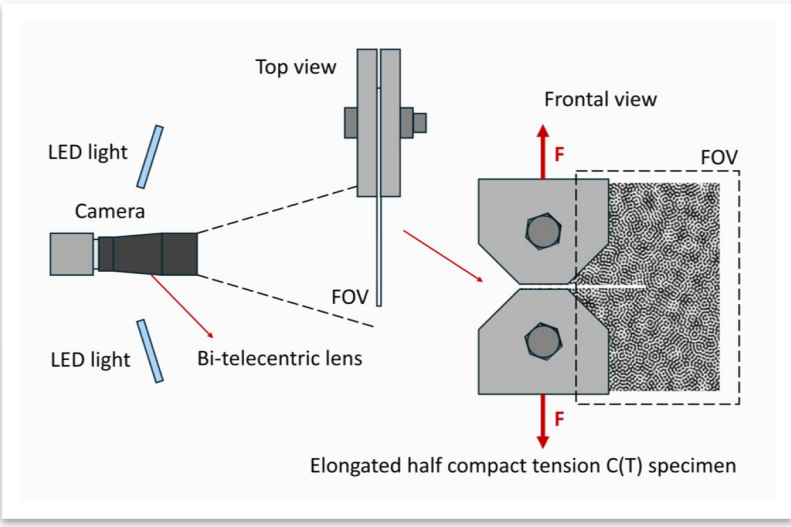
MatchID
Metrology beyond colors

Application Note

J-integral estimation of PMMA C(T) specimens using DIC

Case Description

This application note addresses the extraction of the energy release rate by means of *J*-integrals using Digital Image Correlation (DIC). Experimental work available in the literature was used to illustrate the capabilities of the current developments at MatchID. Here, two applications are reported: the use of the path-independent and equivalent domain-independent *J*-integrals to estimate the energy release rate of PMMA through elongated half compact tension specimens. The fully integrated crack module available in MatchID includes the detection of the crack path and crack-tip position, and the identification of the stress-intensity factors (SIFs) and energy release rate using *J*-integrals.



Experimental setup

- ✓ **Camera:** 5MPx CCD monochromatic
- ✓ **Lens:** TC13036 bi-telecentric
- ✓ **Type:** 2D DIC
- ✓ **Acquisition Speed:** 2 Hz
- ✓ **Field of View:** 37 mm × 27 mm

Analysis

- ✓ ***J*-integrals:** path and domain
- ✓ ***J*-integral study:** analysis different geometries
- ✓ **Type:** 2D DIC
- ✓ **Specimen:** PMMA elongated half compact tension C(T)

Results

- ✓ **DIC-measured displacement fields**
- ✓ **Crack path**
- ✓ **Crack-tip position**
- ✓ ***J*-integrals:** path and domain
- ✓ **Validation:** computed energy release rate using SIFs

Comprehensive crack module with:

- ✓ Automatic **crack path** and **crack-tip** detection
- ✓ Stress-intensity factors identification using **high-order Williams' series expansion**
- ✓ Energy release rate estimation using path and domain ***J*-integrals**

Why MatchID

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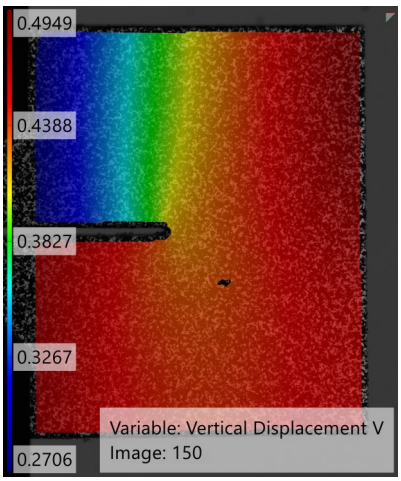
Experimental campaign

A PMMA (E = 3260 MPa, ν = 0.36) elongated half compact tension specimen C(T) was used to show the capabilities of the crack module available in MatchID. The image data was captured by a research group at the University of Cape Town in South Africa. The aim of this application note is to identify the energy release rate using the path- and domain-independent J-Integrals. 2D-DIC was used to compute the full-field displacements using the processing settings given in the table below.

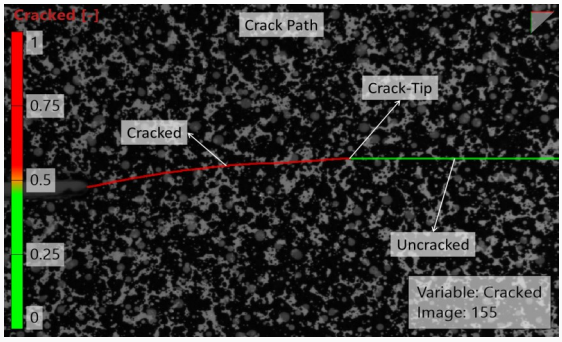


Processing settings	Value
Subset size [pixel^2]	49 × 49
Subset step [pixel]	9
Correlation criterion	ZNSSD
Correlation shape function	Affine
Interpolation	Local bicubic splines
Threshold	0.995

Image data provided by Prof. Thorsten H. Becker, University of Cape Town, South Africa.

Crack path detection and crack-tip identification

Within MatchID, the crack-tip position can be detected from the crack opening displacements (COD) or identified by performing a full-field fitting using a high-order Williams' series expansion. In this application note, the crack path was detected using the last load-step full-field displacements measured by DIC and the crack-tip position was identified using the opening displacements located at the vicinity of the crack. A displacement unit can be used to indicate whether a material point is cracked or not. If the measured opening displacement is larger than this limit, the material will be considered as cracked. Both crack path and crack-tip position were extracted by MatchID using the settings shown in the adjacent figure, which also illustrates the detected path and the portions where the material cracked (red) and remained uncracked (green) at a given load step.



Path detection	Value
Scanning window size [pixels^2]	9 × 9
Scanning window step [pixel]	2
Gaussian smoothing kernel	5
Crack-tip detection via COD	**Value**
Displacement limit [pixel]	0.3

Path and domain J-integrals

J-integrals can be used to estimate the energy release rate of fractured specimens. It can be calculated using the path-independent or equivalent domain-independent J-integral formulations. Here, the energy release rate of the PMMA specimen was obtained by MatchID using both J-integrals. The path or domain choice can be made by means of the J-integral Study module, where a profound geometry analysis can be performed using a combination of domains or paths constructed with different dimensions (*e.g.*, width, height, thickness and offset). The figure below illustrates the J-integral results using the path and domain approaches. It can be noticed that both curves are in accordance with the computed energy release rate using the stress-intensity factors.