Inverse modelling with integrated DIC and FEM for estimation of static and dynamic fracture parameters

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Abstract:

Classical material testing techniques experience limitations for material model parameter identification especially when heterogeneous strain fields occur. Indeed, when only global test parameters such as force and elongation are used to calculate material parameters, significant discrepancies are often observed between finite element simulations of the test and the actual test. These discrepancies can be attributed to inconsistencies in sample machining, material variations and testing conditions, however, also to the material parameter determination based on global data. Major improvements can be obtained when full field comparison of the test data with finite element analysis is considered to calculate the constitutive model parameters. In this study, a coupled numerical- experimental technique has been developed to estimate the fracture parameters of both ductile and brittle materials. The approach is applied to a set of smooth and notched specimens of a dual phase steel targeting at specific stress states and tested in tension at dynamic rates to extract the fracture parameters. Additionally, the method is utilized to find the model parameters from dynamic tensile tests on basalt epoxy composite. The parameter identification is based on an iterative finite element model update procedure in which the results obtained by the numerical simulation are compared with full field deformation measurements using a digital image correlation (DIC) technique. A least square cost function is used to assess the gap between the inhomogeneous displacement or strain fields obtained from measurements and the simulated fields. Minimization of the cost function is ensured by the Levenburg- Marquardt algorithm. Generally, the influence of a parameter on the displacement field is of the order of the image acquisition noise. The tight integration between mechanical model and digital image correlation enables direct identification of unknown parameters while regularizing the displacement field with a set of interpolation functions chosen to span local zones of interest thereby increasing the noise robustness. Through this method, the versatility of the finite element method is translated to the experimental realm, simplifying the existing experiments and creating new experimental possibilities. Moreover, to demonstrate the general applicability of the proposed method, the integrated approach is also coupled with contour plots so as to quantify the effect of radial inertia and end friction in static and dynamic compression tests.

Keywords: Inverse modelling, finite element, digital image correlation, full field measurement, material model parameters

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