Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 213 (2018) 824–829

Procedia Engineering

www.elsevier.com/locate/procedia

7th International Conference on Fatigue Design, Fatigue Design 2017, 29-30 November 2017, Senlis, France

P92 and 15CH2NMFA Steels – A Comparison of Fatigue Characteristics obtained on standard and miniature test specimens

VOLAK Josef*, BUNDA Zbynek, MENTL Vaclav

Regional Technological Institute, University of West Bohemia, Pilsen, Czech Republic

Abstract

In this paper, the results of the fatigue tests of the P92 and 15CH2NMFA steels are presented and discussed. The fatigue S – N curves were obtained by means of both standard and miniature test specimens. The Small Fatigue Test (SFT) specimens were manufactured partially by machining and also by waterjet cutting.
The fatigue tests were performed on Amsler 10 HFP 5100 ZWICK//Roell high-frequency pulsator at room temperature and R = 0,1 and R = -1 cycle asymmetries. The results obtained on standard and SFT specimens are compared and in case of P92 steel are also compared the two methods of SFT specimens manufacturing.
In case of 15CH2NMFA steel, the results of standard and SFT specimens are in a very good agreement both within the time limit fatigue range and the fatigue limit. After taking the stress concentration of SFT specimens into consideration, the results of traditional fatigue test samples and SFT samples are similar.
In case of P92 steel, the leaning branch of S-N curves is much steeper for SFT specimens and the fatigue limits lower than it could be expected after the stress concentration is taken into account. The fatigue limits for equal cycle asymmetry show the same ratio of standard to SFT fatigue limits, for R = 0,1 it is 1,31, for R = 1 it is 1,32. This very good agreement can be used for the evaluation of fatigue behaviour of P92 steel by means of SFT specimens.
The comparison of the two ways of SFT samples manufacturing revealed a scatter of fatigue test results, nevertheless the fatigue limits differ by 5 MPa only, so that even the influence of the manufacturing seems to be negligible.

Peer-review under responsibility of the scientific committee of the 7th International Conference on Fatigue Design.

Keywords: Fatigue; Miniature test specimens; Standard test specimens; Stress concentration; P92 and 15CH2NMFA steels

* Corresponding author..
E-mail address: volak@rti.zcu.cz

1877-7058 © 2018 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 7th International Conference on Fatigue Design.
10.1016/j.proeng.2018.02.078

1. Introduction

At present, a great interest is given to the Small Punch Test method. Its greatest advantage is the almost non-destructive intervention into the integrity of mechanical components thanks to the small amount of the removed material. This "new" (also called) semi-destructive method makes it possible to evaluate the current status of operating components on small samples which do not disrupt the integrity of the operating components and makes it also possible to evaluate the current status without long outages. To perform the fatigue tests, the fatigue specimens "SFT" (Small Fatigue Test) according to [1], [2], see Fig.1, were used.

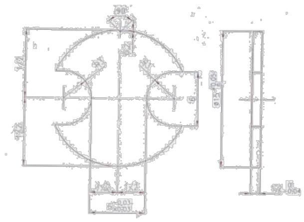

Fig. 1 Small Fatigue Test (SFT) specimen, [2]

2. Material for testing

Steels P92 and 15CH2NMFA were chosen for testing and correlation of small fatigue test and standard fatigue specimens as examples of steels often used in power producing industry.
The steel P92 is alloyed with 2 % of Tungsten (in comparison with the P91 steel) what increases its creep strength and makes it possible e.g. to reduce the pipe wall thickness up to about 20%. Microstructure of P92 samples (virgin material) is formed by tempered martensite (Figs. 2-5) with average hardness value 250 HV10.

