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NEW PREDICTIVE MODELS FOR BALLISTIC LIMIT OF SPACECRAFT HONEYCOMB-CORE SANDWICH PANELS SUBJECTED TO HYPERVELOCITY IMPACT

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Parameters of the honeycomb core (such as cell size and foil thickness), as well as the material of the core, influence the ballistic performance of honeycomb-core sandwich panels in cases of hypervelocity impact (HVI) by orbital debris [1]. Two predictive models capable of accounting for this influence have been developed in this study: one utilized a conventional approach based on a dedicated ballistic limit equation, while the other employed an artificial neural network trained to predict the outcomes of HVI on HCSP. BLE fitting and ANN training were conducted using a database composed of 46 numerical experiments, performed with a validated numerical model and ten physical tests derived from the literature.

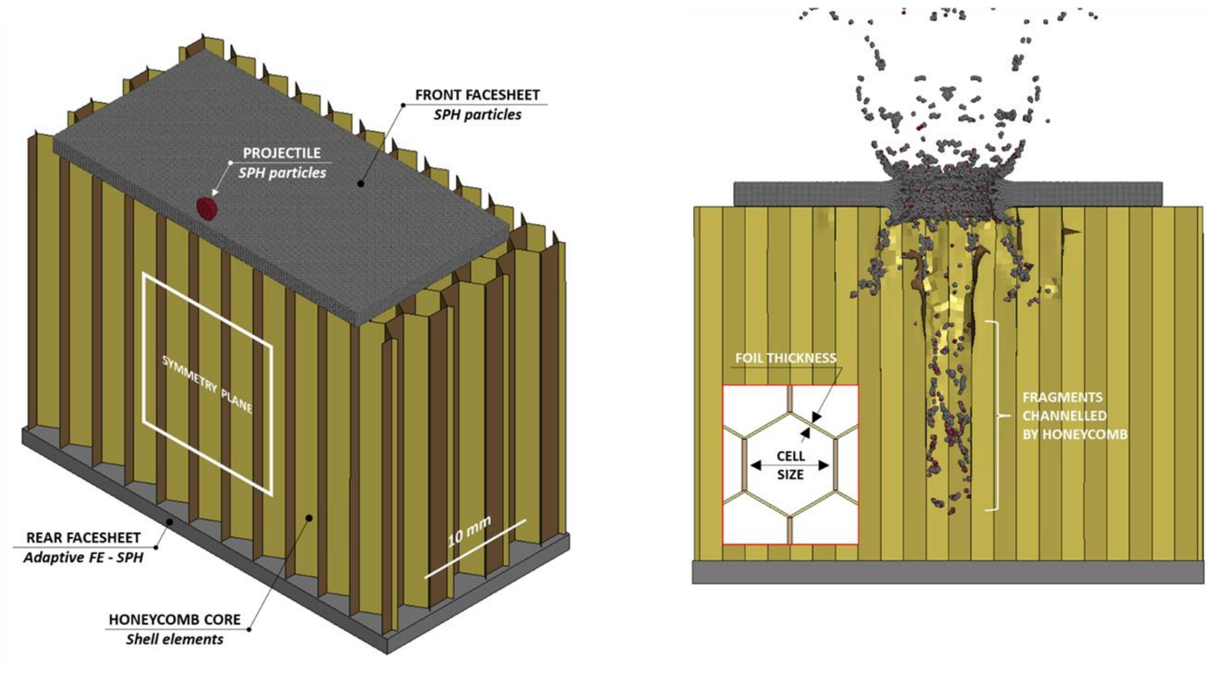

Figure – Simulation model used to fill the HVI database

The new ballistic limit equation is based on the Whipple shield BLE, in which the standoff distance between the facesheets was replaced by a function of the honeycomb cell size, foil thickness, and yield strength of the HC material. The corresponding fit factors were determined by minimizing the sum of squared errors between the BLE predictions and the results of HVI tests listed in the database. The BLE was then tested against a new set of simulation data and demonstrated an excellent predictive accuracy, with the discrepancy ranging from 1.13% to 5.58% only.

The artificial neural network was developed using MATLAB's Deep Learning Toolbox framework and was trained utilizing the same HCSP HVI database as was employed for the BLE fitting. A comprehensive parametric study was conducted to define the ANN architecture best suited for the problem being solved, including such parameters as the activation function, the number of hidden layers and the number of nodes per layer. As a result, the developed ANN utilized the Root Mean Square Propagation (RMSPROP) activation function and one hidden layer with three nodes. The ANN demonstrated a very good predictive accuracy, when tested against a set of simulation data not previously used in the training of the network, with the discrepancy ranging from 0.67% to 7.27%.

Both of the developed predictive models (the BLE and the ANN) are recommended for use in the design of orbital debris shielding for spacecraft, involving honeycomb-core sandwich panels.

REFERENCES

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