

Fatigue Testing by Means of Miniature Test Specimens

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Abstract

The paper describes the results of fatigue tests performed on miniature tests specimens in comparison with traditional fatigue tests for several steels (and one Al-alloy) applied in power producing industry. Special miniature test specimens fixtures were designed and manufactured for the purposes of fatigue testing at the Zwick/Roell – Amsler 10HPF5100 test machine. The miniature test specimens were produced of the traditional test specimens.

Introduction

The fatigue is still the prevailing cause of failure of metallic, plastic and ceramic components. In cases of cyclic loading of test specimens or structural components, the cumulation of cyclic plastic deformation causes failure below ultimate strength and even yield point values [1].

At present, reliable quantitative evaluation of remaining lifetime become urgent and because fatigue is the most frequent cause of materials degradation and resulting structural components failures, the most important means of remaining lifetime assessment is the evaluation of fatigue properties before and after some time of service. The original material data are usually tested by means of traditional test specimens, which can be hardly used in case of components in service, where there is no possibility to withdraw sufficient volume of representative material for the traditional test specimen manufacturing. In such cases today, new untraditional methods of semi-destructive removal of a small volume of test material by grinding or an electro-discharge method are utilized, [2]. This makes it possible to produce a miniature test specimens, for example see Figure 1. The direct comparison of the results must be then based on reliable correlation between traditional and miniature test specimen results, because of the stress concentration in case of miniature specimens, [3].



Figure 1. Miniature Test Specimen for Fatigue Test

Materials and experimental results

The fatigue testing was performed by means of Zwick/Roell - Amsler 10 HPF5100 test machine. New special grips were designed for the purposes of miniature test specimens testing, their design makes it possible an exact test specimens gripping with respect to both longitudinal and transversal axes.

Seven different steels and an Al-alloy were fatigue loaded ($R = 0,1$) at room temperature, the examples of obtained results are shown in Figures 6 – 10.

Miniature steel test specimens were produced by water jet cutting so that the direction of load action was the same as in the traditional flat test specimens, see Figures 2 and 3.



Figure 2. Traditional fatigue test spesimens (steel samples)



Figure 3. Miniature fatigue test specimens (steel samples)

For the test specimens of Al-Alloy, both the traditional and miniature ones, see Figures 4 and 5. The dimensions of cylindrical fatigue test specimens were 8/5 mm (diameters) and 65 mm (length).

The experimental results in this paper come from commercial tests and thus the chemical composition of the tested materials and other details are not specified here. Some results were published also in [4].



Figure 4. Traditional fatigue test specimens (Al-alloy)



Figure 5. Miniature fatigue test specimens (Al-alloy)

Conclusion

It is well visible from the experimental results, that the $S - N$ curves of miniature test specimens have a steeper course in comparison with the traditional ones for all the tested materials. At present, no unique generally valid correlation between the classic and miniature test specimen results was found.

Better agreement was obtained in the case of the Al-alloy, the scatter of traditional test specimen results in comparison with the miniature ones can be explained by material inhomogeneity (containing even macrodefects), whereas the miniature test samples were machined from one location.