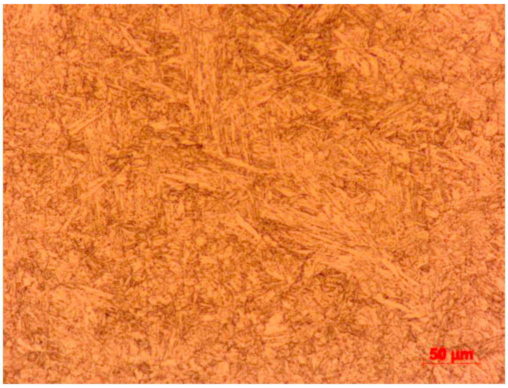

Fig. 2 Microstructure of the P92 steel, LM, 200x

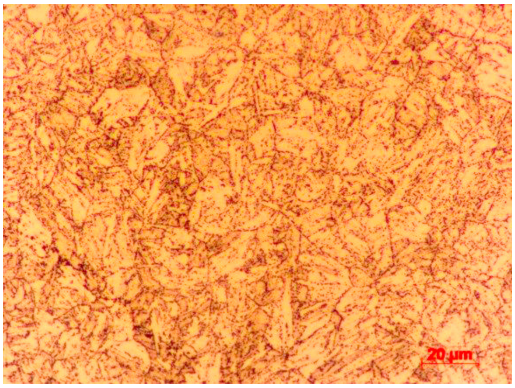

Fig. 3 Microstructure of the P9 steel, LM, 500x

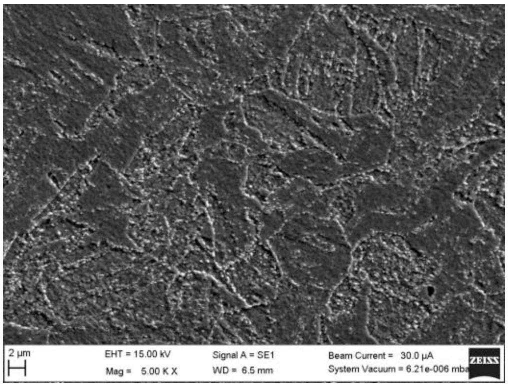

Fig. 4 Microstructure of the P92 steel, SEM, 5 000x

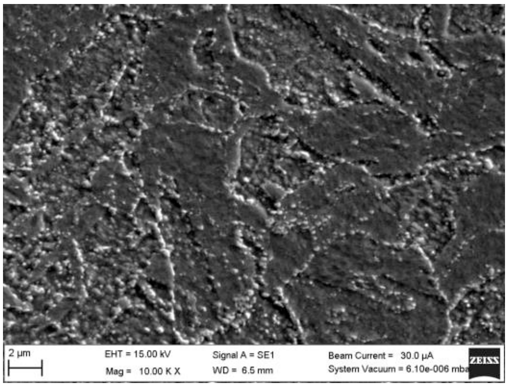

Fig. 5 Microstructure of the P92 steel, SEM, 10 000x

The **15CH2NMFA** steel is used for pressure vessels in nuclear energy industry. Microstructure of the 15CH2NMFA steel is formed by fine bainite (Fig. 6-9). Hardness was measured on the SFT sample and is about 221 HV1. The main requirements on this steel are weldability of thick-walled components, structural stability, good strength properties at operating temperatures, good brittle-fracture and degradation resistance caused by radiation [5].

