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Effect of strain rate and notch geometry on tensile properties and fracture mechanism of creep strength enhanced ferritic P91 steel

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Abstract

Creep strength enhanced ferritic (CSEF) P91 steel were subjected to room temperature tensile test for quasi-static (less than 10^{-1}/s) strain rate by using the Instron Vertical Tensile Testing Machine. Effect of different type of notch geometry, notch depth and angle on mechanical properties were also considered for different strain rate. In quasi-static rates, the P91 steel showed a positive strain rate sensitivity. On the basis of tensile data, fracture toughness of P91 steel was also calculated numerically. For 1 mm notch depth (constant strain rate), notch strength and fracture toughness were found to be increased with increase in notch angle from 45^o to 60^o while the maximum value attained in U-type notch. Notch angle and notch depth has found a minute effect on P91 steel strength and fracture toughness. The fracture surface morphology was studied by field emission scanning electron microscopy (FESEM).

Keywords: Strain rate; P91 steel, Notch, Tensile properties; Fractographs.

1.0 Introduction

In the last decade, because of their enhanced mechanical and thermal properties at high temperature, creep strength enhanced ferritic (CSEF) P91 steel is increasingly used in nuclear and thermal power plants [1–3]. The P91 steel is subjected to dynamic thermal loading during the service condition. P91 steel is considered as the candidate material for out-of-core and in-core components of Gen IV reactors because of high resistance to radiation and oxidation [4,5]. P91 steels are used in steam headers and superheaters for ultra super critical boiler in power plants and for high pressure steam headers and piping in petrochemical plants. The attractive properties of P91 steel are adequate fracture toughness, high tensile strength, yield strength, and toughness [6,7]. Low thermal expansion coefficient and thermal conductivity of P91 steel make it more reliable material against creep and fatigue thermal loading [8,9]. The improved strength of P91 steel is mainly derived from higher solid solution strengthening, precipitation hardening