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## A SHPB digital twin for the optimization of specimens dedicated to heterogeneous high strain rate tests

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**Abstract** — A finite element (FE) model of the ONERA Split Pressure Hopkinson Bars (SHPB) device is built. It is validated by comparing the experimental and numerical incident, reflected and transmitted force signals of a campaign featuring cylindrical specimens. The SHPB validated digital twin can thus now be used so as to explore specimen design and to find "optimal" geometries for the identification of viscoplastic behavior using optical measurements and inverse methods.

**Keywords** — Split Hopkinson Pressure Bar, Digital Twin, Specimen Optimization

**Introduction** Characterizing the behavior of materials at high strain rates is commonly accomplished using uniaxial tests. These tests, along with their setups, often stem from standards initially designed for quasi-static tests. They typically rely on a statically determinate approach, assuming specific conditions during experiments. Consequently, the analysis presupposes uniform strain and strain rate across the specimen's gauge length. Thus, for materials with rate-dependent behavior, conducting the test campaign becomes more demanding, as it requires a significant number of experiments to characterize the behavior across various strain and strain rate ranges.

Thanks to the progress in imaging technology, it is now feasible to measure kinematic fields at numerous points across a test specimen's surface at high frame rates. Based on these measurements, several inverse methods have been developed for the identification of material parameters from full-field measurements. Using these methods results in a paradigm shift, in which it is of prime importance to design specimens that will fulfil two somewhat conflicting objectives: generating heterogeneous strain/stress states and allowing robust optical measurements. The former leads to complex specimen geometries, while the latter tends to require simple ones [1].

**Methods** In this study, we adopt a digital twin approach, similar to the methodology outlined in [2], to investigate the influence of measurement biases on identification results relative to different configurations of specimen geometry. Our approach involves developing a finite element (FE) model of both the testing device and the specimen. To do so, a FE model of ONERA Kolski-type Split Hopkinson Pressure Bar (SHPB) device is built using *EUROPLEXUS* FE solver. It follows a 1D/3D FE approach, similarly to a model built for pre-stretched Split Hopkinson Tension Bar [3]. Note that the contact between the

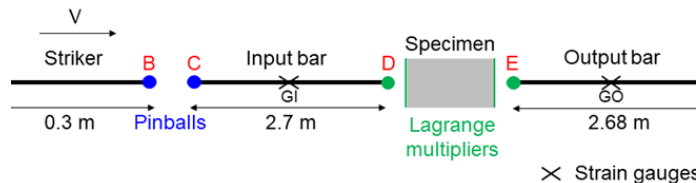


Figure 1: Sckematics of the SHPB FE model.

striker and the input bar is handled by means of pinballs, while the interfaces between the specimen and the input or output bars are handled by means of Lagrange multipliers, see Figure 1.

**Results** The SHPB numerical model was validated by comparing the incident, reflected, and transmitted experimental and numerical force signals at input and output bar gauge locations in a campaign considering cylindrical specimens, see Figure 2.

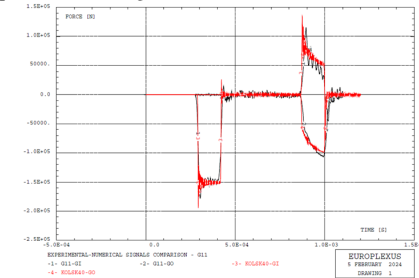


Figure 2: Experimental (black) and numerical (red) force signals recorded at input and output bar gauge locations.

**Discussion and Conclusion** Subsequently, since the developed SHPB model is validated, it will be used to optimize a perforated plate specimen geometry (Figure 3). This will be done by parametrizing the specimen shape, here the hole position and radius in a rectangular specimen. Then, the FE results will be used to generate synthetic images that will be processed by DIC and the Virtual Field Method in an attempt to determine a compromise between the two objectives mentioned previously.

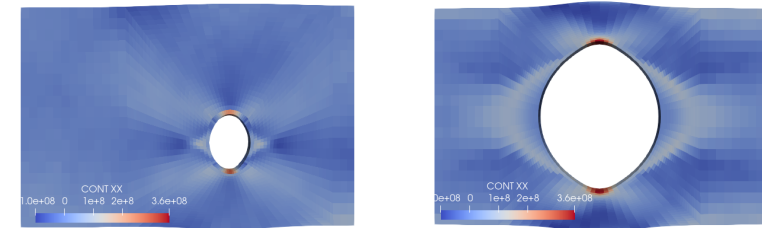


Figure 3: Axial stress at the final stage of the simulations for two specimen geometries with a hole, depending on the hole radius and position.

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