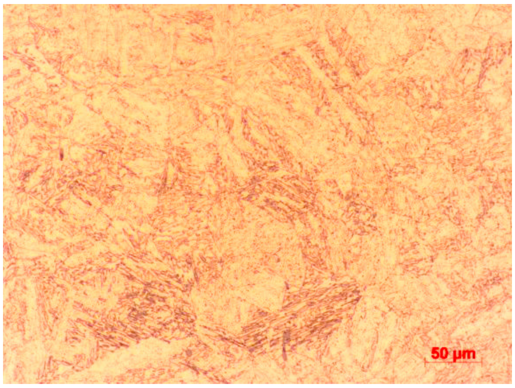

Fig. 6 15CH2NMFA microstructure, LM, 200x

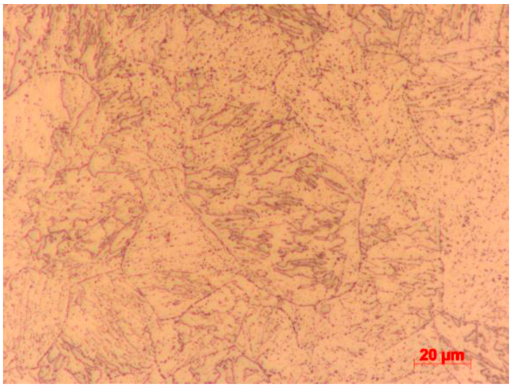

Fig. 7 15CH2NMFA microstructure, LM, 500x

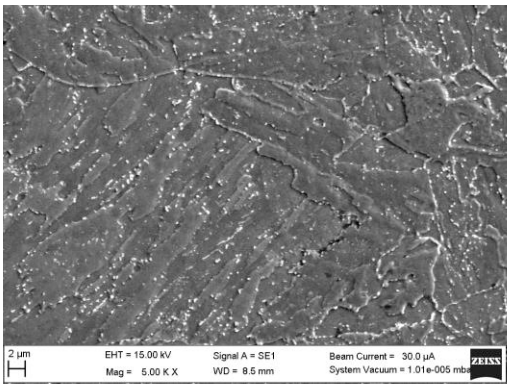

Fig. 8 15CH2NMFA microstructure, SEM, 5 000x

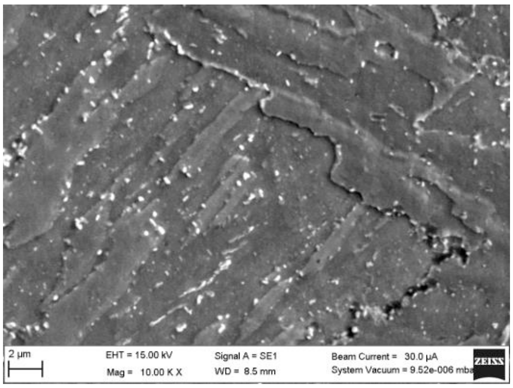

Fig. 9 15CH2NMFA microstructure, SEM, 10 000x

3. Test specimens production

The traditional specimens for fatigue tests were made according to Figure 10. SFT samples were produced both by the traditional methods of machining, see Fig.11, and water jet cutting, see Fig.12. The objective was to compare the conventional fatigue test results with the small specimens and also to compare the influence of SFT waz of production.

Fig.10 Standard test specimens

Fig.11 SFT specimens

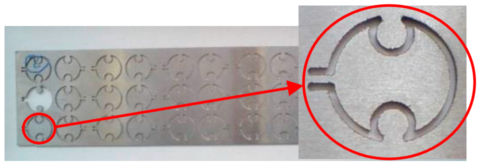

Fig.12 Water-jet cut SFT specimens

4. Fatigue test performance

An Amsler 10 HFP 5100 ZWICK//Roell pulsator was used for the realization of the fatigue tests. The tests were performed at cyclic loading in force control regime, the test frequency was f = 120 - 145 Hz, cycle asymmetry R = 0.1. The termination of tests was set at 107 cycles which corresponds to the fatigue limit of steel materials. The tests were performed at same conditions both on standard and SFT fatigue specimens.

5. Test results

The results of fatigue tests and comparison of standard and miniature test specimens are demonstrated in Figs. 13 to 15.

