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BRIEF NOTE

# Fracture study of ferritic/martensitic steels using Weibull stress analysis at quasi-static and higher loading rates

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**Abstract** Effect of loading rate on cleavage failure probability for ferritic/martensitic steels using Weibull stress analysis is studied. Calibration of Weibull slope for two grades of fusion reactor blanket steels namely, Indian Reduced Activation Ferritic/Martensitic Steel referred as In-RAFMS, F 82H and a non fusion grade modified 9Cr-1Mo steel (P91) are performed for the first time. The calibrated values of Weibull slope is used to predict the fracture behaviour of In-RAFMS at three different loading rates. The effect of loading rate is also examined on reference transition temperature using Wallin's correlation based on Zener-Hollomon strain rate parameter.

**Keywords** Master curve · Loading rate · Weibull calibration · Strain rate

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## 1 Introduction

The fracture behaviour of ferritic and ferritic/martensitic steels in DBT region have been extensively investigated using probabilistic master curve approach (ASTM E1921 2013) developed by Wallin (2002, 2010) in last two decades on huge datasets such as Euro fracture data (Heerens and Hellmann 2002). A similar approach in understanding the cleavage failure mechanism numerically in DBT region is the Weibull stress based local approach (Beremin et al. 1983) which is described as

$$P_f = 1 - \exp\left[-\left(\frac{\sigma_W}{\sigma_u}\right)^m\right], \quad (1)$$

where $P_f$ is the numerical probability of cleavage failure, $\sigma_u$ is the scaling parameter and $m$ is the Weibull slope. $\sigma_W$ is the Weibull stress defined as

$$\sigma_W = \left[\frac{1}{V_o}\int_{V^*} \sigma_1^m \mathrm{d}V\right]^{1/m}, \quad (2)$$

where $V_o$ is the reference volume not too big to have significant stress gradient nor too small to violate the characteristic length of RKR model (Ritchie et al. 1973) which is a few grains. Maximum principal stress, $\sigma_1$, is integrated in the volume $V^*$. The volume $V^*$ is described to be the volume for which $\sigma_1 > \lambda\sigma_o$, where $\sigma_o$ is the yield strength of the material. Generally the value of $\lambda$ is 2 (Petti and Dodds 2005; Gao and Dodds 2005; Wasiluk et al. 2006).

The general variation of fracture toughness measured according to ASTM E1921 (2013) with temper-