CRACK PROPAGATION IN AUSTENITIC SHEETS

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INTRODUCTION

Crack propagation in sheets of austenitic stainless steel is always accompanied by large plastic deformation even at considerable distance from the crack tip. We shall use linear-elastic fracture mechanics to obtain an estimate for the amount of energy needed for the formation of the crack surface although this is not a common procedure in the case of fully plastic crack propagation. Our aim is to establish a set of geometry independent quantities that might be successfully used in a description of the process under consideration.

TESTING PROCEDURE

The specimens cut from austenitic steel sheet of 0.25 mm thickness (Figure 1) were strained at 1 mm/min in a 100 kN tension testing machine. The notches had been produced using a disk saw of 0.1 mm thickness. During the test the actual crack length, a, defined as $(a_1 + a_2)/2$ was marked in the load-displacement-diagram.

It can be seen from Figure 2 that substantial plastic deformation takes place even as the crack propagates. In contrast to linear elastic behaviour the load can still rise during the process of crack propagation. The corresponding elastic strain can easily be calculated from the load and the compliance measured. This part of the total strain proves to be fairly constant during the test (Figure 2, bottom line) and varies with the initial crack length.

Comparing tests for different initial crack lengths (Figure 3), one notices that at given length of the propagating crack the load decreases as the initial crack length increases. The average "true" stress, however, referring to the actual cross section at the start of crack propagation apparently coincides for all specimens at about 500 N/mm^2. For large crack lengths it seems to approach 1272 N/mm^2, which is the true fracture stress of the unnotched specimen. The width of the crack surface (Figure 4) is 0.1 mm for all tests, and the maximum Vickers hardness close to the crack surface lies at about 2800 N/mm^2.

If one tries to evaluate the energy supply during crack propagation using the load-extension-curve one finds a similar behaviour for all specimens (Figure 5). The linear elastic energy release rate (G) can be used to obtain an upper bound for the maximum elastic energy that can be released in the vicinity of the crack tip, which turns out to be approximately 1% of the total energy supplied.

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INTERPRETATION OF RESULTS

We had not been successful in using standard fracture mechanical methods on the Dugdale model [1 - 3] to interpret our results. It is rather the behaviour of the crack extension force calculated without any plastic correction which suggests a tension criterion governing the whole process. It will need some further investigations to complete this result.

REFERENCES

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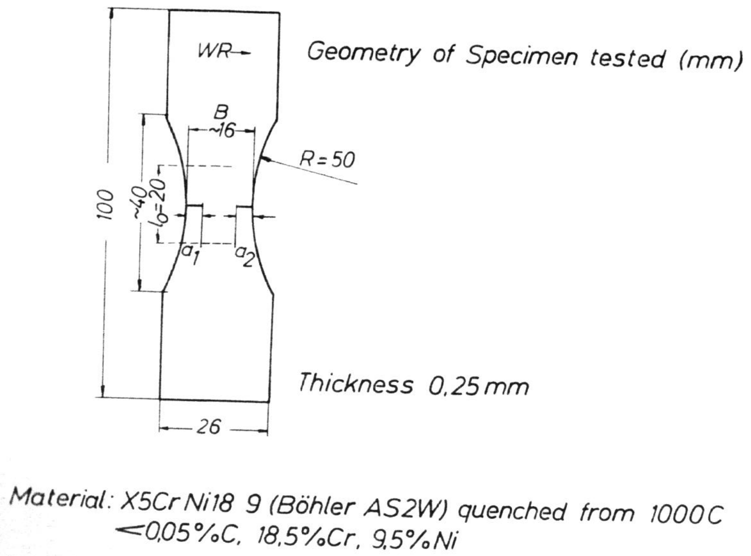

Figure 1 Geometry of Specimen Tested (WR = Rolling Direction)

