STUDY OF TEARING OF METALS FROM THE DAMAGE INITIATION TO THE FINAL RUPTURE

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Experimental details

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ABSTRACT

This report describes the materials and methods used for perform tearing tests on metallic specimens. It includes the specimen preparation, image acquisition, traction machine, testing condition and setup disposition and post mortem analysis details. Several tests are made following the previous methodology.

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1 INTRODUCTION

Characterization of mechanical properties of materials is a common problem usually treated with standard tests. If elasto-plastic phenomena can easely be followed by extensometers or gauges, the process of damage and rupture are more difficult to measure. We report here a methodology for measuring surfacic strains until rupture during tensile tests by the use of high resolution cameras and Digital Image Correlation (DIC).

2 METHODOLOGY

The purposes of the 2D (DIC) are to measure the deformation in a non-intrusive way, do it in planar specimens only and without motion out of that plane.

In general, the implementation of the 2D-DIC method comprises the following three consecutive steps: specimen and experimental preparations; recording images of the planar specimen surface before and after loading; processing the acquired images using a computer program to obtain the desired displacement and strain information.

2.1 EXPERIMENTAL DETAILS

A description of experimental details is shown below. It is useful for all tests of this group: T02, FE02 and FE03.

2.1.1 Specimen preparations

The different tested specimens, in this case, are made of steel (S355) and the first step before testing is to paint the specimen surface with a speckle pattern.

The speckle quality has to be as fine as the camera resolution and has to be done avoiding a repetitive, anisotrophic and low-contrast pattern (random distribution). As shown in the Table 1 and in the Figure 1, the following tools has been used:

Air-brush	SOTAR air-brush. 2020-2-F model.
White paint	Rust-oleum hard hat industrial aerosols. Topcoat-flat-2190 white model.
Black paint	Liquitex Professional Acrylic ink. Carbon Black model.

Table 1: Speckle painting tools reference.

Figure 1: Air-brush and black and white paint.

After painting the speckle pattern, the surface of the specimen is shown above in the Figure 2. This will be the reference image:

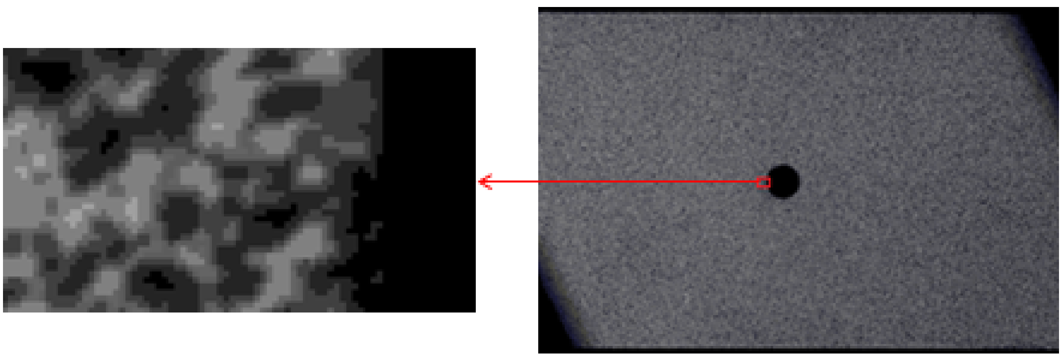

Figure 2: Reference image surface after painting.

2.1.2 Recording images of the planar specimen surface during the test

For this test, a 29 MPx camera has been used and images in grey levels are acquired. The following precautions should be observed:

- The camera must be well fixed (using a tripod).
- Focused (a sharp focus on the entire specimen).
- Has to be independent of out of plane displacements.
- It is uniformely illuminated without saturated points.

As shown in the Table 2 and in Figure 3, the following tools has been used for the image acquisition including materials and software:

Camera	Ultra high resolution pixel shift Vieworks 29 Mpixel camera. VN-29MC- M/C 5 model.
Objective	Nikon ED AF Micro Nikkor 200 mm 1:4D.
Tripod	Manfrotto.
Illumination	Led Flood Light IP65. L.FL-18-35P model.
Image acquisition software	Acqui CamVieworks National Instruments. LabVIEW 2012 v12.0. + Special development by P. Chaudet (LAMCOS UMR 5259)

Table 2: Image acquisition tools reference.

Figure 3: 1) Camera, 2) Objective, 3) Tripod and 4) Illumination.

2.1.3 Traction machine

An electromechanical load frame traction machine has been used (references given in Table 3).

Traction machine	Zwick/Roell ZMARTPRO electromechanical load frame. Dual column floor (100 kN load capacity).
Traction machine software	TestXpert II v3.1.

Table 3: Traction machine and software references.

Figure 4 shows a typical setup where we can see the specimen in the grips pull out by the tensile machine. Camera and lights are disposed in front of the specimen.