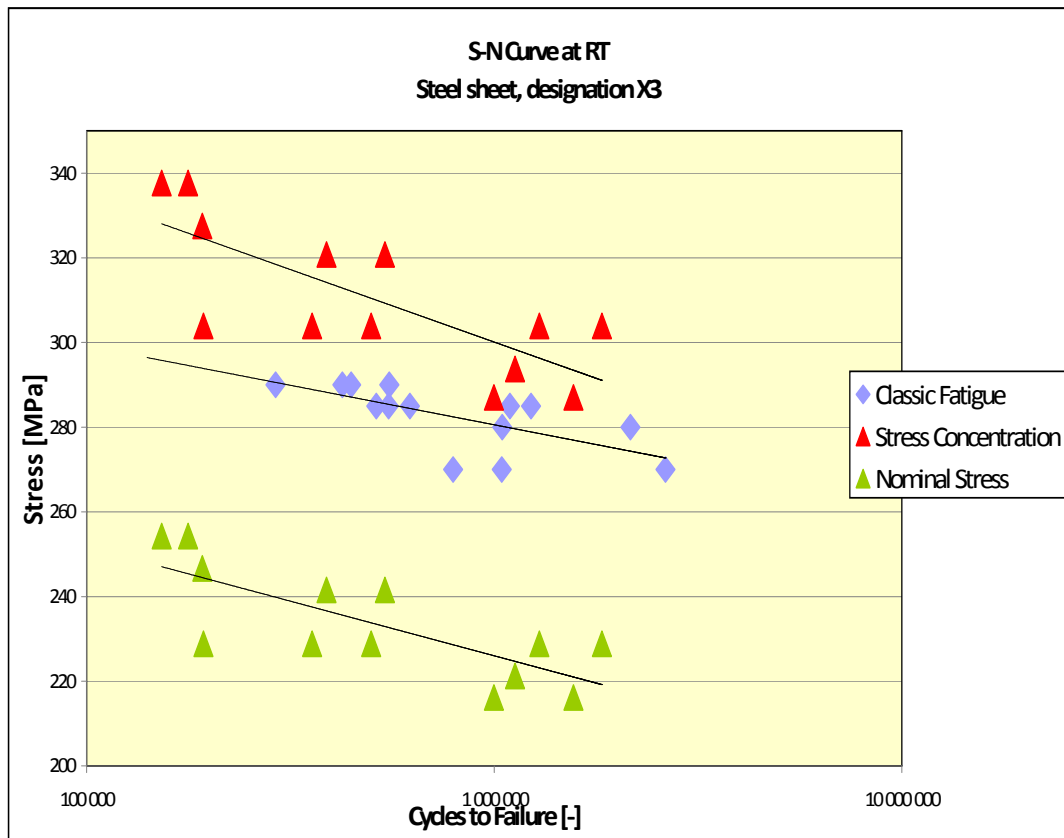


Figure 6. An Example of S-N Curve of the X3 Steel

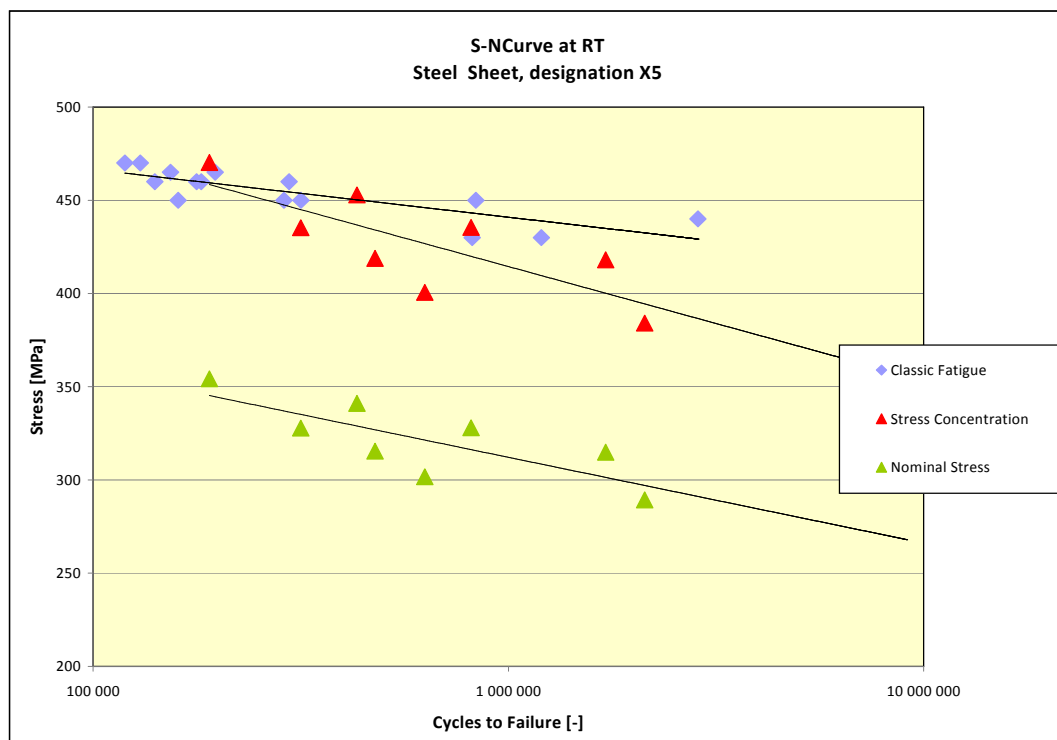


Figure 7. An Example of S-N Curve of the X5 Steel

