Journal of Achievements in Materials and Manufacturing Engineering

VOLUME 55
ISSUE 2
December
2012

Fatigue testing by means of miniature test specimens

J. Volak [a], M. Novak [a], J. Kaiser [b], V. Mentl [b,*]
[a] Research and Testing Inst. Ltd., Pilsen, Czech Republic
[b] University of West Bohemia, Pilsen, Czech Republic
* Corresponding e-mail address: mentl@kmm.zcu.cz

Received 08.10.2012; published in revised form 01.12.2012

Materials

ABSTRACT

Purpose: The purpose of the paper is to describe fatigue testing by means of miniature test specimens.
Design/methodology/approach: 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. Seven different steels and an Al-alloy were fatigue loaded (R = 0.1) at room temperature.
Findings: 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.
Research limitations/implications: At present, questions on 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.
Originality/value: The original material data are usually tested by means of classic 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 classic test specimen manufacturing. In such cases today, new modern methods of semi-destructive removal of a small volume of test material by grinding or an electro-discharge are utilized. This makes it possible to produce a miniature test specimens.
Keywords: Fatigue testing

Reference to this paper should be given in the following way:
J. Volak, M. Novak, J. Kaiser, V. Mentl, Fatigue testing by means of miniature test specimens, Journal of Achievements in Materials and Manufacturing Engineering 55/2 (2012) 386-389.

1. 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 utilised, [2]. This makes it possible to produce a miniature test specimens, for example see Fig. 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].

Fig. 1. Miniature fatigue test specimen

2. Materials and experimental results

The fatigue testing was perfomed 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 Figs. 6-10. In the diagrams, the “classic” signifies the results of traditional test specimens, “stress concentration” and “nominal stress” represent experimental data obtained by means of miniature test specimens, when nominal stress and/or stree concentration was taken into account.

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 Figs. 2 and 3.

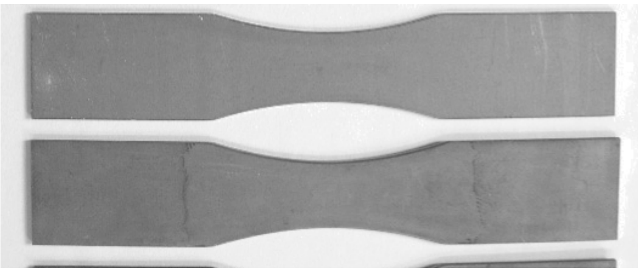

Fig. 2. Traditional fatigue test specimens (steel samples)

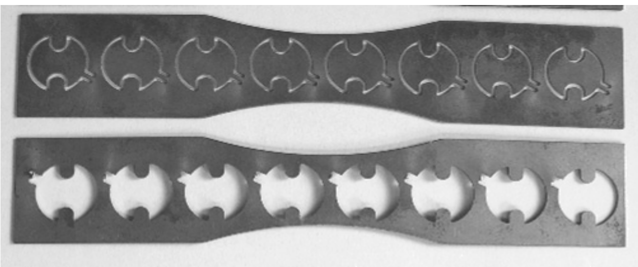

Fig. 3. Miniature fatigue test specimens (steel samples)

For the test specimens of Al-Alloy, both the traditional and miniature ones, see Figs. 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].

