# CREEP CRACK GROWTH BEHAVIOUR OF SELECTED TURBINE STEELS

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## INTRODUCTION

For the characterization of creep cracking under predominantly static loading, the parameters stress intensity factor $K_I$ and $C^*$ -Integral are generally used in creep fracture mechanics. The purpose of this work is to show the limits of the different concepts in describing the crack growth behaviour and to check the transferability to components.

## TEST RESULTS

For the characterization of creep crack growth behaviour specimens of type DENT with 60 x 100 mm (D 60) and 9 x 10 mm (D 9) cross section, side grooved CT-specimen with 25 and 50 mm thickness (Cs 25 and Cs 50) and also CT-specimen without side grooves with 100 mm thickness (C 100) were tested. The specimens made of 1 % CrMoV-steel have been running with constant load at 550 °C and test duration up to 10 000 h. The $C^*$ -values are calculated with the following relations for CT-specimens (plain stress):

$$C_1^* = a \cdot A \cdot \sigma_{net}^{n+1} \cdot g_1\,(a/W, n) \qquad (1)$$

$$C_2^* = \dot{v} \cdot \sigma_{net} \cdot g_2 \cdot (a/W, n) \qquad (2)$$

and for DENT specimens (plain stress)

$$C_1^* = A \cdot h_1 \cdot \sigma_{net}^{n+1} \cdot (W-a) \,/\, (2/\sqrt{3})^{n+1} \qquad (3)$$

$$C_2^* = \sqrt{3}/2 \cdot \sigma_{net} \cdot \dot{v}\,(h_1/h_3) \qquad (4)$$

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In these relations $g_1$, $g_2$, $\beta$ and $\eta$ are determined according to a procedure described in (1), and constants A and n are obtained from the Norton power law. The creep crack growth rate for various specimen geometries and load conditions is shown in Fig. 1 as a function of the stress intensity factor $K_I$ and in Fig. 2 and 3 in dependence on the parameter $C_1^*$ and $C_2^*$ In these figures, $K_{I\,o}$ and $\sigma_{n\,o}$ represent the values at the beginning of the test. A comparison of the parameters $K_I$ and $C^*$ allows the following statements.

- Parameter $K_I$:

A larger crack growth rate can be observed at specimens which have a smaller initial nominal stress $\sigma_{n\,o}$, if there is the same specimen size and constant $K_I$-value. Concerning specimens of different size (e. g. Cs 50 to C 100) and constant $\sigma_{n\,o}$-value, the larger specimens have a smaller creep crack rate. Due to observed influence of the specimen size an upper limit in the scatter band $\dot{a}$-$K_I$ can be estimated.

- Parameter $C_1^*$:

The results of specimens Cs 50 and C 100 fall out of the scatter band of small specimens Cs 25. DENT-specimens lie in the lower region of the scatter band. The influence of the specimen size can't be estimated, that is, an upper limit of the scatter band cannot be specified.

- Parameter $C_2^*$:

The large-sized specimens Cs 50 and C 100 are situated in the upper region of the small-sized specimens' Cs 25 scatter band. DENT specimens lie in the lower region of the scatter band. Since large-sized specimens have higher creep crack growth rates than small-sized specimens the transferability to components is not conservative.

## CONCLUSIONS

In laboratory tests, displacement rate measurement in general does not present any difficulties. However, displacement measurements at structural components are hardly possible in practice. To be able to make an optimum use of the $C_2^*$ results it is indispensable to clarify the differences between $C_1^*$ and $C_2^*$ results.

## REFERENCES

(1) Kumar, V.,H.D. German and C.F. Shih, EPRI NP - 1931, Project 1237-1, July (1981).

