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Investigations in Fracture Mechanics by Moiré Fringe Multiplication

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The in-plane moiré fringe multiplication is a suitable technique to investigate the deformation behaviour of specimens in fracture mechanics.
The method is based on the superposition of two real gratings. Replica techniques for the grating preparation as well as experimental FOURIER-transform and spatial filtering enable its realization.

Keywords: moiré, fringe multiplication, fracture mechanics

1. Introduction

The moiré technique is suitable to measure und to evaluate both the whole near and far field in-plane deformation on the surface of cracked specimens. Curves of the opening displacement near the crack tip as a function of the coordinate along the crack flank as well as integral fracture parameters can be ascertained.

The applied method of moiré fringe multiplication is characterized by some special features, among them

- precise measurement of displacement fields

- analysis of geometrically and physically non–linear problems because of the geometrical nature of the moiré effect
- high sensitivity of the moiré fringe multiplication comparable with that of holographic and speckle interferometry
- variable density of isothetic fields as a function of the multiplication factor
- long-time stability
- no special requirements for the vibration isolation due to a real reference grating.

2. Moiré Fringe Multiplication

The in–plane moiré method used is based on the superposition of two real gratings. For increasing sensitivity and accuracy, the combination of two phase gratings – the deformed object and the reference grating – is analysed by means of spatial frequency filtering [1]–[3], Fig. 1. The required multiplication factor can be selected in the plane of the discrete diffraction spectrum. The displacement components are calculated by

$$u_i = \frac{m_i \cdot p}{r} \qquad i = 1,2$$

with $u_i \ldots$ displacement component, $m_i \ldots$ fringe order, $p \ldots$ pitch and $r \ldots$ multiplication factor.

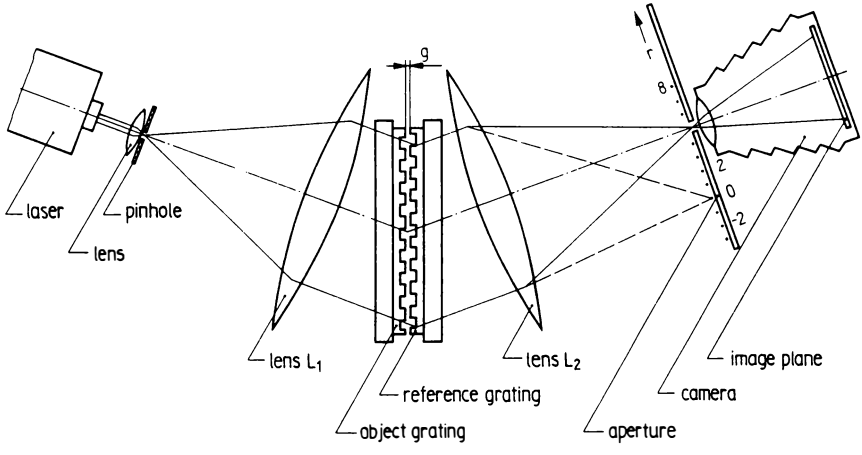

Fig. 1: Moiré fringe multiplication in transmitted light

3. Determination of the Local Crack Opening

The method of moiré fringe multiplication is applied to investigate the elastic–plastic deformation of SENB–specimens made of ductile steel.

The experiments are carried out using gratings of 50 lines/mm. On the surface of the specimens thin phase cross–gratings were prepared with silicon rubber by a replica technique. The replication of the deformed object grating premits the moiré fringe multiplication in transmitted light. Because a variable gap between object and reference grating leads to significant errors, the gap effect was eliminated by the experimental arrangement of Fig. 1 [3]. A multiplication factor of 8 gives the effective pitch $p_{eff} = 4$ μm in the isothetic field of Fig. 2.

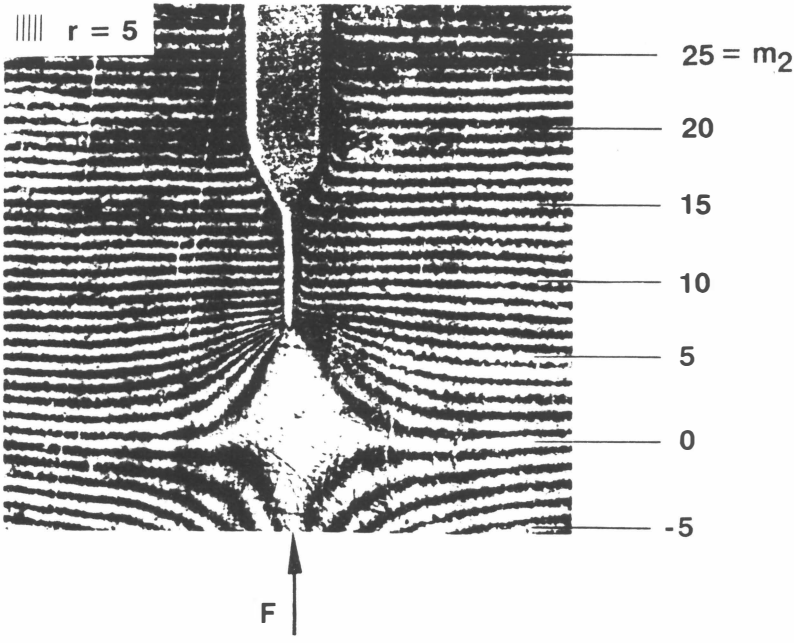

Fig. 2: u_2–isothetics of a three point bending specimen (ASTM E 399) material: X 6 CrNiTi 18 10; width $W = 20$ mm; $p_{eff} = 4$ μm

As a result Fig. 3 shows the curves of crack opening along both flanks beginning at the crack tip. The blunting effect in the immediate vicinity of the crack tip is clearly visible.

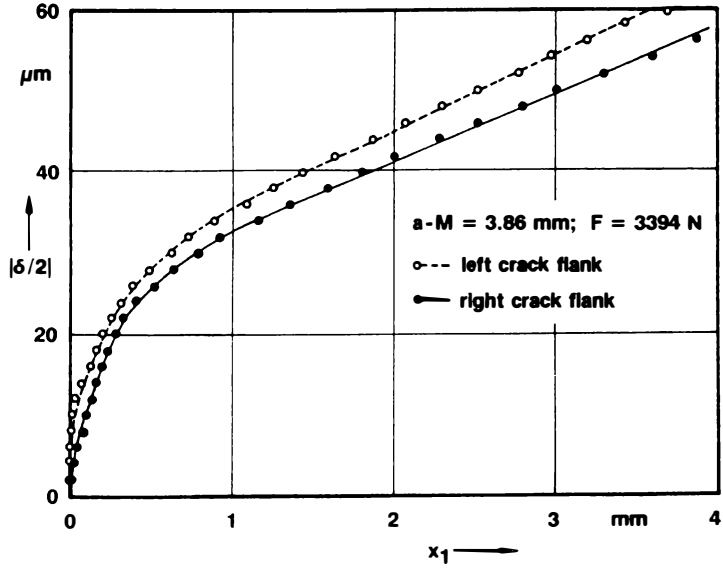

Fig. 3: Opening of the crack flanks in the case of elastic–plastic material behaviour

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