Application Note

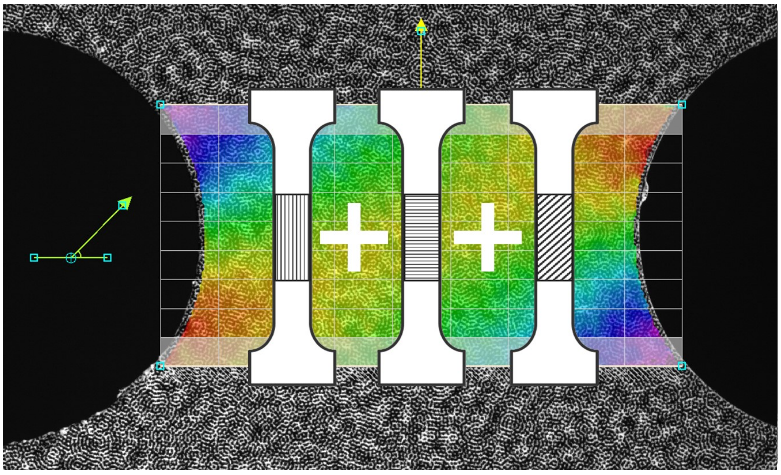
Identification of anisotropic plasticity of DC04 in a deep-notched tensile test

Case Description

Deformation data was obtained during deep-notched tests of cold-rolled sheet of DC04 steel using stereo Digital Image Correlation. The Virtual Fields Method was employed to identify two anisotropic plasticity models (Hill48, Yld2000-2D).

Results presented in this application note are a summary of the work performed at the University of Southampton published in *A. Marek, F. M. Davis, J.-H. Kim, F. Pierron (2020). Experimental Mechanics 60:639–664* and analyzed with the MatchID engine.

It is demonstrated that full-field inverse methods result in a reduced number of tests to perform.



Experimental Setup

- **Cameras:** MantaG-504b, 2448x2048 14bit
- **Lenses**: 105 mm Sigma DG Macro
- **Polarizers** on lenses and LED light
- **Optimized speckle of 65µm** printed via flat-bed printer

Analysis

- **Signal To Noise:** determine optimum DIC settings via PA module
- **Type:** Stereo DIC
- **Material Identification:** Virtual Fields method adopting uniform and sensitivity fields

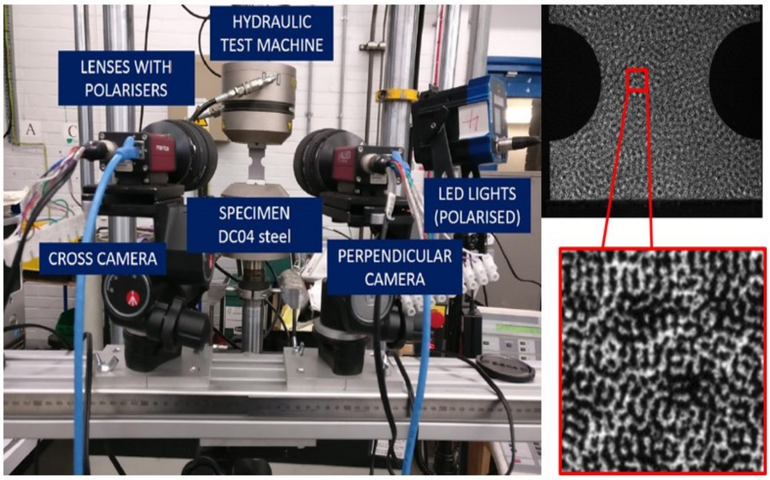
Results

- **Yield criteria**: Hill48, YLD2000-2D
- **Hardening:** Ludwik
- **Reconstructed stresses**
- Results in line with conventional dogbone testing

Why MatchID

- Unique platform to optimize test setup and analysis
- Identification of material properties via the Virtual Fields Method: **reduced number of tests**
- **Large library** of embedded material models
- Direct **stress reconstruction** from a full-field perspective

