COMPARISON OF P92 STEEL FATIQUE TEST RESULTS IN RELATION TO SPECIMEN SIZE AND MANUFACTURING

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Abstract

This paper describes the fatigue properties of the steel P92. This material is widely used in the energy industry, especially for pipes and pipe bends of supercritical steam turbines. Steel P92 is alloyed with 2% of tungsten compared to steel P91. This increases a creep strength of the material. It is possible to reduce wall thickness of the P92 pipe up to about 20%. Fatigue tests were carried out on standard samples and compared with SFT samples (Small Fatigue Test). Using the device SSam 2 made by company Rolce Royce, it is possible to gently remove samples from energy component without power plant shutdowns. Considering these correlations, it is possible to determine mechanical properties of the material from a small amount of removed experimental material.

Keywords: Fatigue, SFT, correlation

1. INTRODUCTION

In this paper the results of the fatigue tests using three types of samples are compared. The results of the standard fatigue samples were compared with two sets of the Small Fatigue Test samples (SFT) produced using 1st machining and also using 2nd water jet. In the present a great interest is given to the Small Punch Test method. Its biggest advantage is almost nondestructive intervention in the integrity of structures thanks to the small amount of removed material which could be advantageous also for production of SFT samples. This "new" (also called) semidestructive method allows to evaluate the current status of operating components on small samples which do not disrupt the integrity of the operating components and it enables to evaluate the current status without long outages. To produce fatigue samples, we used the same shape according to [2], **Fig. 1**. We began using the name SFT (Small Fatigue Test) for the miniaturized fatigue specimens.

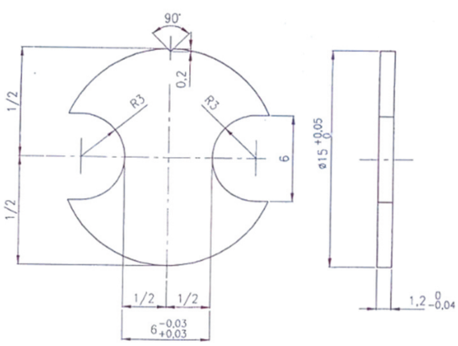

Fig. 1 Shape of Small Fatigue Test samples by [2]

2. SAMPLES PRODUCTION

Standard specimens for fatigue tests were made according to standards (**Fig. 2**). SFT samples were made by traditional methods of machining (turning, milling). First, it was made 15 mm diameter shaft, then milled on both sides of the radii (**Fig. 3**), then the samples were cut to approximately 1.3 to 1.5 mm and finally grinded. Another set of samples was cut by water jet (**Fig. 4**). First, the sample was about 290 mm length, 60 mm width, 8 mm thick milling and then grinding by the plane grinder to the final 1.2 mm. The objective was to compare the results of conventional fatigue tests with small samples and compare the influence of SFT production types on the results of fatigue tests

Fig. 2 Standard testing samples

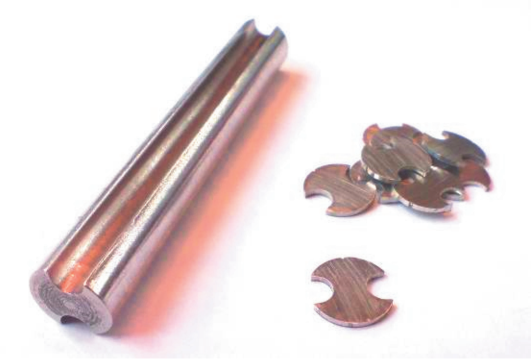

Fig. 3 SFT samples

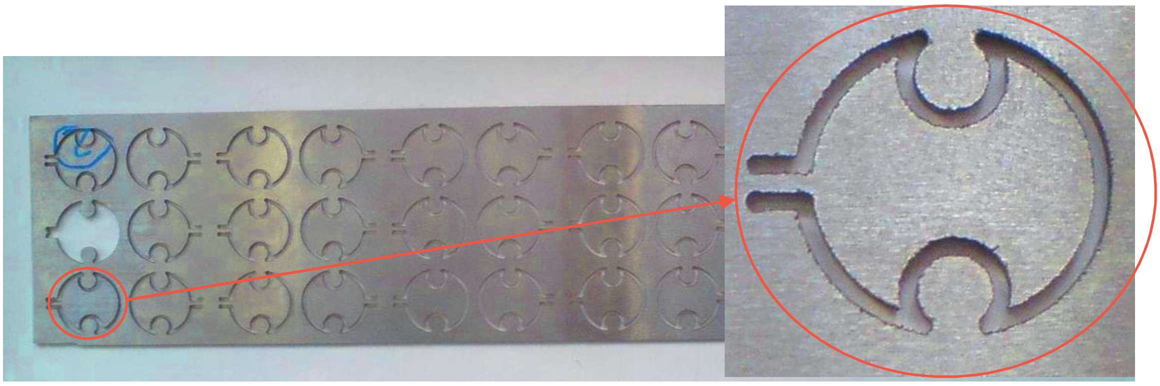

Fig. 4 Samples cut by the water jet

3. FATIGUE TEST PERFORMANCE

Amsler 10 HFP 5100 (high-frequency pulsator) ZWICK//Roell machine was used for the realization of fatigue experiments. To fit standard round specimens, accessories of the machine were used and threads were adapted to the possibilities of this device (**Fig. 5**). To fit the SFT fatigue samples, special grips have been previously made (**Fig. 6**).

