SIMILITUDE A BASIC CORNERSTON FOR THE ANALYSES OF CRACK PROPADARION

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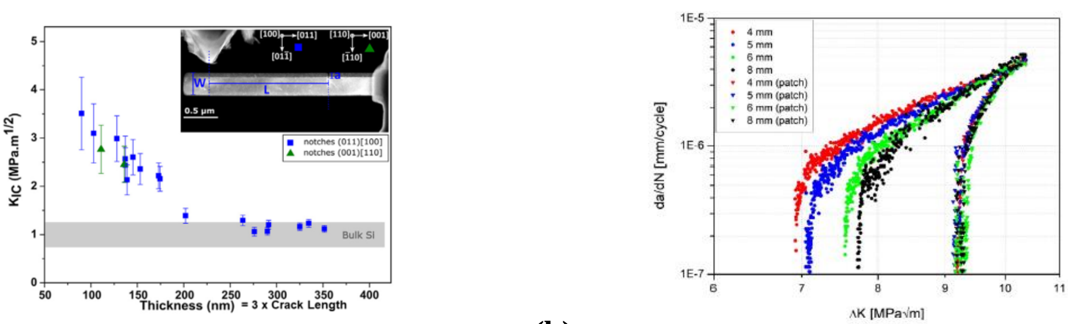
Abstract
The similitude concept in fracture mechanics is the base for the understanding the size and loading condition dependent or independent crack propagation resistance. In the present overview few selected examples for monotonic and cyclic loading will be presented and underlying mechanisms are discussed.

1. Introduction

An important condition in fracture mechanics for the decision if the crack propagation resistance is size and loading condition independent or dependent is the stress and strain as well as the history of the stresses and strains in the volume elements in the fracture process zone in front and sometimes also behind the crack tip. This is a central problem for all cases for the evaluation of crack growth resistance and the transferability to fracture mechanics predictions. The main problem is that the size of the crack propagation controlling zone are not directly measurable and often unknown. In the present paper different examples are presented to illustrate the importance of the crack propagation controlling zone under monotonic and cyclic loading. Special attention is devoted to the determination of fracture mechanism and the measurability of the size of the fracture controlling zone, furthermore it will be shown that the problem that both effect the intrinsic contribution and the extrinsic contribution to the crack propagation resistance and that the size of the zone where both are active can be very different.

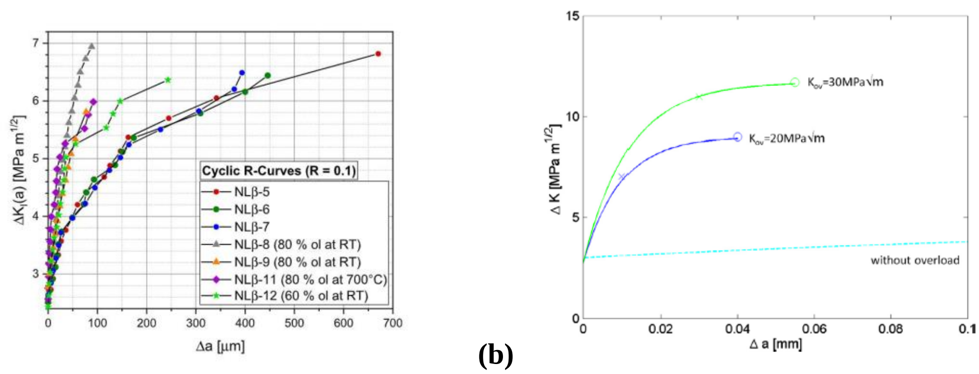
2. Examples of the size dependence of crack propagation resistance



(a) **(b)**

Figure 1. Illustration of two recently observed very different unexpended size dependent crack propagation resistances. (a) exhibit the size dependence of the fracture toughness in Si micro samples and [1] (b) shows the thickness dependence of the fatigue crack propagation behavior obtained in a decreasing stress intensity factor range experiment [2].

Two unexpended size dependent crack propagation resistance are presented in Fig. 1, a crack length dependence for monotonic loading of a Si micro sample and a thickness dependent fatigue crack propagation behavior near the threshold of stress intensity factor range. Whereas the behavior in Si in (a) is caused by a change in the intrinsic fracture resistance by a change in the fracture process the behavior in (b) is caused by a thickness dependent change of extrinsic contribution to the fatigue crack propagation resistance. The importance of the crack propagation mechanisms on the size dependent crack propagation resistance is illustrated in Fig. 2. It exhibits the enormous differences in the effect of single overloads on the R curve for threshold of stress intensity range in a semi brittle TiAl alloy compared to a ductile quenched and tempered steel. The examples clearly demonstrate the importance of the intrinsic and extrinsic fracture processes and size of the zones where they are active. Addition examples illustrating the importance of the scales to obtain a size dependent or size independent resistance fracture resistance will be discussed on the base of the similitude concept.



(a) **(b)**

Figure 2. Illustration of the effect of a single overload on the R-curve for the threshold of stress intensity factor range at a stress ratio R=0.1, in materials with different crack propagation mechanisms [3], (a) in intermetallic TiAl alloy and (b) a quenched and tempered steel [4].

3. Conclusions

When the stress and strain as well as the history of the stresses and strains of the volume elements in the fracture process zone is the same the same crack propagation resistance can be expected. Hence for the occurrence of a size independent or size dependent crack propagation resistance the knowledge of the crack propagation mechanisms and the size of the zones where fracture takes place as well as the size of zone of the extrinsic acting mechanisms are essential.

Selected References

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