STRESS CORROSION CRACKING: DROP EVAPORATION TEST

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The drop evaporation method has been employed for stainless steel to determine how in the stress corrosion process the stress limit varies with the time to rupture. The Drop Evaporation Test is based on the evaporation of a 0.1 mol.l^{-1} NaCl solution on the surface of specimens heated by electric alternating current. The test was selected also in anticipation for the future use of the materials.

INTRODUCTION

The stress corrosion of steel is caused jointly by the effects of a corrosive environment and static or cyclic loading conditions (1). An understanding of the mechanisms involved in this process is essential, especially for assessing causes of failures at elevated temperatures in aqueous solutions of salts.

In practice stress corrosion occurs often in environments containing relatively small amounts of chlorides; in this case, however, salt sediments are formed at hot walls or at other places (e.g. in crevices). This is why attention is focused on a test method simulating the evaporation of a diluted solution of salts at elevated

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temperatures. Another possibility, to test the tendency to stress corrosion in diluted solutions is elevating the temperatures while simultaneously increasing the pressure in the retorts. The former method, consisting in evaporation of a diluted solution of NaCl on hot specimen, is simple and no specially high pressure are required; it very well simultates conditions under which stress corrosion cracking is frequently encountered in practice. Effects of thermal fatigue are also intercepted in this method.

Experiments and results. The susceptibility of materials to stress corrosion is evaluated by the "drop evaporation test" devised by Henrikson and Asberg (2). In this test the measurement and regulation of the temperature wasn´t possible so far.

The modified drop evaporation test for susceptibility to stress corrosion (3) was applied to austenitic and duplex stainless steels. The Evaporation Test, based on evaporation of NaCl solution (0.1 mol.l^{-1}) to the surface of specimen heated by electric alternating current, it was selected also in anticipation of the future use of the materials i.e. as parts of heat exchangers and coolers where relatively pure water is used, or where media containing low levels of aggressive substances.

The specimen which working length is 10 mm and diameter is 1,8 mm, is fixed horizontally in the tester and the uniaxial, constant-weigth load is applied on it. The specimen is resistance-heated by alternating current of approximately 24 A/1 V or less, according to the tested materials. The temperature is measured and adjusted by using optical thermometer. Droplets of the test solution of NaCl, are allowed to fall on the central portion of specimen at a rate of 10 droplets/min; the droplets fall from 135 mm long glass capillary tube (Ø D x Ø d = 4.7 x x 0.3 mm). Because the specimen is alternately heated and cooled due to the falling droplets, low-temperature fatigue load is also superimposed to the constant load. Since, under these testing conditions, general corrosion takes place in addition to the stress corrosion during prolonged testing, especially in case of lower-alloy material(for instance after approximately 500 h on 08Cr18Ni9 steel), a period of 1500 h was selected for determining threshold stress in higher-alloy materials.

Results of the testing of stress corrosion cracking of stainless steels (Table 1) with evaporation of a diluted aqueous solution of NaCl after regression analysis are shown in Figures 1-3,6 (where N means that the specimen wasn´t ruptured). Titanium-stabilised austenitic CrNi steel has very low resistance to stress corrosion cracking under these conditions, and the determination of threshold stress is rather doubtful (Figure 1). Threshold stresses in duplex steels are substantially lower-between 70 and 115 MPa-compared with those for the standard testing in $MgCl_2$(35%) at 120 °C (Figures 4,5). Comparing the conditions under which these two tests are carried out, it can be seen that the reduction in the level of corrosion strength limit in the duplex stainless steels was radically affected by the testing temperature. Ferritic stainless steel 03Cr18Mo2 demonstrates higher threshold stress, somewhere around 190 MPa, under these conditions.

CONCLUSIONS

The drop evaporation method has been employed to determine how the stress limit varies with the time to rupture in the stress corrosion process. It was found that stress corrosion not longer develops below a threshold stress of the tested steels.

SYMBOLS USED

R = stress limit (MPa)

R_m = tensile stress (MPa)

$R_p0.2$ = yield stress (MPa)

τ = time to rupture (h)

REFERENCES

(1) Sudarshan, T.S., Srivastan, T.S. and Harvey, D.P., Engineering Fracture Mechanics 36, 1990, 827.

