Material Characterization by J_R-Curves for Component Safety Assessment — A Study on a 20 MnMoNi 55 Forging

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For the characterization of fracture resistance of materials used in the upper shelf toughness region J_R-curves are considered as the most promissing candidates. Though their use for prediction of the ductile tearing instability was successfully demonstrated in evaluations of large-scale tests, there still remain several problems concerning both the generation of J_R-curves and their application for the fracture safety assessment. This paper reports on results of investigations conducted on one specific forging, covering as well different methods of J_R-curve determination for different conditions of constraint and temperature as comparisons of ductile tearing instability predictions with test results.

For the measurement of J_R-curves mainly the partial unloading compliance method was used. The partial unloading tests generated J_R-curves which compare very well with J_R-curves obtained by the multi-specimen method for the same specimen dimensions and temperatures. A comparison is made also with limited data obtained by the "key curve" and the potential drop method.

The measurement of material J-integral values for crack initiation using the DC-potential drop technique or an extrapolation from multi-specimen series enable interesting comparisons of J_i with J_{Ic}-values evaluated by different procedures from J_R-curves.

The test specimen geometries involve compact specimens of dimensions ranging from B = 25 mm to B = 100 mm with and without side grooves. A comparison of results shows some effects of specimen geometry on J_R-curves. The influence of the test temperature on material crack resistance was determined in the range from room temperature up to 300°C.

The tearing instability concept in connection with approximate methods for the calculation of $J_{applied}$ was used to predict crack initiation, the amount of stable crack growth and the maximum load of large-scale specimens on the basis of J_R-curves measured on small specimens. By comparing these results with available experimental data some limits are discussed in using J_R-curves as material characteristics for predicting the failure behavior of specimens and components in the ductile tearing regime.