Fig. 5 Testing machine Amsler 10 HFP 5100. Detail of the standard specimen fitting (left)

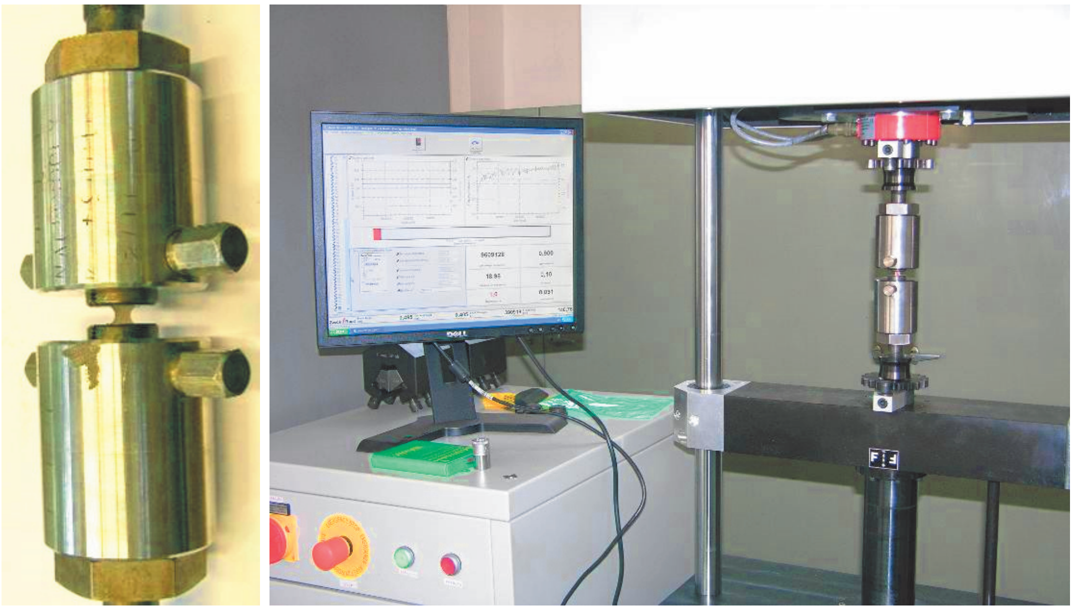

Fig. 6 Principle of fitting SFT specimens (special grips)

4. EXAMINATION PROCESS

Tests were performed as a cyclic loading with force control, the frequency of the material (f = 120Hz to 145Hz) with a cycle asymmetry (R = 0.1). Termination of fatigue limit was set at 10^7 cycles which corresponds to the fatigue of steel materials. The tests were performed on standard and SFT fatigue samples.

4.1. Test Results

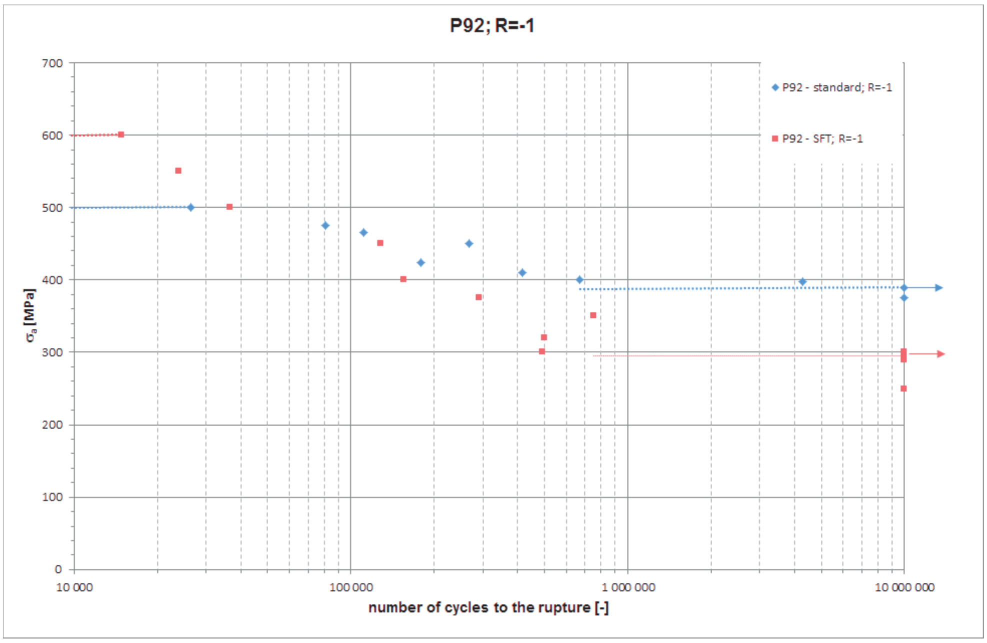

Fig. 7 Comparing results of standard and SFT fatigue samples, cycle asymmetry R=-1

