S2-O-046201

STUDY OF PROCESSES OCCURRING IN POLYMERS TARGETS UNDER HIGH-ENERGY EXPOSURE *

O.G. OLKHOVSKAYA[1], *D.S. BOYKOV*[1], *V.A. GASILOV*[1], *E.D. KAZAKOV*[2], *S.I. TKACHENKO*[3], *A.R. SMIRNOVA*[2,3]

[1]*Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences, Moscow, Russia*
[2]*National Research Center "Kurchatov Institute", Moscow, Russia*
[3]*Moscow Institute of Physics and Technology, Moscow, Russia*

Polymers and composites are often used as construction materials for aircraft, space, terrestrial transport, and many other industrial applications due to their high strength characteristics and relatively low weight of structures. The impact of powerful energy flows on polymer samples, for example, in experiments with relativistic electron beams, is one of the effective methods for analyzing the resistance of polymer materials to extreme loads. Experimental studies of short high intensity action on polymers usually are accompanied by numerical simulations. Modern tools of modeling thermomechanical effects during pulse loading of polymer samples allow study the details of wave structures as well as zones of material failures.

We studied the impact of a powerful relativistic electron beam on polymer targets at energy density up to 600 J/cm^2. Experiments were carried out on high current electron accelerator "Kalmar" at beam current up to 45 kA and electron energy up to 300 keV. Laser shadow streak image was used to visualize the dynamics of the passage of shock waves in transparent materials [1] and to record the plasma dynamics in the diode gap of the generator [2].

Three-dimensional numerical simulation of gasdynamic phenomena in the diode gap and elastoplastic phenomena that depend on them in the target material was performed using MARPLE3D [3] multiphysics software package. Our report concerns with the new technique designed for end-to-end modeling including hydrodynamic of heating and evaporation of the target under the action of the electron beam; evaporation of the cathode material and interaction of plasma streams in the diode gap; nonlinear wave processes leading to internal fractures and spalling phenomena in the target material. We use wide-range equation of state (semi-empirical QEOS model) [4] for the description of the liquid and solid phases of matter at low temperatures.

Appropriate modeling of this complex multiphysics problem is based on high resolution numerical methods as well as on high performance computing. The implemented computer models are verified by experimental data. Comparison of simulation results with experimental data are used to test the used models of volumetric fractures and spallations in brittle solids and validate wide-range equations of state. The developed software can be used for numerical stress-strain analysis of various structural units loaded by strong pulsed forces and/or energy fluxes.

The calculations were performed using supercomputers K-60 and K-100 in KIAM RAS.

REFERENCES

[1] Demidov, B.A., Kazakov, E.D., Kalinin, Y.G. *et al.* Application of Laser Shadow Streak Image for Studying the Dynamics of Shock Waves in Transparent Materials. *Instrum Exp Tech* **63,** 370–374 (2020). https://doi.org/10.1134/S0020441220030094

[2] Kazakov, E.D., Kalinin, Y.G., Krutikov, D.I. *et al.* Methods of Laser Shadow Photography with Recording by Streak Camera to Study Plasma Dynamics in the Diode of a Relativistic Electron Beam Generator. *Plasma Phys. Rep.* **47,** 803–813 (2021). https://doi.org/10.1134/S1063780X21080067

[3] Gasilov, V.A., Grushin, A.S., Ermakov, A.S. *et al.* Simulation of the Destruction of Polymer Materials under the Action of Intense Energy Flows. *Math Models Comput Simul* **11,** 198–208 (2019). https://doi.org/10.1134/S2070048219020066

[4] https://www.keldysh.ru/cgi/thermos/navigation.pl?en,home.

* The work was supported by the grant of the Russian Science Foundation, RSF № 21-11-00362, https://rscf.ru/project/21-11-00362/.