## MatchID Metrology beyond colors

## Southampton

**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	Analysis	Results
<ul> <li>✓ Cameras: MantaG-504b, 2448x2048 14bit</li> <li>✓ Lenses: 105 mm Sigma DG Macro</li> <li>✓ Polarizers on lenses and LED light</li> <li>✓ Optimized speckle of 65µm printed via flat-bed printer</li> </ul>	<ul> <li>Signal To Noise: determine optimum DIC settings via PA module</li> <li>Type: Stereo DIC</li> <li>Material Identification: Virtual Fields method adopting uni- form and sensitivity fields</li> </ul>	<ul> <li>✓ Yield criteria: Hill48, YLD2000- 2D</li> <li>✓ Hardening: Ludwik</li> <li>✓ Reconstructed stresses</li> <li>✓ Results in line with convention- al dogbone testing</li> </ul>
✓ 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





Specimens were water-jet cut out of a cold-rolled sheet of DC04 lowcarbon 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  $\mu$ m 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.

**Identified Results** 

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.





more. This was recently coined "Materials Testing 2.0" part in this process.

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 anyand MatchID has the ambition to play an active