BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXIV No. 4/2012	71 - 74	Seria Tehnică

Crack Length Determination for Non-standardized Test Specimens Using Graphical Analysis of Video Images

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Abstract

Experimental determination of facture parameters (stress intensity factors, J integral, crack tip opening displacement) is limited by the use of standardized test specimens, thus allowing the specialized software to calculate the crack length. If these tests must be performed using non-standardized specimens or the actual geometry of the structural part, the crack length can be determined via optical technologies, electrical potential variation or digital image correlation. This paper presents a simple and cheap method for crack length calculation by graphical analysis of video images. Using a high resolution video camera, snapshots of the crack are taken at certain intervals. The images are then analysed using specialised software and the crack length is calculated. The method allows fracture tests to be performed on test machines that do not have implemented fracture software.

Key words: *fracture test, crack length, graphical analysis, video image.*

Introduction

Experimental determination of fracture mechanics parameters is strictly regulated in both American and ISO standards, like ASTM E813, ASTM 561. These standards stipulate two main types of fracture test specimens: the compact tensile specimen (CT) and the single edge notched bending specimen (SENB). SENB specimens are to be used exclusively for plane strain conditions, while CT specimens can be used in both plane stress and plane strain conditions.
Nevertheless, in special cases, these types of test specimens cannot be used: the bulk material does not offer the possibility of machining these specimens or the application imposes the use of the real life configuration.

A cheaper and more convenient alternative can be the single edge notched traction specimen (SENT, fig.1), which provides a more flexible design.

In Figure 1: a is the crack length; L is the length of the specimen; B is the thickness of the specimen; W is the width of the specimen.

If non-standardized specimens must be used, the problem resides in the adaptation of different measuring devices to the new geometry, in order to provide accurate data and valid test results. The most challenging operation is the determination of the crack length, as for the majority of test machines and associated fracture software, the extensometer is calibrated only for CT specimens. Complementary procedures must be, thus, used in this case.

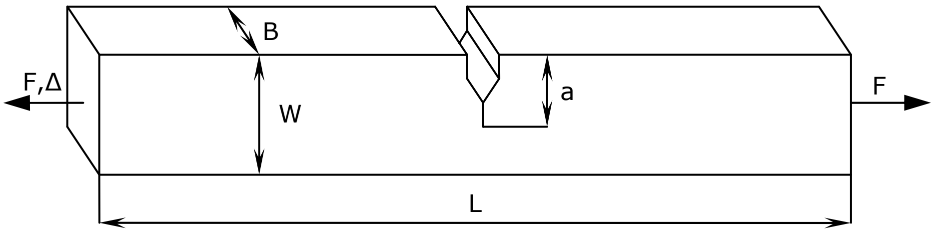

Fig. 1. SENT specimen

Procedure Description

The crack length monitoring procedure proposed consists of a Samsung SIR-4160 video camera and an AMAX DVR H264 digital video recorder. By manually synchronizing the video recording and the loading graph, the applied load and the crack length could be correctly correlated. Any synchronization errors can subsequently be eliminated by analyzing the recorded file frame by frame.

For exemplification, non-standardized AL6060T6 specimens were used (figs. 2, 3). The specimens were 5 mm thick, and the notch was obtained by electro-erosion with 0.2 mm wire.

Fig. 2. The AL6060T6 non-standardized test specimen

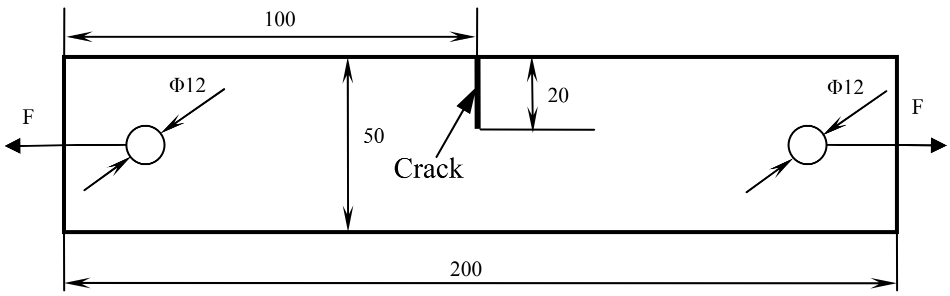

Fig. 3. The size of the specimen

The crack length was determined by graphically analysing the recorded images, using Alfasoft AB's SigmaScan Pro evaluation software.

The video camera can record images composed of either 600 colour lines or 700 black-and-white lines, has an integrated chipset for digital video signal processing an digital image stabilizer. The DVR (digital video recorder) uses a built-in operating system (Linux), has a 500

GB hard-disk and can be connected directly to the internet for real-time monitoring. Furthermore, a DVD or compact disk recorder can be attached easily.