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

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

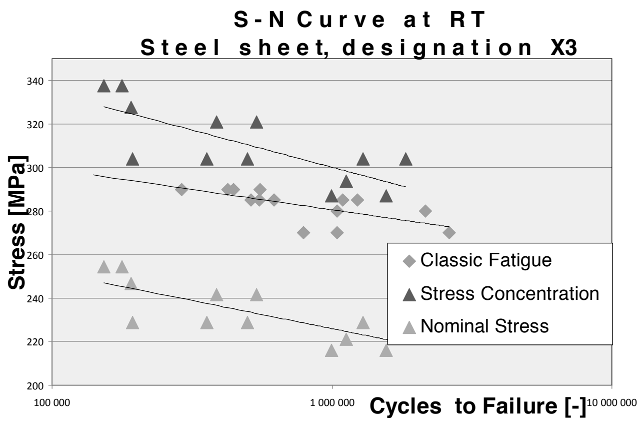

Fig. 6. S-N Curves of the X3 steel

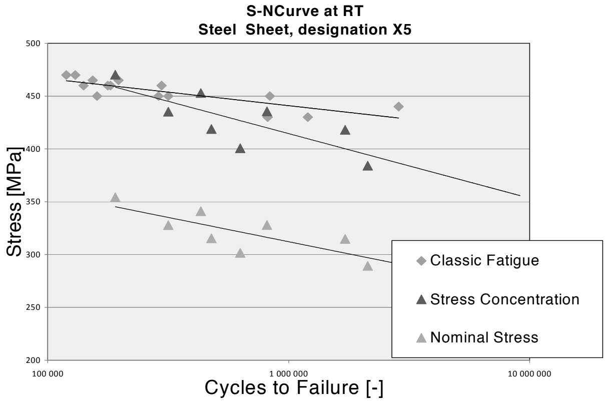

Fig. 7. S-N Curves of the X5 steel

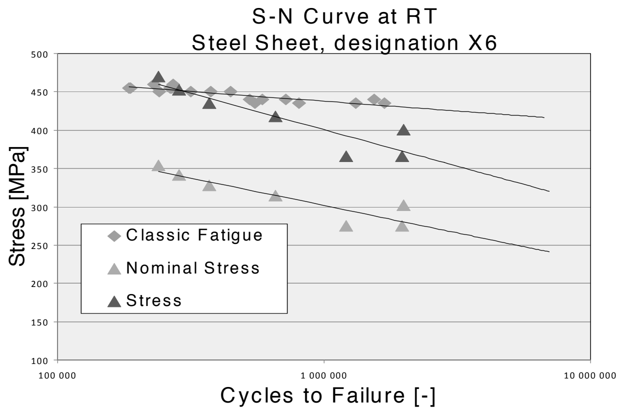

Fig. 8. S-N Curve of the X6 steel

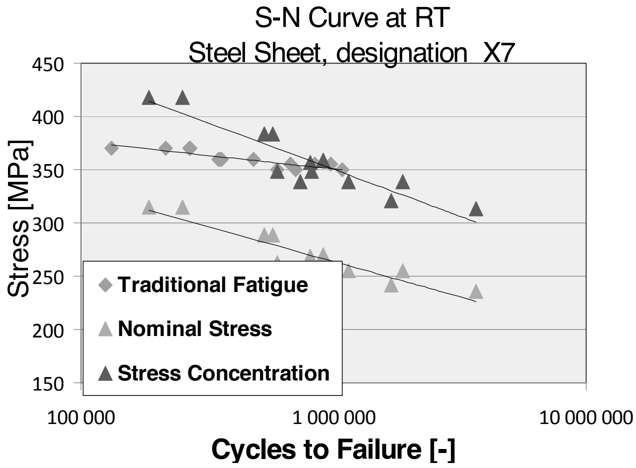

Fig. 9. S-N Curves of the X7 steel

3. Conclusions

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 inhomogenity (containing even macrodefects), whereas the miniature test samples were machined from one location.

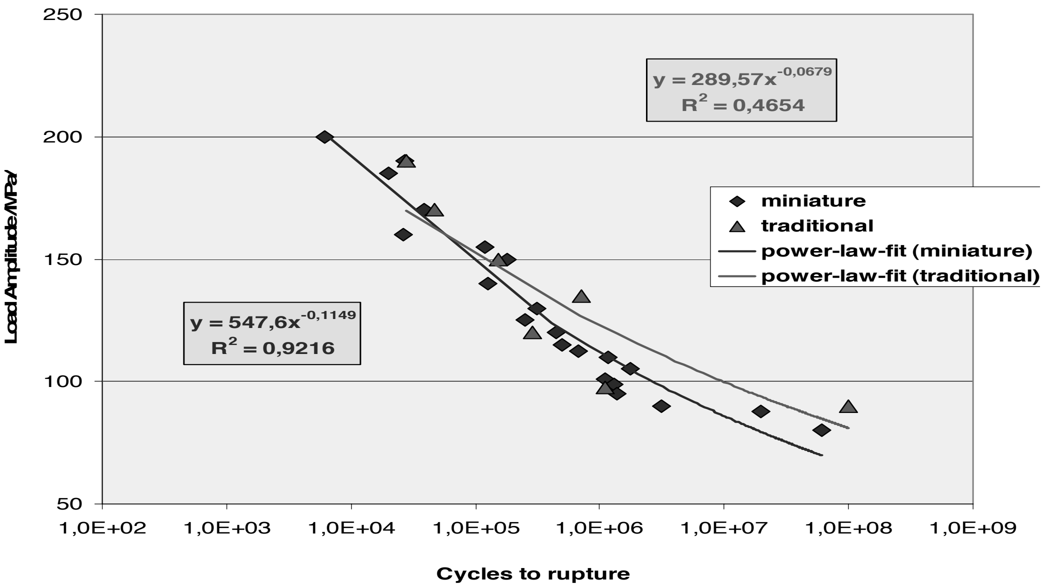

Fig. 10. Comparison of S - N Curves for Al-alloy

Acknowledgements

The research was supported by the Czech Grant Agency, project No. P105/10/2052.

References

[1] M.E. Fine, Y.W. Chung, Fatigue failure in metals, fatigue and fracture, ASM International Handbook Committee, Vol. 19, 1996.

[2] V. Mentl, J. Volák, Comparison of fracture toughness values determined by standardized: method and small punch test, Proceedings of the 18th European Conference on Fracture „Fracture of Materials and Structures from Micro to Macro Scale“, Dresden, 2010, 126.

[3] V. Mentl, M. Chocholoušek, J. Volák, P. Kindelmann, Korelace únavových charakteristik ocelí pro energetiku měřených na klasických a miniaturních zkušebních tělesech, Proceeding of the Conference “Zvyšování životnosti komponent energetických zařízení v elektrárnách“, Srní, 2009 (in Czech).

[4] J. Volák, V. Mentl, A Comparison of fatigue characteristics of structural steels measured by means of classic and miniature test samples, The Ninth International Conference on Multiaxial Fatigue and Fracture, Parma, 2010.