Experimental Setup

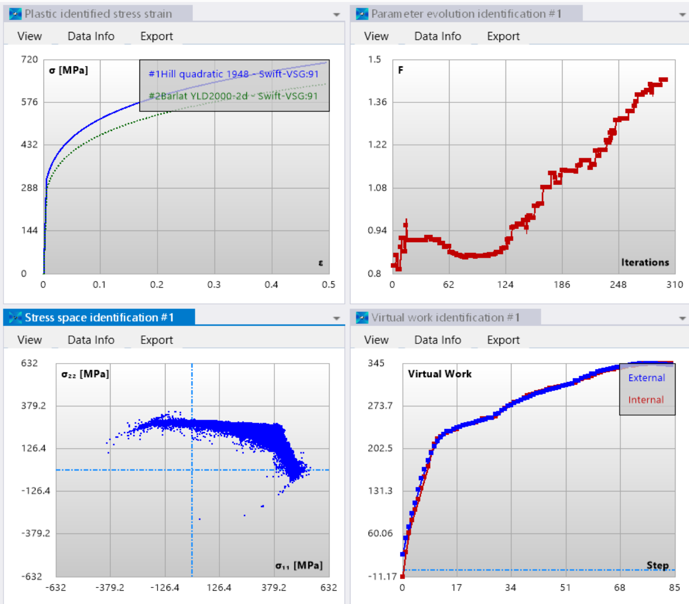


Specimens were water-jet cut out of a cold-rolled sheet of DC04 low-carbon steel alloy with a nominal thickness of 1.5 mm. An optimized speckle pattern was printed on the specimen using a flat-bed printer which provided good consistency and reproducibility. An average speckle size of approximately 65 µm was achieved. Deformation was measured using a stereo-DIC set-up. By setting cross-polarization specular reflection was minimised which resulted in a grey level histogram spread across most of the dynamic range of the cameras. The images were taken every 1 s and synchronised with the force measured from the load cell.

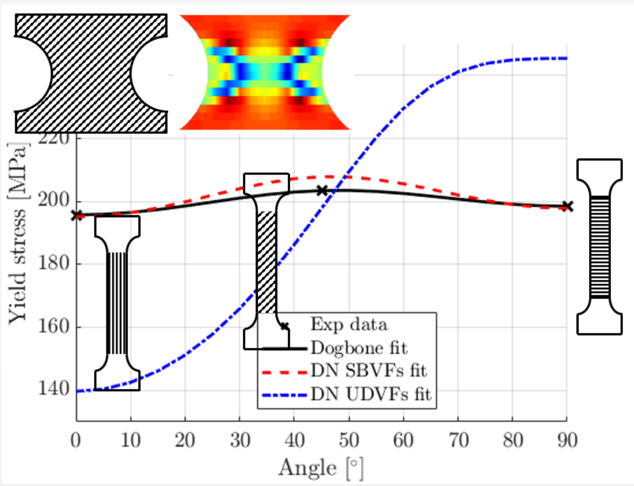
The Virtual Fields Method

The analyzed DIC displacement results were seamlessly transferred into the VFM module, where two types of virtual fields can be adopted: (1) uniform fields giving equal weight to each data point (2) sensitivity-based fields that will put more stress on data points with a higher parameter sensitivity and signal-to-noise robustness.

A full identification was performed for both Hill48 and YLD2000-2D yield criteria adopting both types of virtual fields. The charts display the resulting stress strain curves, parameter evolution, stress space and work equilibrium.



Identified Results



When the heterogeneous tests combined with sensitivity-based virtual fields were used to identify Hill48, the material parameters matched the yield stress variation and the loading force well. The selection of the sample geometry, however, still remains an open problem, and the results could certainly be improved further if the test was richer in terms of load paths. There is no doubt that the next generation of mechanical tests of materials will rely on DIC. But to get there, new test configurations will be needed where shape and loading are not constrained by the need for an a priori stress distribution anymore. This was recently coined “Materials Testing 2.0” and MatchID has the ambition to play an active part in this process.