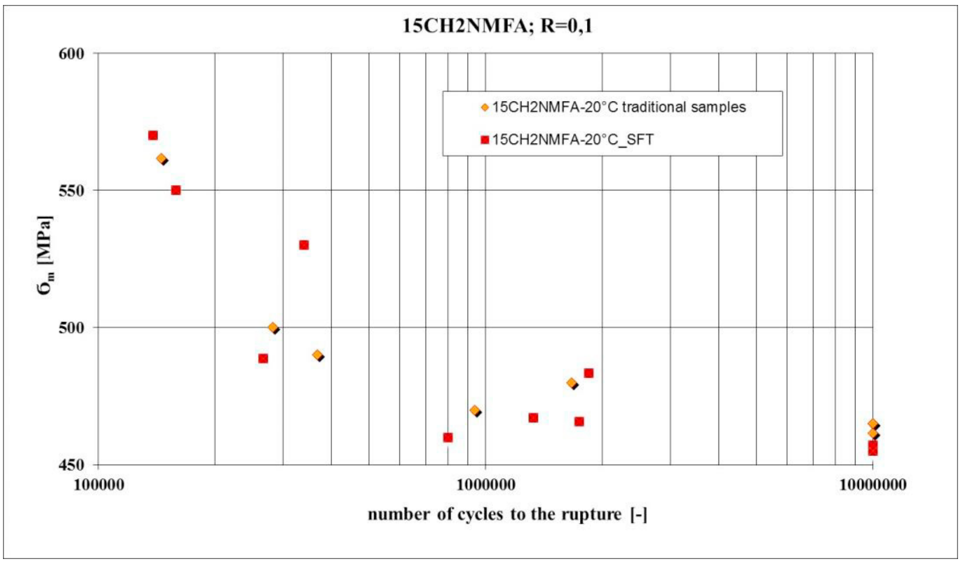

Fig. 13 Comparison of fatigue test results of traditional and SFT specimens, steel 15CH2NMFA, cycle asymmetry R = 0,1

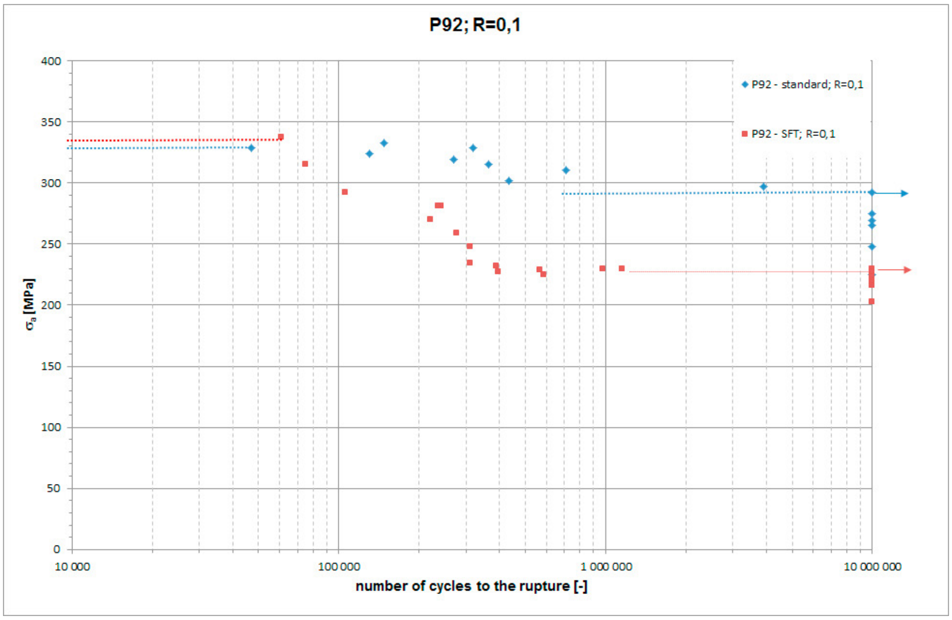

Fig. 14 Comparison of fatigue test results of traditional and SFT specimens, steel P92, cycle asymmetry R = 0,1

