Selection and Analysis of Material Models in Copper Jet Penetration into Water

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INTRODUCTION

A reliable choose of material models is quite important to correctly conduct the numerical simulation of copper jet into water. In the present paper, we compared three copper models, i.e., Steinberg Guinan, Piecewise JC and Zerilli Armstrong models and two water EOS of Mie-Grüneisen (Shock) and Polynomial. With referencing the experimental results, the numerical simulations of copper jet into water were carried out and analysed by employing different material models in Euler algorithm of AUTODYN. It concluded that Zerilli Armstrong model was suitable for copper and Shock EOS was suitable for water.

The Choice of Material Model

This section introduces equation of state (EOS) and Strength model of materials required for numerical simulation. We needed to identify strength model of liner and EOS of water. So we found Shock and Polynomial EOS of materials and Steinberg Guinan model, Piecewise JC model and Zerilli Armstrong model of Strength model.

Numerical simulation and experiment

The experimental results of Shi et al[1] and numerical simulation are compared in order to determine the better EOS and strength model of materials. The copper adopts Piecewise JC model and Zerilli Armstrong model respectively, while water adopts Shock and Polynomial respectively. Other material models are same as selected by Shi et al[1]. The better model of copper is determined first, and then the better EOS of water is selected.

Selection of strength model for copper

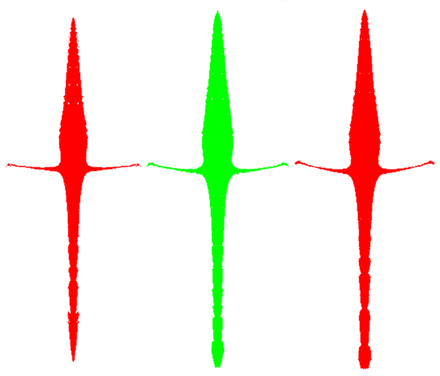

Fig.1 Different jet forms of three metal models at t=23μs (SG model, Piecewise JC model, ZA model)

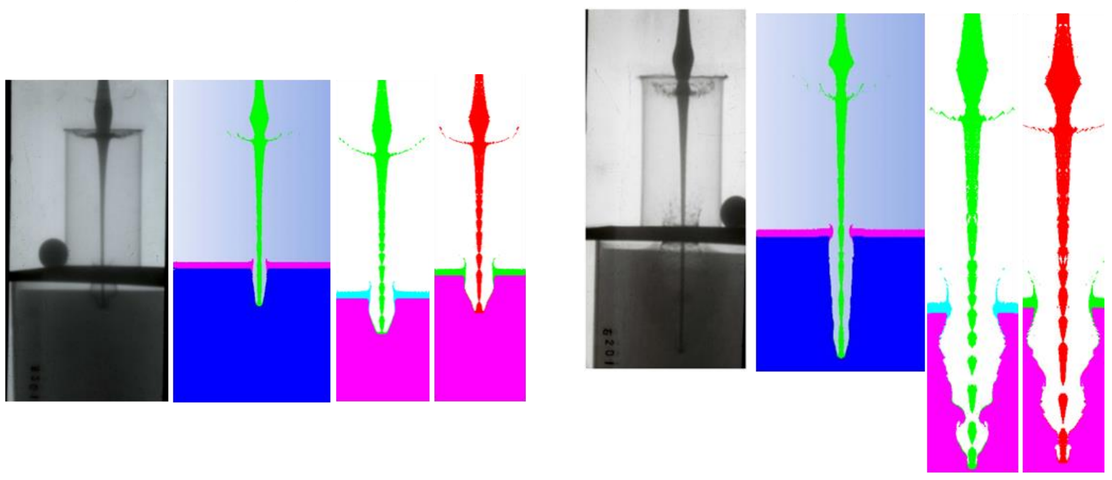

Fig.2 The comparison of experimental photos[1], results of SG model, Piecewise JC model and ZA model, respectively. (left t=31μs, right t=39μs)

