Modeling of Fabric Impact with High Speed Imaging and Nickel-Chromium Wires Validation

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Extended Abstract

Ballistic tests on single-yarn, single-layer and ten-layer targets were performed. The materials used were Kevlar® KM2 (600 and 850 denier), Dyneema® SK-65 and PBO® (500 denier). The objective of the tests was to serve as data for validation of numerical models so multiple diagnostic techniques were used during the tests: 1) ultra-high speed photography, 2) high-speed video and 3) nickel-chromium wire technique. These techniques allowed for thorough validation of the numerical models through five different paths. The first validation set was at the yarn level, where the transverse wave propagation obtained with analytical and numerical simulations was compared to the one obtained in the experiments. The second validation path was at the single-layer level: the propagation of the pyramid observed with the high speed camera was compared to the one in the numerical simulations. The third validation consisted in comparing, for the targets with ten layers, the pyramid apex and diagonal positions from tests and simulations. The fourth validation, which is probably the most relevant one, consisted on comparing the numerical and experimental ballistic limits. Finally for the fifth validation set nickel-chromium wires were used to record electronically the waves propagating in the fabrics. It is shown that for the three materials the waves recorded during the tests match well the waves predicted by the numerical model.

Figure 1: Images recorded with Imacon camera for a single layer impact on Dyneema. One image every 5 µs.

An example of how the validations were performed for single layer is shown in Figure 1 where the impact was recorded by an ultra-high speed camera. The position of the corner of the diagonal was tracked to produce Figure 2 and computations at the yarn level, see Figure 3, were used to compare and validate the models produced. Validations for all the three materials are

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Figure 2: Dyneema single layer results. Experimental results are shown as symbols for the warp direction (DV) and for the fill direction (DH). The lines are the simulation predictions.

Figure 3: Pyramid development for the .30 cal FSP impacting Dyneema fabric. The pyramid corner is being tracked manually to determine its position at different times: a) 5 µs, b) 15 µs, c) 25 µs, d) 35 µs.