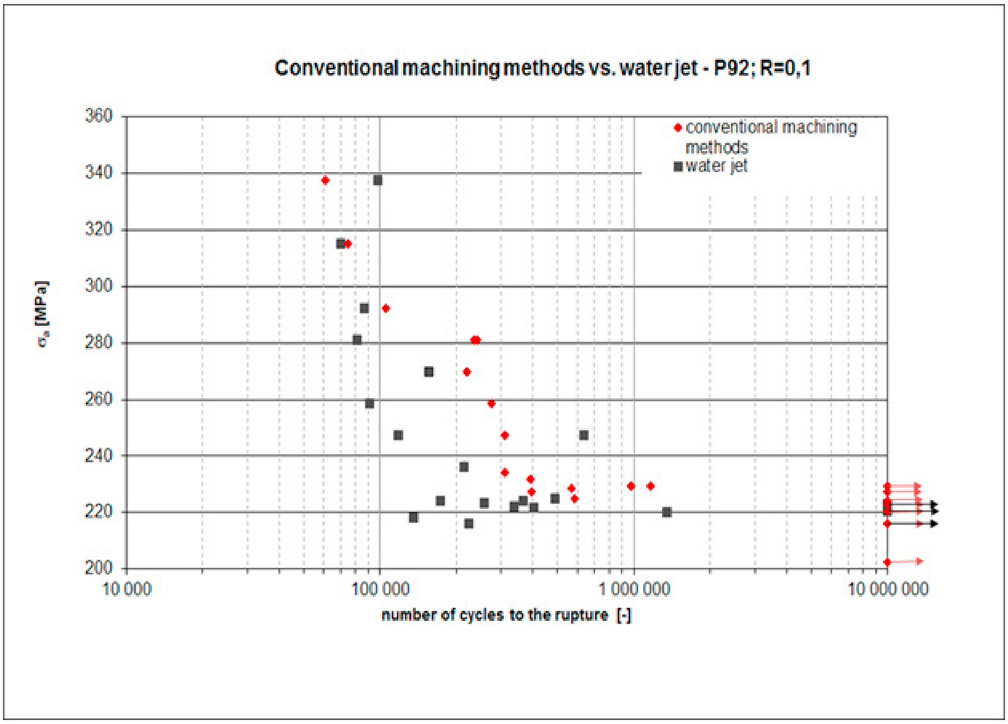

Fig. 15 Comparison of the fatigue test results of SFT fatigue samples produced by conventional machining and water-jet cutting methods, steel P92, cycle asymmetry R = 0,1

6. Conclusions

In case of 15CH2NMFA steel, the results of standard and SFT specimens are in a very good agreement both within the time limit fatigue range and the fatigue limit. After taking the stress concentration of SFT specimens into consideration, the results of traditional fatigue test samples and SFT samples are similar.

In case of P92 steel, the leaning branch of S-N curves is much steeper for SFT specimens and the fatigue limits lower than it could be expected after the stress concentration is taken into account.

The fatigue limits for equal cycle asymmetry show the same ratio of standard to SFT fatigue limits, for R = 0,1 it is 1,31, for R = 1 it is 1,32. This very good agreement can be used for the evaluation of fatigue behaviour of P92 steel by means of SFT specimens.

The comparison of the two ways of SFT samples manufacturing revealed a scatter of fatigue test results, nevertheless the fatigue limits differ by 5 MPa only, so that even the influence of the manufacturing seems to be negligible.

Acknowledgements

The present contribution has been prepared under project LO1502 'Development of the Regional Technological Institute' under the auspices of the National Sustainability Programme I of the Ministry of Education of the Czech Republic aimed to support research, experimental development and innovation.

A.1. Example of a sub-heading within an appendix

There is also the option to include a subheading within the Appendix if you wish.

References

[1] Mentl, V.; Volák, J., Chocholoušek, M., Kindelmann, P.: Korelace únavových charakteristik ocelí pro energetiku měřených na klasických a miniaturních zkušebních tělesech. Sborník 4. konference Zvyšování životnosti komponent energetických zařízení v elektrárnách, Srní, pp. 254-257, říjen 2009
[2] Francisko, P.: Únavové vlastnosti materiálu stanovené pomocí malých vzorků, ZČU Plzeň 2003
[3] Polach, P., Volák, J., Kindelmann, P., Hajžman, M.: Degradation of Material Mechanical Properties and Its Evaluation Using Miniature Test Specimens, Proceedings of 49th International Scientific Conference Experimental Stress Analysis 2011, Znojmo, pp. 333-340, June 2011, ISBN 978-80-241-4275-7
[4] Volák, J.: Upínací čelisti pro vzorky únavy na malých vzorcích, Chladící komora pro Small Punch, Vypracováno v rámci výzkumného záměru MŠMT ČR: MSM 4771868401, „Výzkum provozní degradace konstrukčních materiálů", VYZ/TGZ 53/1/2008
[5] J. Koutsky: Steels for Power Engineering. Prague: SNTL, 1981, 337 s.