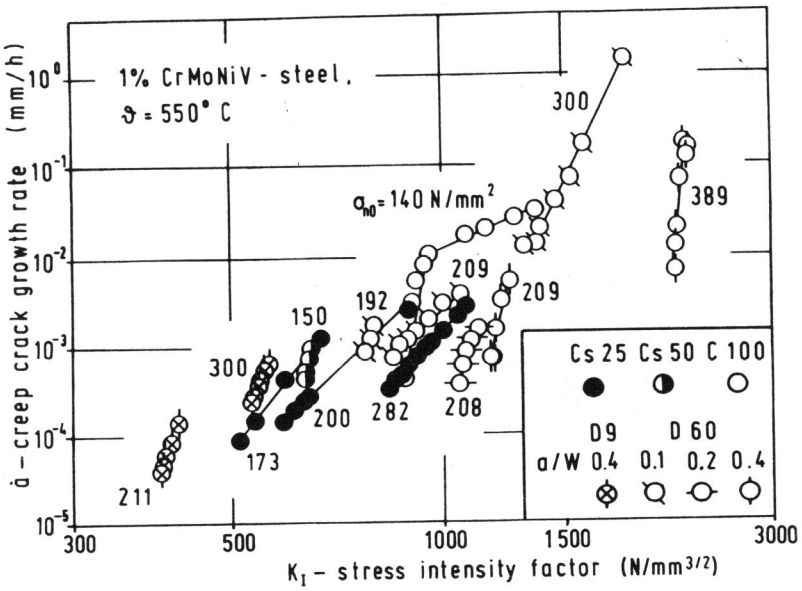


Figure 1 Relationship between creep crack growth rate and stress intensity factor $K_I$

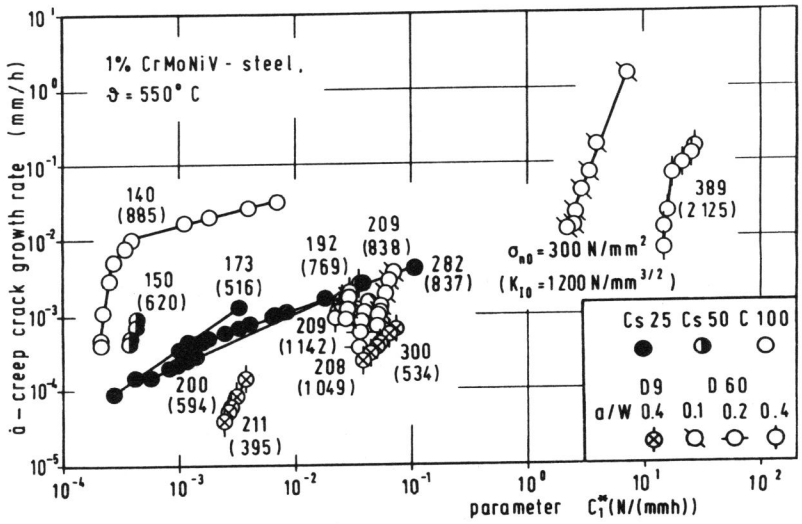


Figure 2 Relationship between creep crack growth rate and $C_1^*$

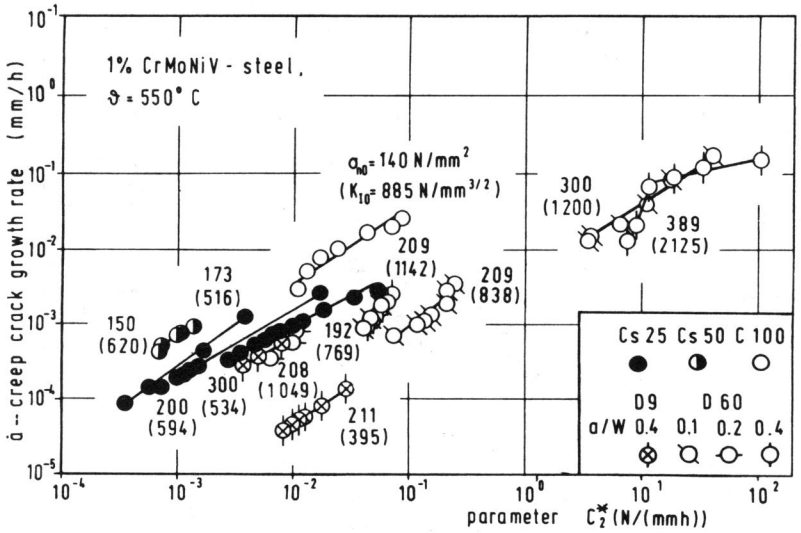


Figure 3 Relationship between creep crack growth rate and $C_2^*$