyphase Flow Forum, by F. G. Hammitt, J. B. Hwang, and Linh N. Do (01357-22-I)

The authors would like to thank the discussors for their comments, which certainly add to the understanding and value of our paper. In general we feel that their comments are very well taken. We will now attempt to reply to the various points which they raise.

We agree that air entrainment in the jet may influence the results obtained to some extent. However, we believe that there are other factors, probably more important, which cause the jet shape to change with velocity. The mechanism of jet formation in this automated water-gun device is certainly very complex, and it is no doubt not "linear" over the range of operation, in that application of additional kinetic energy to the striking hammer through additional compression of the driving spring (the method by which the liquid jet velocity is increased) does not necessarily produce a proportionate increase in the kinetic energy of the striking portion of the jet, since complex shock wave interaction effects in the liquid reservoir from which the jet is produced are involved. We have made no attempt to study this non-steady complex flow phenomenon in detail, so we really cannot at this time pinpoint the causes of changes in jet shape with velocity.

We agree that a correction to the effective impact area should be made for non-perpendicular impacts, to further explain reduction of damage for oblique impacts.

We are not familiar with the paper by Homma and Sakamoto on air entrainment effects in reducing the area of the mostly liquid portion of a free jet, but certainly this effect may be involved in the results here obtained.

The curve in Fig. 3 for nickel at 600 m/s does not indicate damage at zero impacts, as suggested by the discussors. The abscissa is in units of  $10^3$  impacts, and the curve is carried down to only about 500 impacts, where some damage was measured. The results cannot evidently be safely extrapolated to still lower numbers of impacts than those tested. The fact that impact at 600 m/s produces less damage in this particular device with this material than that at 400 m/s can only be ascribed in our opinion to the aforementioned change of jet shape with velocity.

We agree that additional experimental data would be desirable to support the conclusions indicated by Fig. 4, but unfortunately financial and time limitations prevented the attainment of this admittedly desirable goal.

Discussion on the paper  
"Interrupted Jet Water Gun Impact-Erosion Studies  
On Metallic Alloys"

by F.G.Hammitt, J.B.Hwang and Linh N. Do.

by

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We would like to thank Prof.F.G.Hammitt for the courtesy of sending us a preprint of the above paper. There are a few points that we would like to discuss.

It is stated that the existence of a maximum in the damage vs. velocity curve is a result of the change in shape of the jet leading edge as velocity is varied. Is this trend due to the air entrainment in the liquid jet or are there any other factors?

Regarding the assumption made in considering the cross-sectional area of the liquid jet as the impact area it is felt that this will hold good only for a perpendicular ( $90^\circ$ ) impact. A correction may have to be applied for the area to be considered in case of inclined jets. The change in the area for the various angles of attack is obviously the reason for the decrease in the damage, as shown by the experiments.

For choosing the cross-sectional area of the liquid jet as the impact area for evaluating the mean depth of penetration, one of the reasons presented is that it is the area on the specimen actually subjected to maximum surface load. But due to air entrainment the area of the jet consisting of dense liquid may be much smaller than the area of the jet opening. This point has been experimentally investigated by Homma and Sakamoto<sup>1</sup>. Moreover, when the area of the damaged portion is

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1. M.Homma, and T.Sakamoto, 'Breaking up of a circular shaped stream of falling water,' Proc. IAHR, 8th Congress, Montreal, 24-29. Aug. 1959, pp. 2-D-1 to 2-D-14.

larger than the area of the jet, the deflected jet would be acting on a larger area than the jet. This deflected jet may shatter away some of the protrusions in the damaged area of the material, thus resulting in an increased area of surface load.

The reason for the damage in the case of nickel to be more at 400 m/s than at 600 m/s velocity may need some explanation. Moreover, the curve for 600 m/s in Fig.3 indicates some damage even at zero number of impacts. It is felt that the curve needs some modification.

It would have been better if more experimental data were collected (for various other velocities) to support the conclusions based on Fig.4, in view of the variability of damage for the same conditions of operations.