FRACTURE STUDIES IN Cr, Mo LOW ALLOY STRUCTURAL STEELS

by
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dedicated
to

his holiness

swami
sahajananda saraswati

Atheetha Ashram
Hosur TN

CERTIFICATE

This is to **certify that the Thesis entitled, "FRACTURE STUDIES IN Cr, Mo LOW ALLOY STRUCTURAL STEELS" being submitted by P.SUNDARAM 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 the results presented in this thesis have not been submitted in part or in full to any other University or Institution for the award of any degree or diploma.

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ABSTRACT

In the present work, two low alloy steels (2¼Cr-1Mo and ½Mo steels) have been employed to investigate the methods for determination of J and CTOD parameters for critical events using R-curve approach. The study has been conducted over a range of 30-400°C temperature. The investigation has also been carried out in the weldments of above alloys upto 200°C temperature. Besides, the fatigue crack growth has been studied in the alloys and their weldments.

The crack tip stretching has been studied microscopically and related to the critical fracture mechanics parameters. Various methods and blunting line equations used for the determination of J_{Ic} have been compared and a new blunting line equation is proposed which is a function of flow stress and strain hardening exponent. The crack growth resistance for the alloys and weldments (heat affected zone (HAZ), weld zone (WZ) etc.) has been studied using tearing modulus approach and correlated with the observed micro-fracture mechanisms. The quantitative microstructural analysis has been performed to understand the fracture and fatigue behaviour in the HAZ and WZ of the alloys.

Chapter I deals with the significance of parameters characterizing toughness like J, CTOD, tearing modulus, etc., and necessity of investigation is

highlighted for enhanced application of materials for structural applications.

Chapter II presents a review of literature on various models for evaluating J and CTOD and methods for determination of Jic and Sic values. The stretching at the crack tip and various blunting line equations are also reviewed and their limitations highlighted. Literature on welding fracture and fatigue crack growth in low alloy steels are also reported along with the role of microstructural parameters on crack growth and fracture. Finally, the aim and scope of the present investigation has been highlighted.

Chapter III deals with the details of materials, specimen preparation, experimental techniques, etc. for fracture mechanics' tests in the as-received alloys.

Chapter IV reports the results of the J and CTOD evaluation as well as the J and S-resistance curves using various models. The nature of the R-curves is also discussed.

In Chapter V, the initiation toughness (Jic, Sic) values are determined by applying various approaches and a comparison is made. The micromechanics at the crack tip in the vicinity of stretched zone has been examined closely and representative Sic are chosen based on these observations. Limitations of ASTM and EGF (European Group on Fracture) methods of Jic/Sic determination are also presented. The various blunting line equations are critically analyzed and a new equation for the blunting

line is proposed based on the observations from the present work as well as the reported work from literature. An attempt is also made to investigate the J-CTOD relationship. The resistance curves are further investigated for J-controlled crack growth regime.

The micromechanism of fracture in as-received alloys are discussed in Chapter VI. The experimental procedure on welding are presented and quantitative analysis of microstructures from the HAZ, WZ, etc., is reported to correlate with the toughness parameters. Fatigue experimentation and results are also reported in this chapter for the as-received and welded alloys. The results are discussed for the as-received, weld zone and HAZ vis-a-vis microstructure, fracture micromechanism and mechanical properties.

Conclusions, based upon the above studies, are given in chapter VII.

C O N T E N T S