MatchID
Metrology beyond colors

Application Note

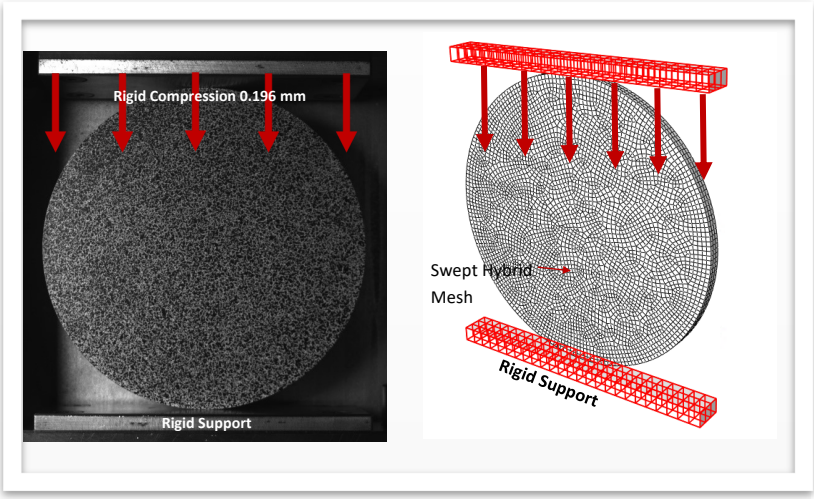
Finite Element Model Validation Case Study: Disk Under Compression

Case Description

A 4mm thick and 100mm diameter PMMA (Polymethyl methacrylate) disk is compressed in a clamping device with 0.196mm clamp displacement. DIC images are taken in uncompressed and compressed state.

The case is simulated with benchmark material properties from literature and identical displacement-driven boundary conditions in a finite element analysis software.

Thanks to MatchID FEA Validation Strategy, the simulation and experimental results are compared quantitatively at every measurement point generating full-field error maps.



Experimental Setup

- ✓ **Cameras:** 2 x Flir Pointgrey Blackfly S USB3 5MPx with 12.5mm Lenses
- ✓ **Load:** Disk compression setup with load cell
- ✓ **Field of View:** 160 x 160 mm

Analysis

- ✓ **Type:** Stereo DIC
- ✓ **Calibration**: MatchID Calibration with 50 calibration target images
- ✓ **Signal To Noise:** Setting optimization by MatchID performance analysis module

Results

- ✓ **Stereo DIC:** Displacement and Strain results
- ✓ **FEA Model:** Implicit model with displacement boundary conditions
- ✓ **Comparison:** Quantitative validation using MatchID FEVAL

Why MatchID

- ✓ Creates a **true digital twin** by leveling both FEA and DIC through the same process
- ✓ **Avoids user dependent biases** due to wrong DIC settings selections
- ✓ No interpolation, frame alignment, data-coincidence or strain formulation errors
- ✓ Generates **full-field error and validation maps**

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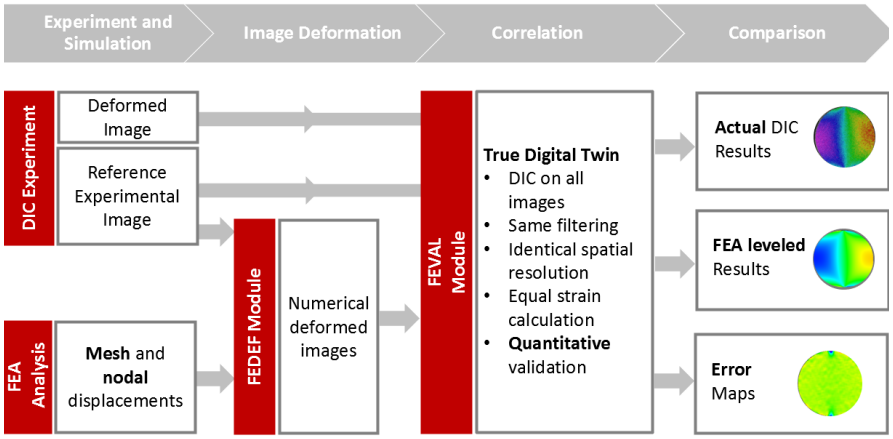
Innovative Finite Element Analysis Validation Strategy

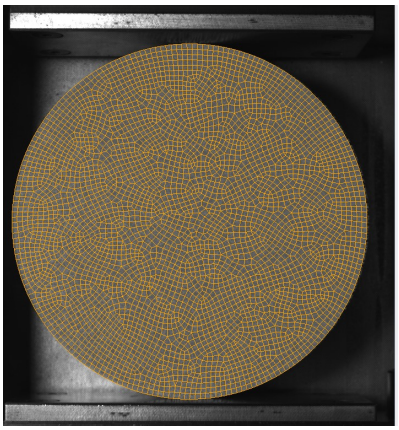
Quantitatively comparing FEA and DIC results is a very challenging task with traditional methods. Both experimental and simulation worlds are generally expressed in different coordinate frames and data point locations. Moreover, both methods adopt different solution strategies and dimensions (mesh vs. subset) that will introduce by default a bias in a direct comparison.

MatchID has developed an innovative validation strategy, based on synthetic image deformation, where the FEA data are 'levelled' to the DIC data, by ensuring that both sets of data have the same filtering, spatial resolution and strain calculation method. Hence, yielding a true digital twin.

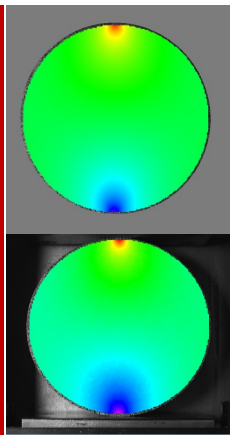


FEA Model Based Image Deformation

The first part the validation strategy is to numerically deform the reference image using the FEA results. To that purpose, the FEA mesh and nodal displacements are imported into MatchID' s FEDEF module. The mesh is aligned onto the experimental reference image, which is then numerically deformed according to the FEA nodal displacements. Accordingly, synthetic deformed images are generated ready for further DIC analysis.



Qualitative comparison



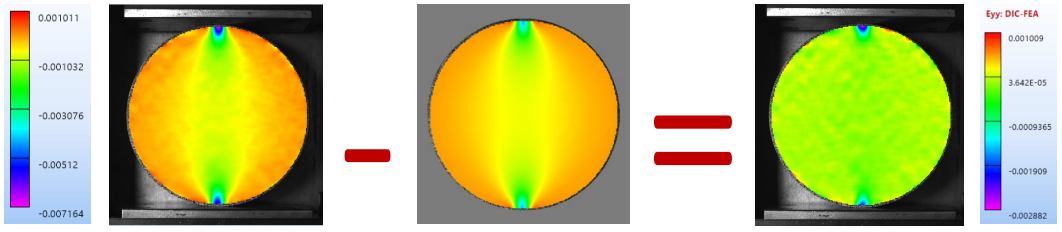
FEA Results

? identical ?

DIC Data

Quantitative comparison

To establish a quantitative comparison, hereby adopting MatchID 's unique validation strategy, the virtual experimental images driven by FEA results are analyzed with 100% identical settings as their experimental siblings. This enables to directly subtract FEA and DIC data at every measurement point. Although the qualitative comparison suggests a good match between FEA and DIC, resulting quantitative difference map shows large differences in the areas with high strain concentrations. This is a true model error and not resulting from wrong DIC setting decisions. This error map can be used to improve the FEA model directly.



DIC Results — Leveled FEA — Full-Field Error

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