What is the second most important quantity at fracture? Discussion of fracture paper #17

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2017

Document Version:
Förlagets slutgiltiga version

Link to publication

Citation for published version (APA):
Ståhle, P. (Red.), & Ståhle, P. (2017). What is the second most important quantity at fracture? Discussion of fracture paper #17. Elsevier.

Total number of authors:
2

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Engineering Fracture Mechanics
An International Journal

iMechanica Blog

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18 October 2017

No doubt the energy release rate comes first. What comes next is proposed in a recently published study that describes a method based on a new constraint parameter Ap. The paper is:
Fracture assessment based on unified constraint parameter for pressurized pipes with circumferential surface cracks, M.Y. Mu, G.Z. Wang, F.Z. Xuan, S.T. Tu, Engineering Fracture Mechanics 175 (2017), 201–218
The parameter Ap is compared with established parameters like T, Q etc. The application is to pipes with edge cracks. I would guess that it should also apply to other large structures with low crack tip constraint.
As everyone knows, linear fracture mechanics works safely only at small scales of yielding. Despite this, the approach to predict fracture by studying the energy loss at crack growth, using the stress intensity factor KI and its critical limit, the fracture toughness, has been an engineering success story. KI captures the energy release rate at crack growth. This is a well-founded concept that works for technical applications that meet the necessary requirements. The problem is that many or possibly most technical applications hardly do that. The autonomy concept in combination with J-integral calculations, which gives a measure of the potential energy release rate of a stationary crack, widens the range of applications. However, it is an ironin that the J-integral predicts the initiation of crack growth which is an event that is very difficult to observe, while global instability, which is the major concern and surely easy to detect, lacks a basic single parameter theory. For a working concept, geometry and load case must be classified with a second parameter in addition to KI or J. The most important quantity is no doubt the energy release rate, but what is the second most important. Several successful parameters have been proposed. Most of them describe some type of crack tip constraint, such as the T-stress, Q, the stress triaxiality factor h, etc. A recent suggestion that, as it seems to me, have great potential is a measure of the volume exposed to high effective stress, Ap. It was earlier proposed by the present group GZ Wang and co-authors. Ap is defined as the relative size of the region in which the effective stress exceeds a certain level. As pointed out by the authors, defects in large engineering structures such as pressure pipes and vessels are often subjected to a significantly lower level of crack tip constraint than what is obtained in laboratory test specimens. The load and

geometry belong to an autonomy class to speak the language of KB Broberg in his book "Fracture and Cracks". The lack of a suitable classifying parameter is covered by A_p.

The supporting idea is that K_I or J describe the same series of events that lead to fracture both in the lab and in the application if the situations meet the same class requirements, i.e. in this case have the same A_p. The geometry and external loads are of course not the same, while a simpler and usually smaller geometry is the very idea of the lab test. The study goes a step further and proposes a one-parameter criterion that combines the K_I or J with A_p by correlation with data.

The method is reinforced by several experiments that show that the method remains conservative, while still avoiding too conservative predictions. The latter of course makes it possible to avoid unnecessary disposal and replacement or repair of components. The authors' conclusions are based on experience of a particular type of application. I like the use of the parameter. I guess more needs to be done extensively map of the autonomy classes that is covered by the method. I am sure the story does not end here.

A few questions could be sent along: Like "Is it possible to describe or give name to the second most important quantity after the energy release rate?" The paper mentions that statistical size effects and loss of constraint could affect A_p. Would it be possible to do experiments that separates the statistical effect from the loss of constraint? Is it required or even interesting?

It would be interesting to hear from the authors or anyone else who would like to discuss or comment the paper, the proposed method, the parameter or anything related.

Per Ståhle