(2) Henrikson, S. and Asberg, M., Corrosion 35, 1985, 429.

(3) Čihal, V. and Šandera, M., Equipment for testing to stress corrosion cracking of steels and alloys, PV 1970-88.

TABLE 1 - Chemical composition of the tested steels (weigth %)

No.	Type of steel	C	Cr	Ni	Mo	Ti	N
1	02Cr22Ni5Mo3N	0.022	21.95	4.98	3.10	-	0.118
2	02Cr22Ni6Mo3N	0.016	21.80	5.99	3.09	-	0.116
3	08Cr18Ni10Ti	0.076	18.02	9.98	0.013	0.52	0.018
4	03Cr18Mo2	0.020	18.76	0.37	2.10	0.42	0.114

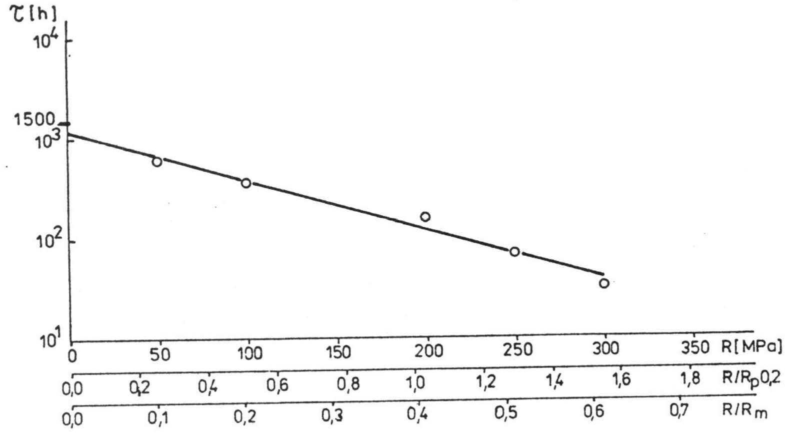

Figure 1 Stress/time to rupture dependence of steel N^{o}.3 (NaCl)

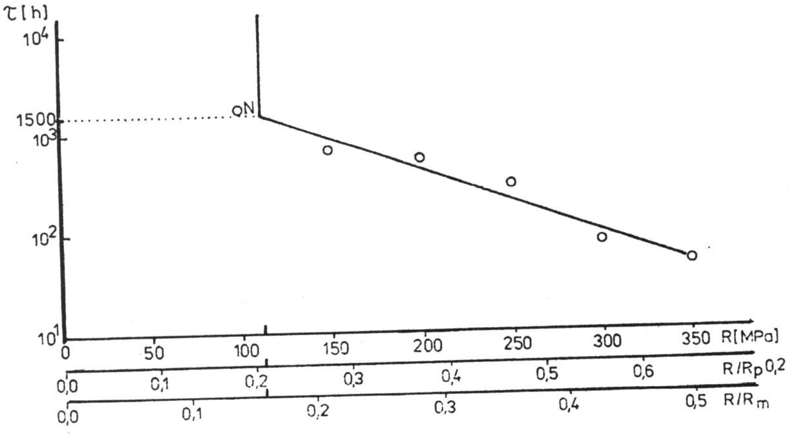

Figure 2 Stress/time to rupture dependence of steel N^{o}.1 (NaCl)

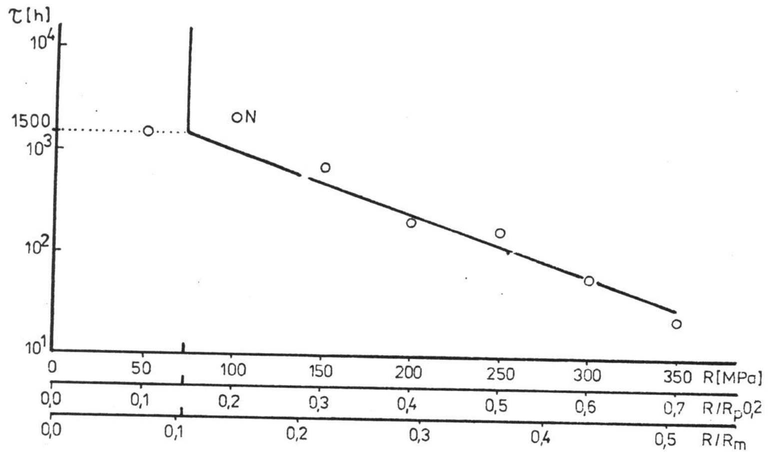

Figure 3 Stress/time to rupture dependence of steel N^{o}.2 (NaCl)