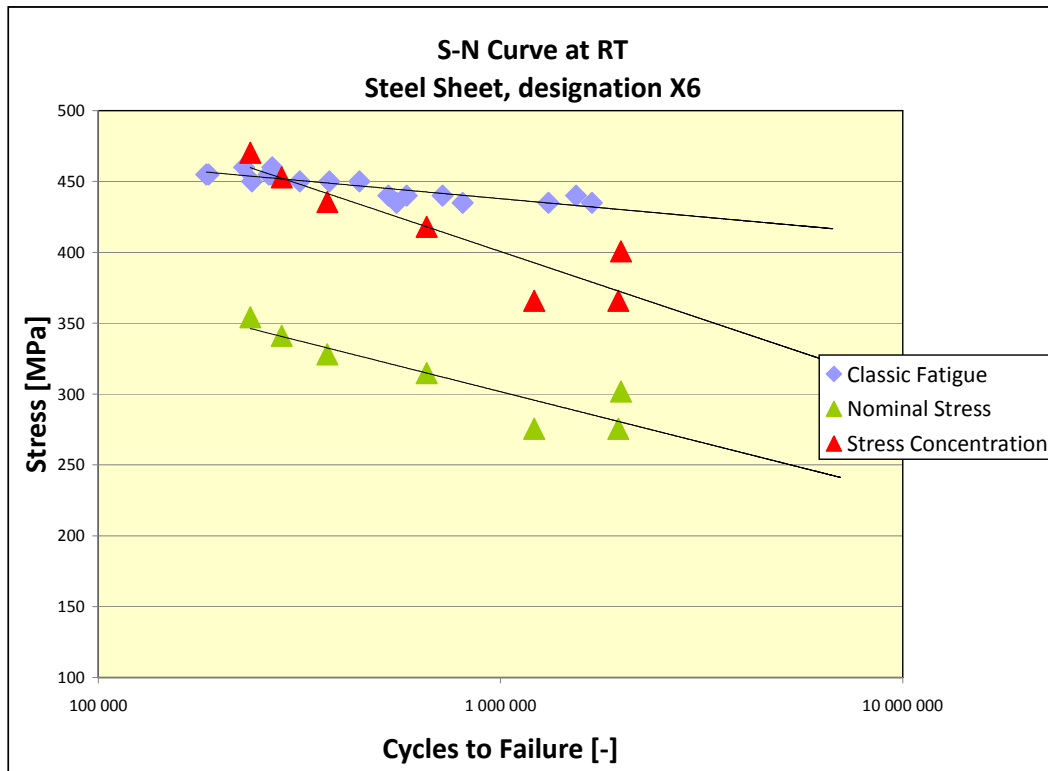


Figure 8. An Example of S-N Curve of the X6 Steel

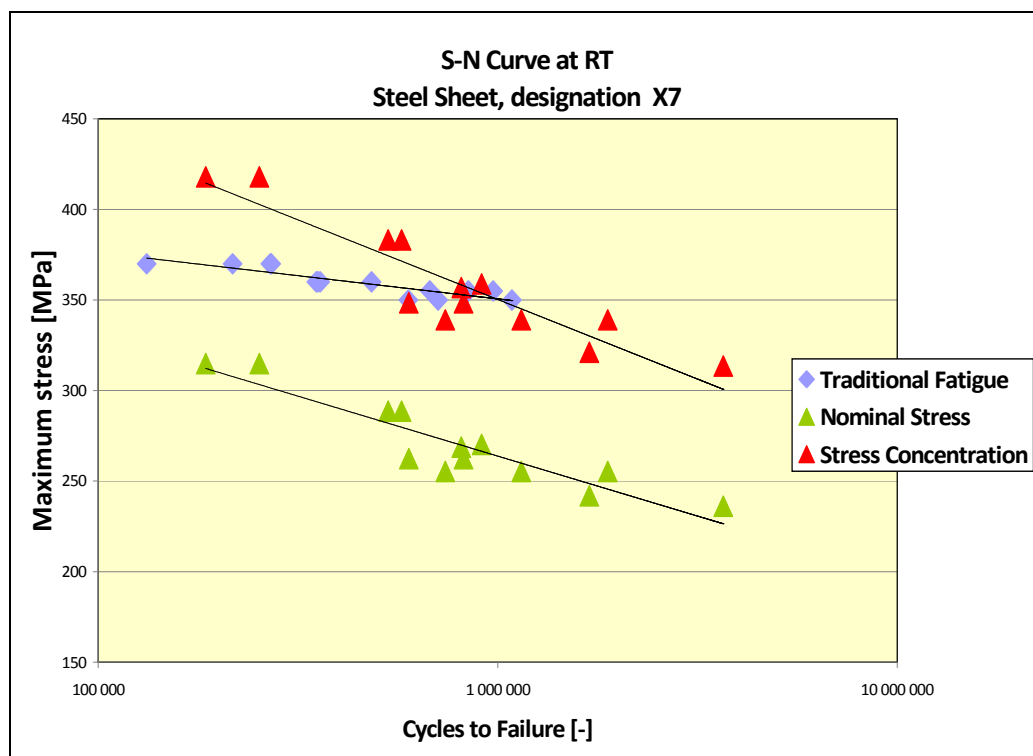


