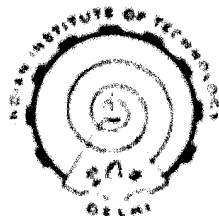


**STUDIES ON ELASTIC-PLASTIC FRACTURE
CRITERIA USING J-INTEGRAL AND
CTOD METHODS**

by

V. R. RANGANATH

Submitted
in fulfilment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY



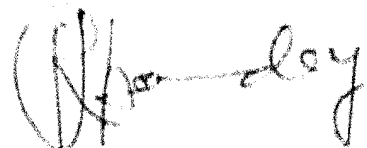
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INDIAN INSTITUTE OF TECHNOLOGY, DELHI
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CERTIFICATE

This is to certify that the Thesis entitled, "STUDIES ON ELASTIC-PLASTIC FRACTURE CRITERIA USING J INTEGRAL AND CTOD METHODS" being submitted by V.R. HANGANATH to the Indian Institute of Technology, Delhi, India, for the award of the degree of 'Doctor of Philosophy' in Applied Mechanics Department is a record of bonafide research work carried out by him under our supervision and guidance. The thesis work, in our opinion, has reached the standard fulfilling the requirements for the Doctor of Philosophy-Degree. The research report and results presented in this thesis have not been submitted in part or in full to any other University or Institute for the award of any degree or diploma.



(Dr. A.N. Kumar)
Lecturer
Department of Applied
Mechanics
Indian Institute of
Technology
New Delhi-110 016
INDIA



(Dr. R.K. Pandey)
Assistant Professor
Department of Applied
Mechanics
Indian Institute of
Technology
New Delhi-110 016
INDIA

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ABSTRACT

In the present work, two of the widely used elastic-plastic fracture mechanics (EPFM) parameters, the J -integral and the crack tip opening displacement, have been investigated vis a vis the various models available for their determination by employing a microalloyed steel (yield strength \approx 400 MPa) and a low alloy steel (yield strength range \approx 400-1250 MPa). An improved method for determination of toughness values (J_{1c} and δ_{1c}) from crack growth resistance curves has been proposed and compared with the existing methods of J_{1c} or δ_{1c} determination. The studies on crack initiation and crack growth toughness have been conducted by changing the specimen parameters (i.e. specimen thickness and type of loading) and material parameters (microstructure, yield strength, strain hardening exponent etc.). The material in as-welded condition has also been investigated in order to assess the toughness behaviour in the three zones (namely, weld zone, heat affected zone and parent metal) of the weld plate. Besides, the critical toughness parameters have also been studied in notched specimens and the effect of dimensional parameters on toughness has been noted.

Chapter-I deals with the emergence and significance of the EPFM parameters like J,CTOD, tearing modulus etc. The necessity of an investigation with regard to the behaviour of the above parameters has been brought out.

In Chapter-II, a review of literature is presented. Various models for evaluating the J and CTOD have been reviewed and their limitations have been outlined. The available methods of determining J_{1c} or δ_{1c} have been given. A brief assessment of the status of J-CTOD relationships is also made. The findings of earlier investigators in correlating the microstructural parameters, crack initiation toughness and crack growth toughness have also been outlined. The aim and objectives of the present investigation have finally been included.

The details of materials, specimen preparation, experimental techniques, calibration procedure etc. are presented in Chapter-III. The fracture mechanics' test procedures are also described in this chapter.

The results of J and CTOD evaluation using various available methods are reported in Chapter IV. Also the R-curves obtained from the experiments have been presented and their nature briefly discussed.

In Chapter-V, the J-CTOD relationship has been examined and the significance of the m value vis a vis material flow properties, specimen size and the loading geometry has been discussed. The stretched zone width has been correlated to CTOD. A proposal for obtaining a more realistic blunting line has been outlined. The J_{1r}/δ_{1r} values thus obtained have been employed to assess their dependence on specimen loading geometry and material properties. The J-R and δ -R curves have been further investigated using the tearing modulus concept and the crack growth toughness of different materials and loading geometries have been compared. The plastic zone size and process zone size have been studied for their possible correlation with the crack initiation toughness.

The effects, of notch acuity on the toughness parameters, process zone size, critical strain etc. in a microalloyed steel has been considered in Chapter-VI and the results have been compared with the sharp crack case. The role of specimen dimensions (viz., thickness, width, a/W) on toughness behaviour of the notched plates has also been discussed.

The studies on crack initiation and stable tearing in the welded plates of microalloyed steel has been taken up in Chapter-VII and the role of microstructure in influencing the toughness levels of weld metal and HAZ has been

described. The studies pertaining to J-CTOD relationship, tearing modulus, process zone, etc. have also been conducted in the weld metal and the HAZ.

Based on the above studies, the conclusions arrived at in the present investigation are given in Chapter-VIII.

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