The whole system has a compact size, therefore can be easily used for any test machine (fig. 4).

Fig. 4. The compact size allows easy placement of the video camera on the side of the specimen

After the recording was completed, the video file was decomposed into individual frames using special software. These pictures were subsequently imported in SigmaScan and analysed (see fig. 5).

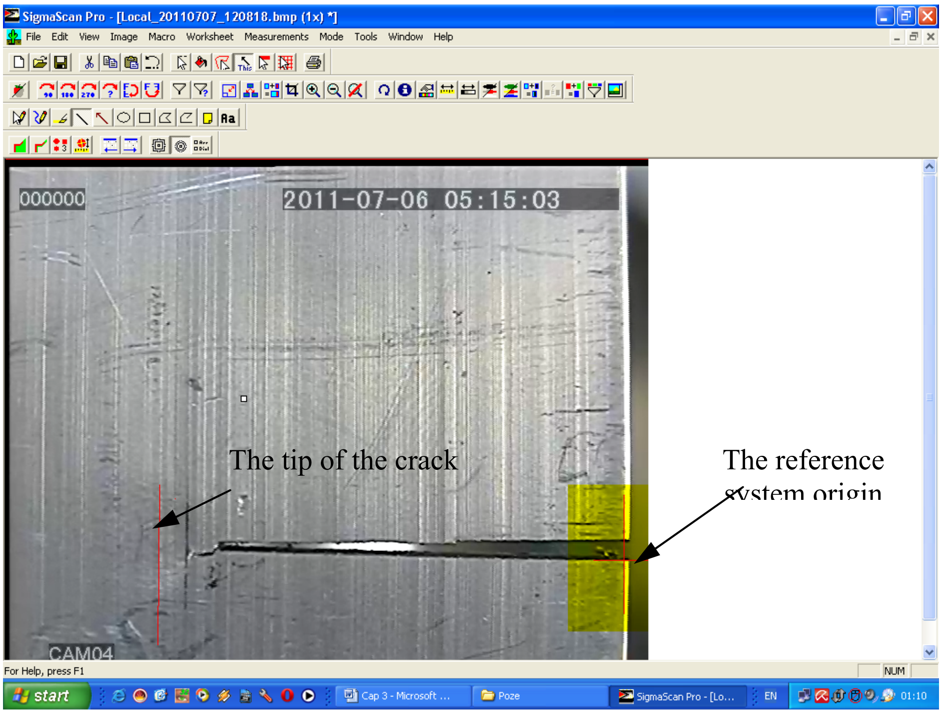

Fig. 5. Crack length determination by graphical analysis using SigmaScan software

The graphical analysis, in order to determine the crack length, consists of the following steps:

1. First of all, the origin of the coordinate system must be chosen. For that, the intersection of the two auxiliary red lines was used.

2. The image is calibrated used a known reference. In this test, the calibration was performed relative to the length of the initial notch (measured with a 0.01 mm precision). Automated calibration can also be used.
3. The crack tip is localized and marked using a vertical line.
4. The crack length is measured between the two vertical lines.
5. If the crack propagates in a random trajectory, the crack flank is divided in consecutive straight segments which are subsequently measured. The crack length is obtained by adding the results.

Conclusions

The implementation of crack length calculation using graphical analysis of video images lead to the following conclusions:

1. Non-standardized specimens can be used in experimental fracture analysis;
2. Graphical analysis of video images does not require expensive technology;
3. Graphical analysis of video images provides accurate values for crack length;
4. Graphical analysis of video images represents a cheap, easy and flexible way for crack length determination;
5. The procedure can be used for almost any test specimen geometry.
6. The method allows fracture tests to be performed on test machines that do not have implemented fracture software.

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Determinarea lungimii fisurii epruvetelor nestandardizate prin analiza grafică a imaginilor

Rezumat

Determinarea experimentală parametrilor de mecanica ruperii (factorii de intensitate a tensiunii, integrala J, deschiderea la vârful fisurii) este limitată de utilizarea epruvetelor standardizate, astfel încât algoritmii integraţi în softurile maşinilor de încercat să poată calcula lungimea fisurii. În cazul în care este necesară efectuarea unor încercări pe epruvete cu geometrie nestandardizată sau chiar pe piese reale, determinarea lungimii fisurii se poate face optic, prin analiza variaţiei potenţialului electric sau prin corelarea digitală a imaginilor. Lucrarea de faţă propune o metodă deosebit de simplă şi ieftină pentru determinarea lungimii fisurii, care constă în prelucrarea grafică a imaginilor. Utilizând o cameră video cu rezoluţie înaltă, se preiau instantanee la intervale de timp calculate, iar cu ajutorul unui soft se obţine rapid lungimea fisurii. Metoda poate fi utilizată şi pentru efectuarea unor încercări pe maşini fără software de mecanica ruperii dedicat.