TEMPERATURE INFLUENCE OF FRACTURE TOUGHNESS K_{IV} FOR TWO THERMORESISTING STEELS

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These paper presents the metodology, the range of specimens and experimental results which were obtained in order to estimate the fracture toughness K_{IC} for two thermoresisting steels: X20CrMoV121 and 12H1MF. These steels are usualy used for romanian thermoelectrical power stations. The variation of fracture toughness K_{IC} is presented in function of testing temperature between 20°C and 600°C which covers the normal working temperature of pipe (T=540°C).

INTRODUCTION

Steam pipes are basical components of Romanian thermoelectrical power stations.These pipes have to be manufactured by steels having a well behaviour at high temperatures and pressures (T=540°C;p=14 MPa). The behaviour is estimated by the fracture toughness which is a global parameter also for deformability as well as for strength. Fracture toughness has to be measured with the aid of critical stress intensity factor K_{IC}, because the internal craks (their shape and orientation) are essential for the internal pressure in a steam pipe.

It was necessary to estimate the fracture toughness between 20°C and 600°C, which cover the normal working temperature of pipe, because the temperature is not constant and during switch-on and switch-off periods of the power station, temperatures take values between very large limits.

WORKING SPECIMENS AND APPLIED METHODOLOGY

In the beginning, for determining the fracture toughness K_{IC}, we used compact

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specimens for traction, Figure 1 (1). We suppose there are satisfied assesments regarding the plane strain, so it was possible to use this kind of specimen. There was not satisfied for the two thermoresisting steels X20CrMoV121 and 12H1MF, the relation:

$$a,t > 2.5(K_{IC}/R_{p0,2})^2 \qquad (1)$$

So, the values for K_{IC} which were estimated, could be resonable only without satisfying the plane stress or it is obviously necessary to use longer specimens. Unfortunatelly, it was not possible to use longer specimens because the wall of pipe is of a small thickness. That is the reason why we used Chevron specimens (see Figure 2), (2,3,4).

Fracture toughness K_{IV} was estimated for two thermoresisting steels by testing specimens from steam pipes which were not actually in work but will be fixed in the power station.

Chemical composition of thermoresisting steels which were analysed is emphasized in TABLE 1.

TABLE 1 - Chemical composition of thermoresisting steels X20CrMoV121 and 12H1MF

Steel	Chemical composition (%)						
	C	Si	Mn	Ni	Cr	Mo	V
X20CrMoV121	0.19	0.40	0.66	0.46	11.7	0.92	0.25
12H1MF	0.13	0.28	0.65	0.20	1.2	0.24	0.21

RESULTS AND CONCLUSIONS

There were used Chevron specimens (see Figure 2) in order to estimate the fracture toughness which was calculated by using relation (2):

$$K_{IV} = 22\, F_{max} / B^{1.5} \qquad (2)$$

Results which were obtained are emphasized in Figure 3. In this diagram is presented the average value of three estimations of K_{IV} at the same testing temperature.

It can be observed that temperature is influencing the fracture toughness K_{IV}. Increasing the temperature influence decreasing the fracture toughness K_{IV}.

Relations between K_{IV} and testing temperature T (°C) for steels which were analysed and for a temperature between 20°C and 600°C are as follow:

- for steel X20CrMoV121:

$$K_{IV} = 227.057 - 0.10435\,T \qquad (3)$$

- for steel 12H1MF:

$$K_{IV} = 126.279 - 0.05163\,T \qquad (4)$$

In these conditions, for keeping the safety of pipe when discovering cracks in the steam pipes, the solution is decreasing the working temperature.

SYMBOLS USED

a = crack length (mm)

t = thickness specimen (mm)

$R_{p0,2}$ = yield stress (MPa)

F_{max} = maximum force during loading (N)

B = width of Chevron specimen (mm)

K_{IV} = fracture toughness ($N/mm^{3/2}$)

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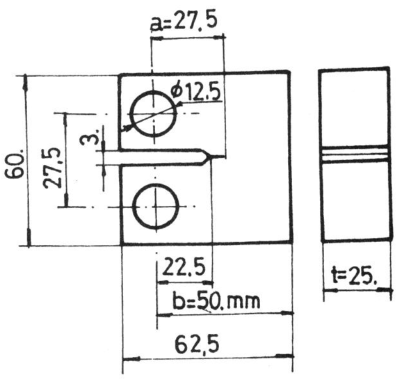

Figure 1 Compact specimen for traction

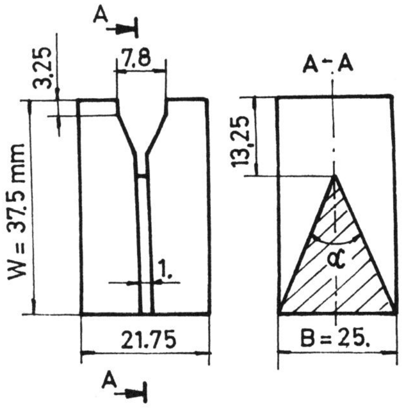

Figure 2 Chevron specimen used

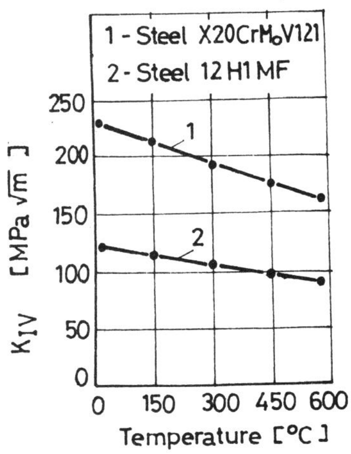

Figure 3 Variation of K_{IV} with the testing temperature