Figure 9. An Example of S-N Curve of the X7 Steel

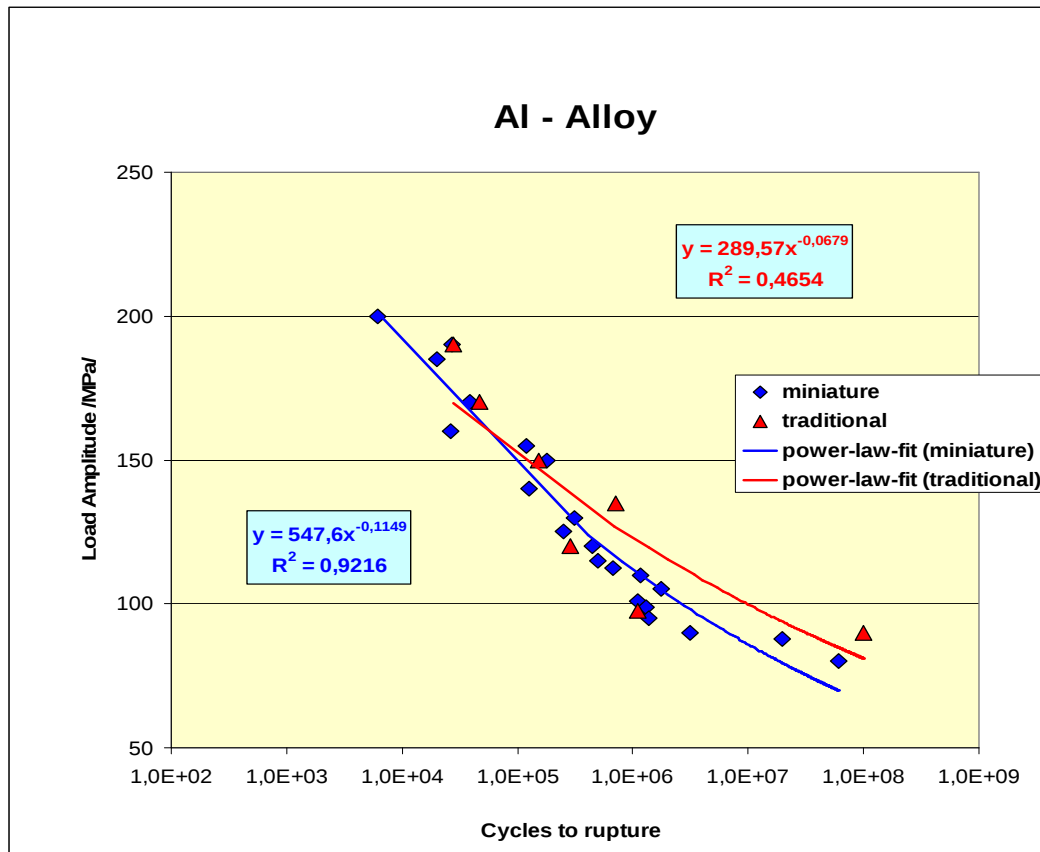


Figure 10. Comparison of S – N Curves for Al- Alloy

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