Accounting for strain hardening effects in J estimation schemes

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Aim of the study

In nuclear industry, high attention is paid to avoid any defect in components during manufacturing, assembly and in service. Moreover, during lifetime flaw evaluation may be required to assess the integrity of a structure at design level, after repair or in service at locations where inspection is difficult and/or sensitive to ageing. For all of these reasons, a large amount of work was performed in France by CEA, EDF and AREVA_NP on Flaw Evaluation methods, for nuclear class 1 components and a Js estimation scheme for piping components is proposed in the RSE-M code (2005). See, among other publications, Gilles (1997), Le Delliou et al. (2005).

In the frame of the development of this RSEM Js estimation scheme, further investigations are conducted on pipes having a crack located in or close to a circumferential weld. In such configurations accounting properly for strain hardening effects is very important. This paper revisits the problem of strain hardening modeling in J estimation schemes.

Short description of the work

The crack driving force J behavior with increasing loading is mainly influenced by the stress strain behavior. In the various J estimation schemes, this stress-strain dependence has been accounted for in several ways and with varying efficiency. Namely accounting properly for strain hardening in J estimation scheme is not so simple. The GE-EPRI type (1981) approaches are only valid for power law stress-strain curves and may present difficulties in interpolating coefficients. Reference stress approaches introduced with the R6 option 2 scheme (Ainsworth, 1984) overcome these limitations but their accuracy depends on the quality of the selected reference load formulation.

This paper investigates the three following problems for which, to our knowledge, only partial answers have been brought:

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- Failure of the reference stress approach when applied to linear strain hardening materials (Bootheman, 1997).
- Effects of crack tip triaxiality on J variations.
- Strain hardening effects in cracked welded specimens as illustrated below:

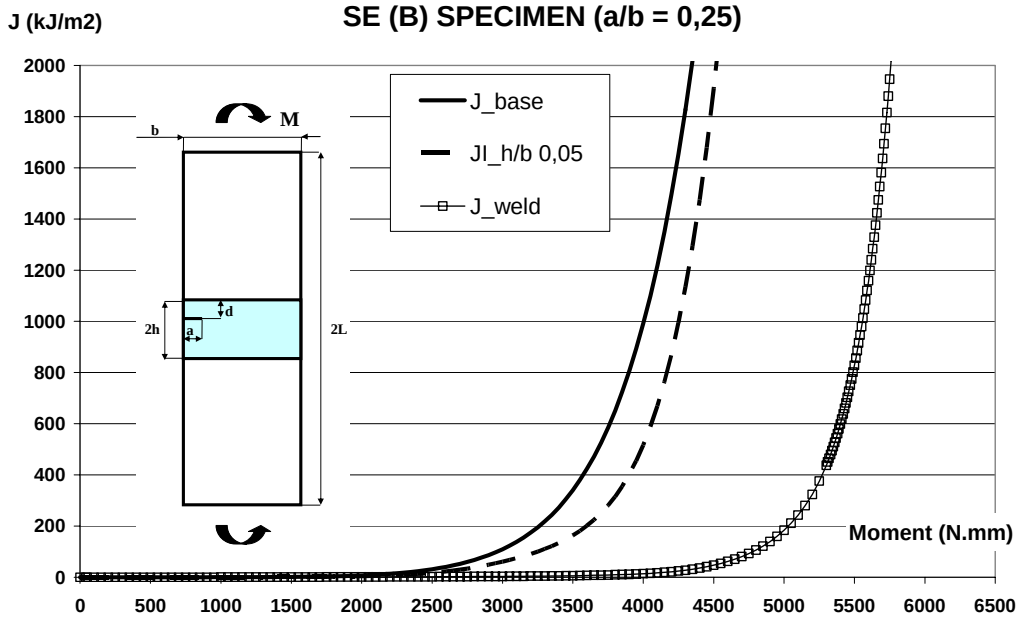

Figure 1. Single Edge specimens under bending: homogeneous & bimaterial J-M variations.

Conclusions

The material stress strain law has a strong influence on J variations with increasing loading. However, several difficulties arise for including strain hardening effects in J estimation schemes. The paper proposes some new approaches accounting these effects.

References

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