OPTIMIZATION OF JOHNSON–COOK MATERIAL MODEL CONSTANTS FOR OFHC COPPER

R.O. CHEREPANOV[1], S.A. ZELEPUGIN[1,2], Y.L. ZOLOTAREV[2]

[1]Tomsk Scientific Center of the Siberian Branch of the Russian Academy of Sciences, Tomsk, Russia
[2]National Research Tomsk State University, Tomsk, Russia

Numerical modeling of the processes of dynamic and shock-wave interaction of deformable solids is an urgent problem. The adequacy and accuracy of numerical results for such problems is based on a material model that relates the yield strength to the accumulated plastic deformation, strain rate, and temperature. The most commonly used empirical model in engineering applications is the Johnson–Cook (JC) constitutive model. However, as the impact speed increases, the difficulties in selecting the constants of this model to ensure consistency between the numerical and experimental data increase.

In this work, a method has been developed for selecting the JC model constants using an optimization algorithm based on Nesterov's gradient-descent method [1, 2]. A solution quality functional is proposed, with the help of which one can quantify the degree of deviation of the calculation results from the experimental data and determine the optimal parameters of the JC model. Numerical calculations of the classical Taylor impact test (impact on a non-deformable target) for cylindrical OFHC copper samples were carried out. The obtained results of numerical simulation with optimized parameters of the JC model are in good agreement with the experimental data [3, 4] obtained by the authors of this work, as well as with experiments taken from the literature.

REFERENCES

[1] S. A. Zelepugin, R. O. Cherepanov, and N. V. Pakhnutova, "Optimization of Johnson–Cook constitutive model parameters using the Nesterov gradient-descent method," Materials, vol. 16, no. 15, p. 5452, 2023, doi: 10.3390/ma16155452.

[2] S. A. Zelepugin and R. O. Cherepanov, "Determination of Johnson–Cook constitutive model parameters by optimization method," Proceedings of the XII All Russian Scientific Conference on Current Issues of Continuum Mechanics and Celestial Mechanics. CICMCM 2023. Springer Proceedings in Physics, vol. 1067, pp 347–355, 2024, doi: 10.1007/978-981-97-1872-6_47.

[3] S. A. Zelepugin, N. V. Pakhnutova, O. A. Shkoda, and E. N. Boyangin, "Experimental study of the microhardness and microstructure of a copper specimen using the Taylor impact test," Metals, vol. 12, p. 2186, 2022, doi: 10.3390/met12122186.

[4] N. V. Pakhnutova, E. N. Boyangin, O. A. Shkoda, and S. A. Zelepugin, "Microhardness and dynamic yield strength of copper samples upon impact on a rigid wall," Advanced Engineering Research, vol. 22, no. 3, pp. 224–231, 2022, doi: 10.23947/2687-1653-2022-22-3-224-231.