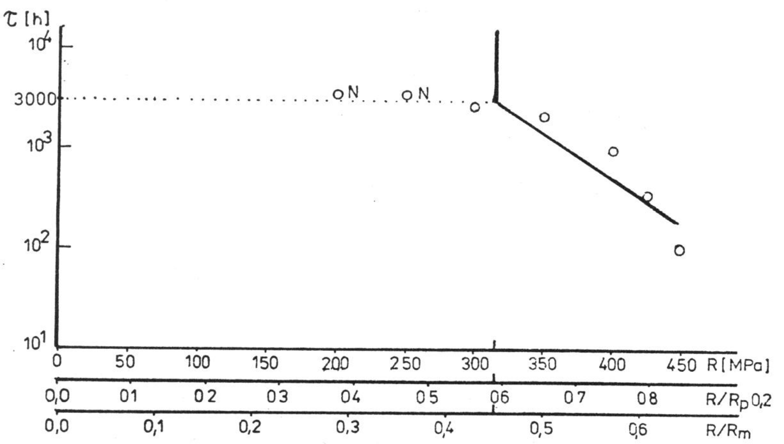

Figure 4 Stress/time to rupture dependence of steel N^{o}1. ($MgCl_2$)

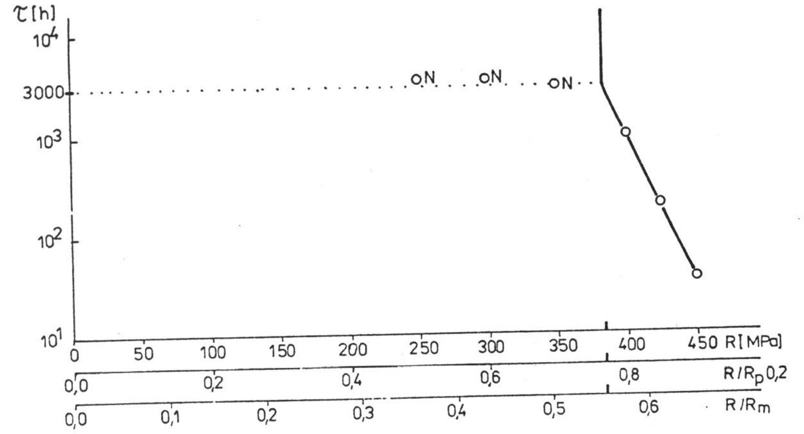

Figure 5 Stress/time to rupture dependence of steel N^{o}2 ($MgCl_2$)

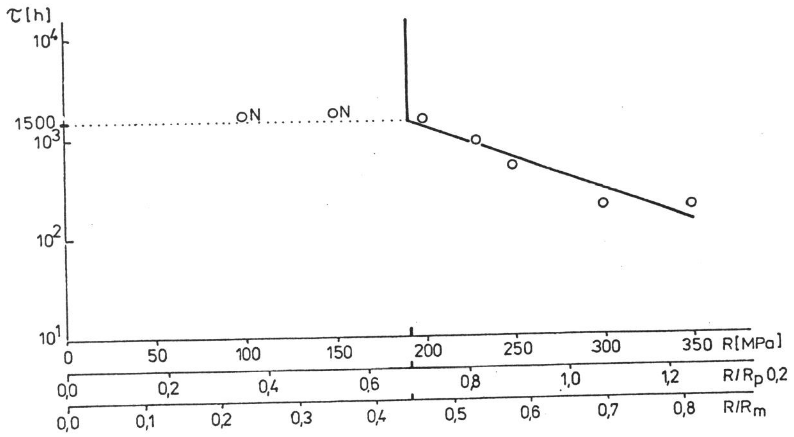

Figure 6 Stress/time to rupture dependence of steel N^{o}.4 (NaCl)