Application of Fracture Mechanics to Ductile Material

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When a material with an elastic plastic behaviour is used in a structure, every engineer will require that the structure must withstands at least to stresses of yield stress magnitude.

This means that full yield must be reached without crack initiation.

However when such a specification is required the material must dispose of sufficient plasticity, indeed; when residual stresses or strain concentrations are present full yield occurs only after a local plastic yielding. This amount of local plasticity is about 2 ε_y, when residual stresses are present, but is much higher in the vicinity of strain concentrations.

Full yield can be defined as the situation in which Lüdersli are developed from one free border to another.

When cracks or other physical discontinuities exist in the specimen, there are two possibilities of obtaining full yiel one with Lüders lines running from a free border to one crac end and further from the other crack end to the other free border, the other with Lüders line running through the speci without passing along the crack.

The gross strain obtained with the first mode is limited, because the elongation must be obtained from the deformatior of the crack tip. Such a "full yield" mode is rather instabl because in such a condition crack initiation is at other verc of starting at the crack tip.

On the contrary when full yield is obtained by yielding of the metal above and under the crack, a gross strain of 2 % can easily be reached; without requiring to high strains at the crack tip. Such a situation is only possible if the metal is strain hardening. For this reason defect tolerance depends essentially on the strain hardening characteristics of the metal.

Specifications based on the measurement of local yielding such as C.O.D., can give false judgment, specially when applied to welds. If for instance the C.O.D. is measured in a weld metal with high yieldpoint, small C.O.D. values will be recorded, while good gross strain are obtained due to the fact that the farme metal yields.
If the weld metal has a low yield point a vice versa situation may occur, good C.O.D. values will be recorded but gross strain will be small because the parent metal does't yield.
To avoid such situation a requirement of a gross strain of 2 à 3 % measured on a large gage length and on sufficient wide specimen with a notch is guarantied a sage performance