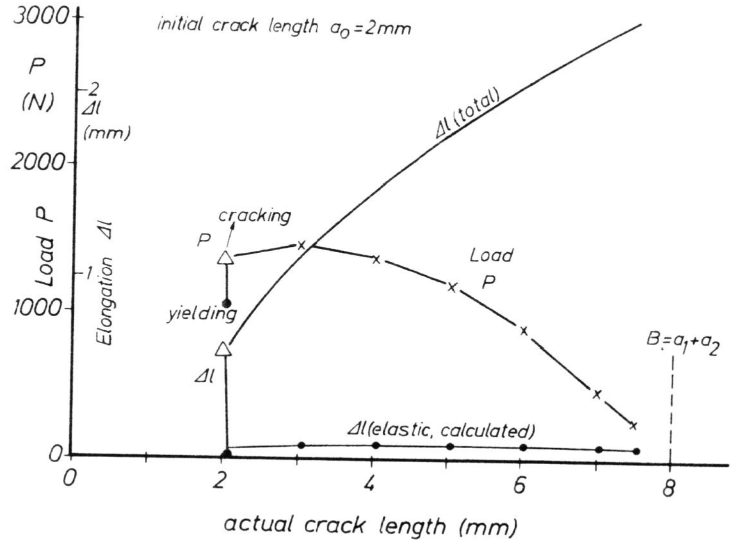

Figure 2 Quantities Measured During a Crack Extension Test (a_o = 2 mm)

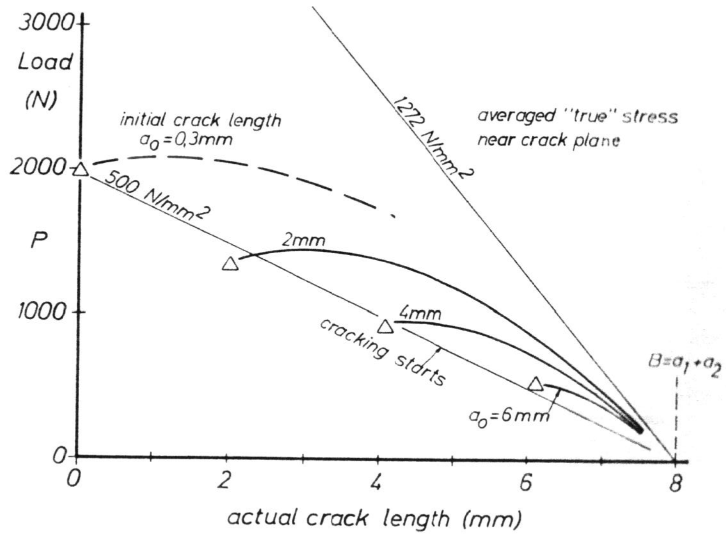

Figure 3 Crack Extension Curves for Different Initial Crack Lengths

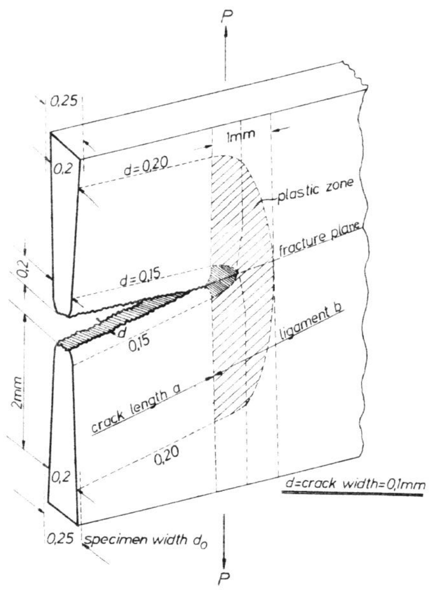

Figure 4 Geometry Near the Crack Tip in Austenitic Steel Sheets

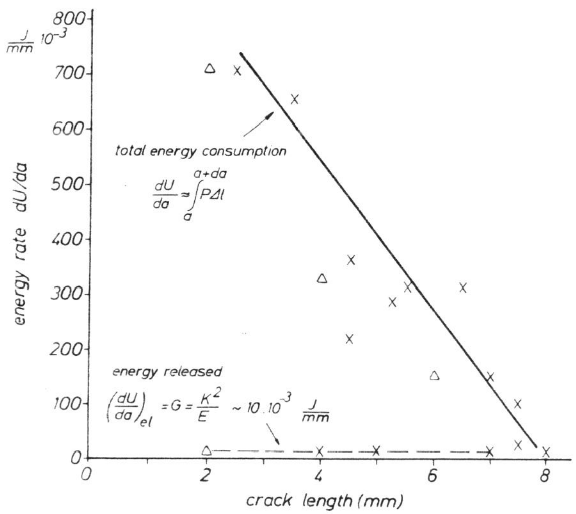

Figure 5 Comparison of Crack Extension Energy Rates