

ANALYSIS OF CYCLIC STRESS-STRAIN AND STRAIN-LIFE FATIGUE PARAMETERS AND BEHAVIOUR OF HIGH-ALLOY STEELS

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Abstract: Previous analyses of strain-life fatigue parameters and behaviour of different groups of metallic materials showed that statistically significant differences in fatigue parameters and behaviour exist among unalloyed, low-alloy and high-alloy steels. However, existing methods for estimation of cyclic and fatigue parameters consider these differences among different material groups in a very limited manner. While certain methods consider unalloyed and low-alloy steel groups separately, high-alloy steels as a group are generally omitted - likely due to the large differences and scatter in strain-life behaviour. Identification of specific material subgroups within high-alloy steels could be a solid basis for improving the accuracy of estimation methods. In this paper, systematic investigation and analysis of cyclic stress-strain and strain-life parameters and behaviour of materials belonging to high-alloy steel group was performed.

Keywords: stress-strain, strain-life, behaviour, high-alloy steels, parameter estimation

1. Introduction

Performing calculations and simulations of cyclic and fatigue behaviour of components and structures is possible only if materials' cyclic stress-strain and fatigue curves/parameters are known. Experiments are the most accurate way to determine these properties, however, cyclic/fatigue experiments are expensive, complex, time-consuming and often not available in the early design phases. Due to the fact that monotonic experiments are inexpensive, simple and fast, and their results are readily available, number of methods for estimation of cyclic stress-strain and strain-life fatigue parameters based on monotonic properties of material are proposed in the literature [1-8].

2. Material groups in existing cyclic/fatigue parameters estimation methods

Previous analyses of strain-life fatigue parameters and behaviour of different groups of metallic materials showed that statistically significant differences in fatigue parameters and behaviour exist among unalloyed, low-alloy and high-alloy steels [9]. However, existing methods for estimation of cyclic and fatigue parameters consider these differences in a very limited manner. For example, Universal slopes method and Four-point correlation method do not discern materials by the alloy family at all. Certain methods such as Hardness method [7] is developed for steels only while Uniform Material Law [6], considers unalloyed and low-alloy steels groups separately from aluminium and titanium alloys. Method of variable slopes [8] was developed specifically for prestrained steel sheets and divided steel materials into high-strength steels, mild steels, multiphase steels and austenitic steels subgroups. It can be noted that high-alloy steels are either included in some general material (steel) group or are, as a group, excluded altogether from the consideration in the above methods.

3. Analysis of stress-strain and strain-life parameters and behaviour of high-alloy steels

Analysis of the cyclic stress-strain and strain-life behaviour of high-alloy steels has shown significant amount of scatter and large differences among individual materials within high-alloy steels group. It is therefore expected that identification of specific material subgroups within high-alloy steels could be a solid basis for improving the accuracy of estimation methods. For this purpose, analysis of variance (one-way ANOVA) was performed on cyclic and fatigue parameters of high-alloy steels which were divided in subgroups. Furthermore, cyclic stress-strain and strain-life behaviour of these subgroups was evaluated by comparing corresponding data. Required material data for high-alloy steels were gathered from the MATDAT Material Properties Database [9].

4. Conclusions

Previously shown significant amount of scatter and large differences among individual materials within high-alloy steels group might be the reason for omission of this material group from existing estimation methods. Statistical analyses performed in this paper confirm the possibility that the classification of high-alloy steels into separate subgroups, possibly according to their microstructure or some other criteria, might improve the accuracy with which their cyclic and fatigue parameters can be estimated.

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