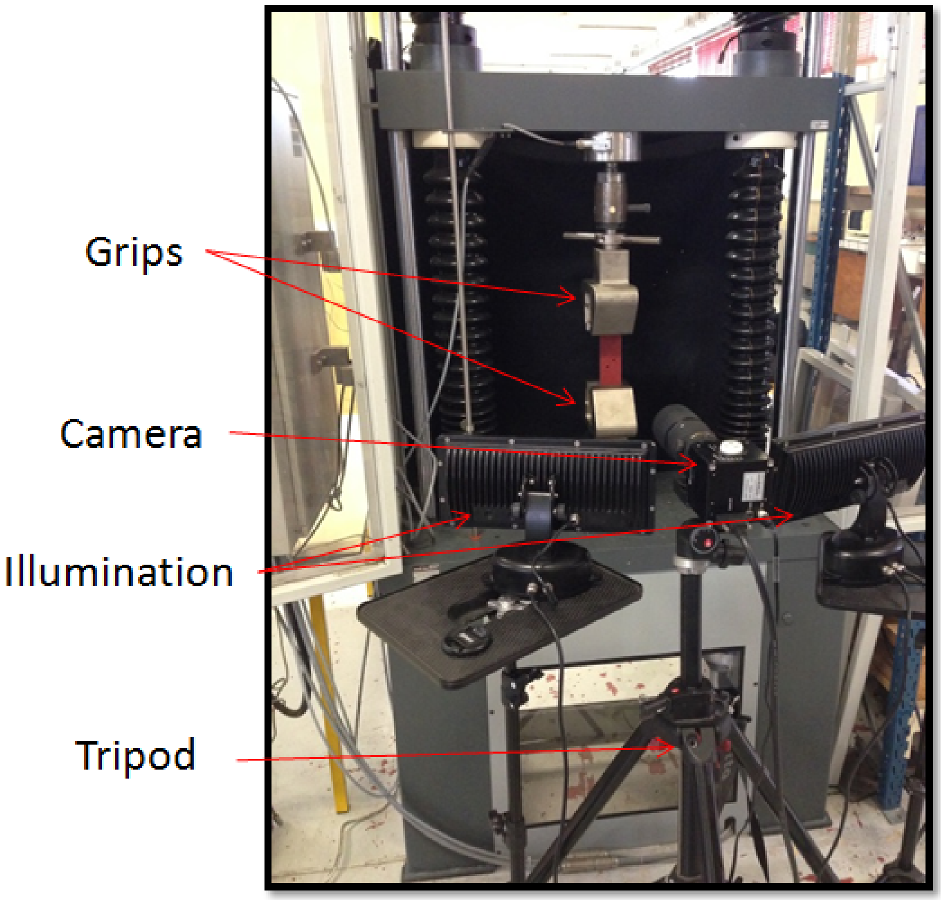

Figure 4: Setup for tensile test and image acquisition.

2.1.4 Testing conditions and setup explanation

Figure 5 shows the setup and the synchronization method.

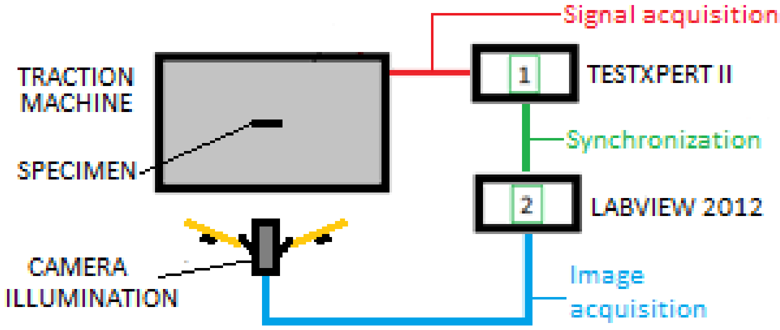

Figure 5: Tensile test setup scheme.

The tensile test trigger is made by an analogical signal. The force/displacement acquisition and the image acquisition will start at the same time synchronized.

After the test, force,displacement and time are saved in a text file. Another text file is recorded giving the force, displacement, time and the number of image.

2.1.5 Processing the acquired images

Digital image correlation technique. VIC-2D 2009 software is used.

3 POST MORTEM ANALYSIS

With some tested specimens (T02 and FE02), further studies on the fracture surfaces by Scanning Electron Microscope (SEM) have been performed (see Table 4 and Figure 6).

SEM	JEOL, JSM-6060LA.

Table 4: SEM references.

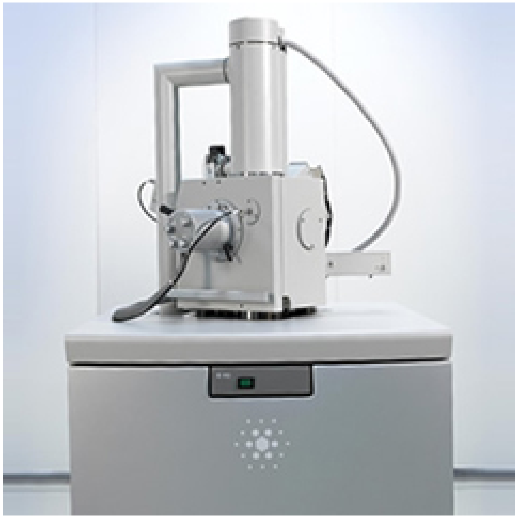

Figure 6: Scanning Electron Microscope.