RELIABILITY EVALUATION OF CARBON AND LOW-ALLOY STEEL PRODUCTS FOR HIGH TEMPERATURE SERVICE

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A new method to characterize the service behaviour of steel products operating in creep conditions is presented based upon the reliability parameter - the probability of creep rupture initiation in given stress conditions. The reliability diagrams are presented for one grade of carbon steel and one grade of low-alloy steel. The use of reliability parameter in design of boilers and steam pressure vessels is discussed.

Creep strength of steels depends both on material and stress factors. Teking into account mainly the average values - as most current rules for creep evaluation state - the problems of finding the best correlation between product performances and specific service conditions is not entirely solved (1).

According to the data regarding the diminishing of the effective service reliability value for classical components of pressure vessels and steam boilers, it is considered that the creep loaded elements or mechanical structure must have a value of 1.10^{-3} - 1.10^{-5} (0,1% - - 0,001%) for the probability of creep rupture initiation after 100 000 hours of life (2).

The specific elements of the proposed method to evaluate the creep behaviour of heat-resistant steel products are shown in Figure 1. To exemplify this new approach, creep rupture tests were carried out on tube steel OLT 45 K - a carbon steel, similar to TS 9 in ISO 2604 - and on tube steel 14 CrMo 4 - a low-alloy steel equivalent to TS 32 in ISO 2604 for 1,93 x 10^6 hours (59 tests being over 10^4 hours).

The analysis of the results distribution found the classical Manson-Haferd method suitable for the two grades of steel. The results were then processed by the new method using the Weibull distribution on the entire range of test temperatures and stresses. Using optimising method, based upon the evolution tendency of the

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entire population of data for each grade of steel, the extrapolation constants and the parameters defining creep lives distribution were determined. The stresses ensuring specified values for the reliability parameter in the usual operating temperature range were calculated for 100,000 hours service life. On this basis the typical reliability diagrams for both steel grades at different service lives were drawn. For 100,000 hours service life these diagrams are shown in Figure 2.

It was also pointed out that in given creep condition a diminuation of the reliability parameter takes place during service.

The typical reliability diagrams bay be used in the design of elements of mechanical structure operating in creep conditions. They indicate the recommended range of service temperatures and stresses of steel products in a given safety value of the respective metallic structure. It is confirmed that the reliability parameter represents a material characteristic which emphasizes, better than the allowable stress, the products behaviour at high temperature. The reliability parameter has different values according to the main factors determining the initiation and growth of creep phenomenon - the stress and material factors. Using the reliability parameter, the maximum allowable limits of loading factors (stress, temperature) can be established for one steel grade and the appropriate selection of the steel grade can also be done in specified service conditions.

REFERENCES

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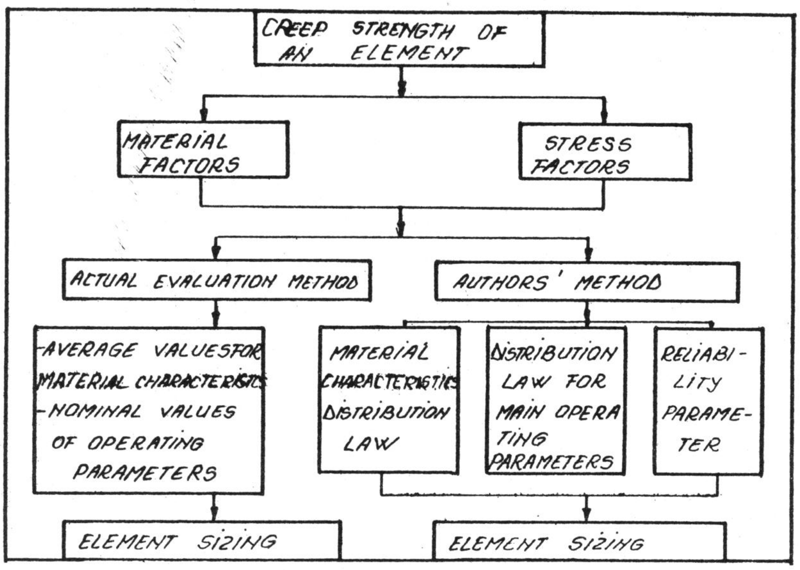

Figure 1 Methods for evaluation of creep behaviour

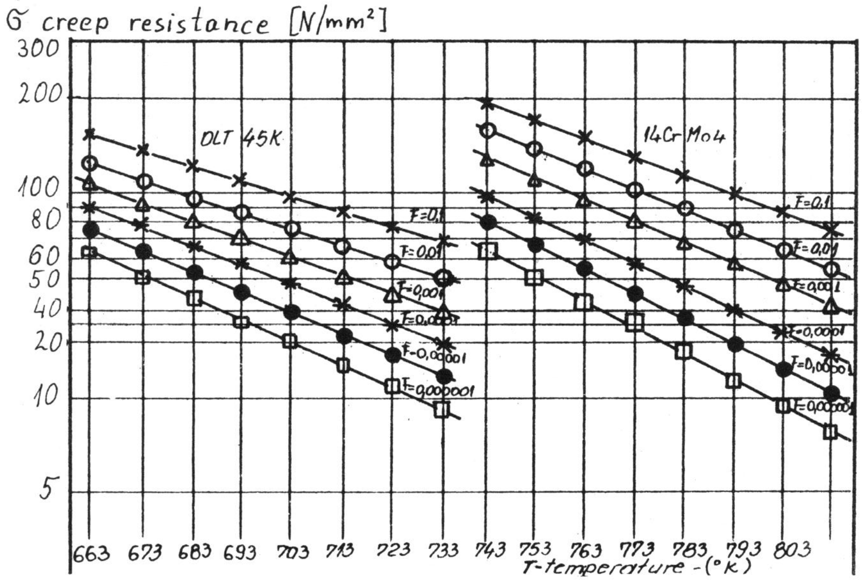

Figure 2 Reliability diagrams for 100,000 h service life