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Evaluation Model for Assessing the Effect of Steel Properties on Correlation between Fracture Transition Temperatures in Charpy Impact Testing and CTOD Toughness Testing

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Summary: There have been many correlations between Charpy test results and fracture toughness test results such as CTOD test results.However, these correlations are not based on the theoretical model but quite empirical. Therefore, the current empirical correlations between both test results, that is especially the brittle-to-ductile transition temperatures, would not be necessarily applicable to the structural steels with various properties. In this study, an analytical evaluation model to correlate Charpy transition temperature with CTOD transition temperature is proposed only after applying the following new ideas with aiming at the effect of steel properties on the transition temperature difference. One is the definition of fracture transition temperature where brittle fracture coincides with ductile crack initiation in both Charpy and CTOD testing. Another one is employing "local plastic strain criterion" for ductile cracking and "Weibull stress criterion" for brittle fracture initiation. This proposed evaluation model provides fracture transition temperature difference ΔT_i (= T_i^{Charpy} - T_i^{CTOD}) between Charpy transition temperature T_i^{Charpy} and CTOD transition temperature T_i^{Charpy}, and on effect of steel properties quantitatively. It is analyzed that strength level and work hardening as well as toughness and ductility level of steels can influence transition temperature difference ΔT_i. A higher strength and a higher ductility of steels decreases ΔT_i, on the contrary, a higher work hardening and a higher toughness increases ΔT_i. The effects of these mechanical properties on ΔT_i can be interpreted by strain rate and temperature effects on flow stress of steels.