notch weakened, the initiation time and propagation time both increase and, therefore, the rupture time increases.

For steel B which is notch strengthened, the initiation time decreases with size, but the propagation time increases. The initiation time, however, is much longer in this case than the propagation time. The rupture time of a notched bar, therefore, decreases with size, since it is primarily that of initiation, and approaches that of the unnotched bar.

The maximum stress and maximum triaxiality of stress occur at or near the periphery of the root of the notch. The highest accumulative damage, therefore, is near the periphery and accounts for the higher rate of crack propagation in this area.

Summary

A size effect can be demonstrated for elevated temperature notched rupture strength. As the size is increased, the rupture strength approaches that of the unnotched bar. For a material which is notch strengthened, the rupture time of a notched bar is primarily that of the initiation time which decreases as the size is increased, since the stress gradient and strengthening effect at the base of the notch is decreased.

For a material which is notch sensitive or weakened, the initiation time and propagation time both increase with specimen size, therefore, the rupture time increases with size.

The fracture propagation is higher in the peripheral direction of the notch because of the higher rupture damage accumulation in this higher stressed region.

References


DISCUSSION

Volker Weiss

The author is to be congratulated for his fine paper. The experimental results are not exactly what one might have expected from an extrapolation of notch tensile test results. There, an increase in specimen size generally leads to a loss in strength which is more pronounced for notch sensitive materials, i.e., materials showing notch weakening [11, 12, 13]. It is the discussor's view that this is due to a decreasing stress gradient with increasing size which causes an increase in the highly stressed portion of the test volume. Thus, one might conclude that the severity of the above test series increases with increasing size for both materials, the notch weakened steel A and the notch strengthened steel B. However, only for the latter is a decrease in notch rupture time observed. The author's statement that "the notch effect decreases as the stress gradient decreases" must be considered a conclusion based on the experimental results rather than a general statement concerning all notch tensile behavior. The following failure mechanism is offered for consideration: In steel B, a rather notch ductile material, yielding during the early stages of the test changes the stress distribution in all specimens to a stress distribution which is nearly identical for all sizes. The decrease in rupture time with increasing size is primarily a manifestation of an increased statistical risk of rupture with increased test volume.

The original stress distribution for specimen of steel A is nearly maintained. Rupture is preceded by the nucleation of cracks at or near the root of the notch. In a given amount of time a statistical assembly of such cracks is nucleated which is nearly independent of specimen size. This assembly increased the notch-crack severity of small specimens far more than that of large specimens; hence the time to rupture increases with increasing specimen size.

Additional References


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