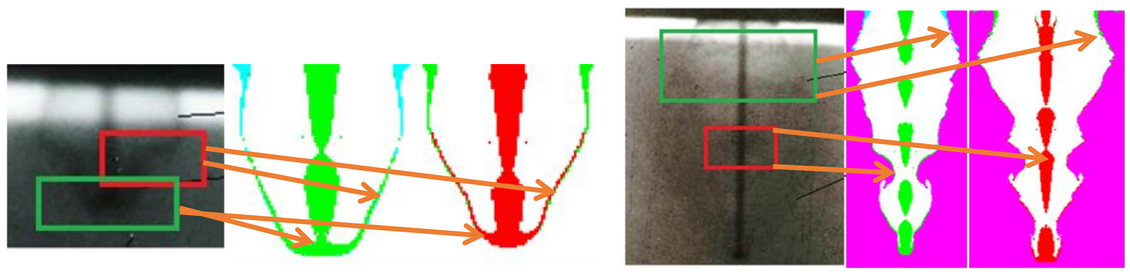

Fig.3 The comparison of zoom of jet in water[4], results of Piecewise JC model and ZA model.(left t=31μs, right t=39μs)

It can be seen that jet head formed by SG model (as shown in Fig. 1) is arrow cluster. The shape of jet head formed by Piecewise JC model is smoother than SG model, but still sharper than ZA model. The diameter of cavity formed by jet of SG model is too small compared with experimental pictures in Fig.2. Therefore, it can be concluded that SG model is not suitable for jet into water.

We can see more details by zooming in Fig.3. It can be seen that ZA model is much better than Piecewise JC model in reflecting experimental details from arrow in Fig.3.

It is stated that the EOS of water in Fig.1 to 3 adopts Shock EOS.

Selection of EOS for water

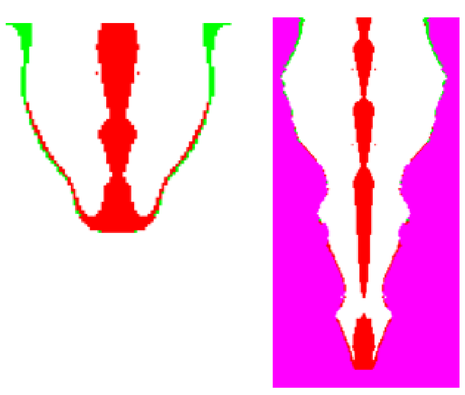

Fig.4 Result of Polynomial EOS. (t=31μs and 39μs)

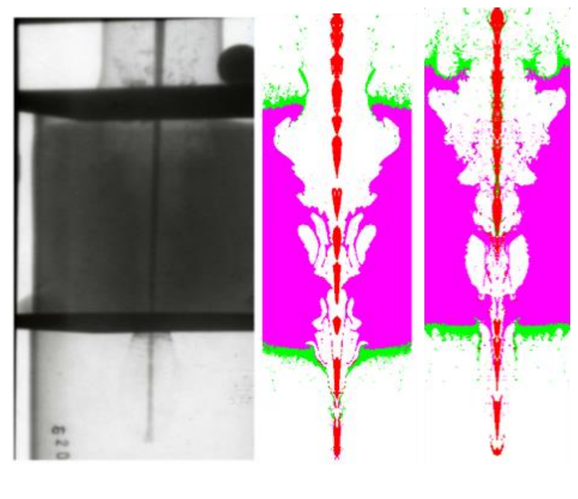

Fig.5 The comparison of jet cavity in water[4], results of Shock EOS and Polynomial EOS(t=54.1μs).

We can observe that Shock EOS is better than Polynomial EOS from Fig. 4 and Fig. 5, especially the comparison between Fig. 5 and experimental photos.

CONCLUSIONS

The numerical simulation is carried out by AUTODYN and compared with experimental photos in this paper. It is determined that Zerilli Armstrong model is suitable for copper, and the same method is used to determine Shock EOS for water. The combination of two models makes numerical simulation fitting to experimental photos, especially gourd cavity. It establishes a foundation for future study of the influence of compressibility of water.

PARTIAL REFERENCES

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