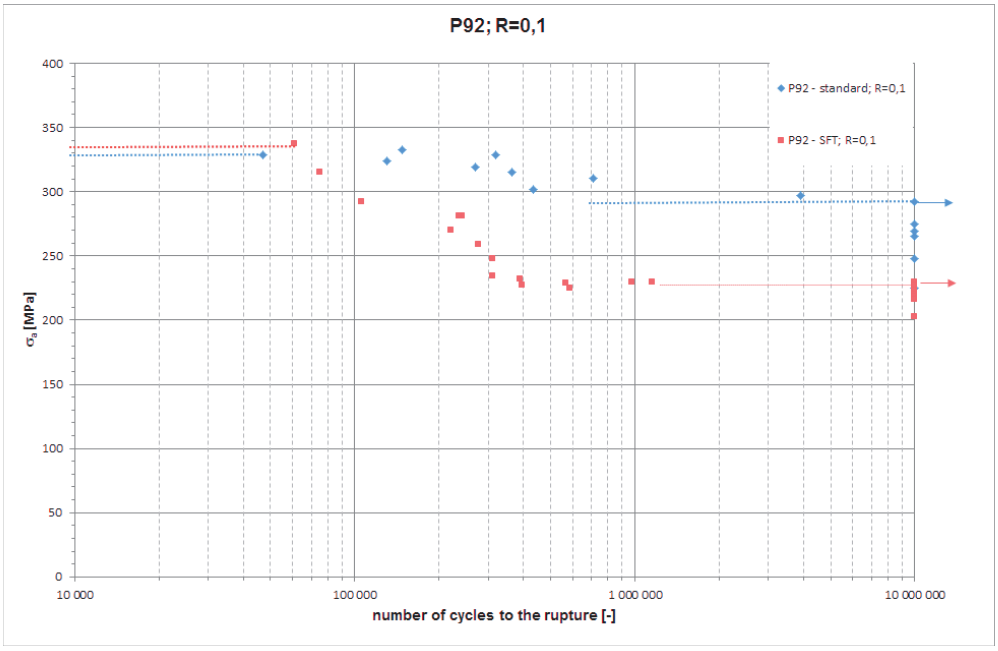

Fig. 8 Comparing results of standard and SFT fatigue samples, cycle asymmetry R=0,1

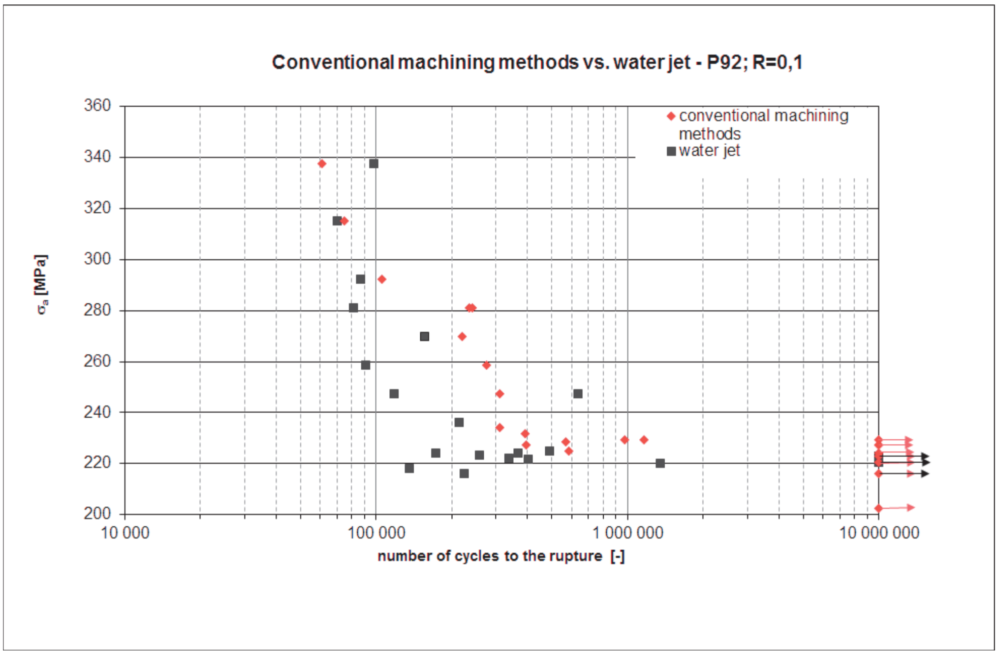

Fig. 9 Comparing results of standard and SFT fatigue samples, cycle asymmetry R=0,1

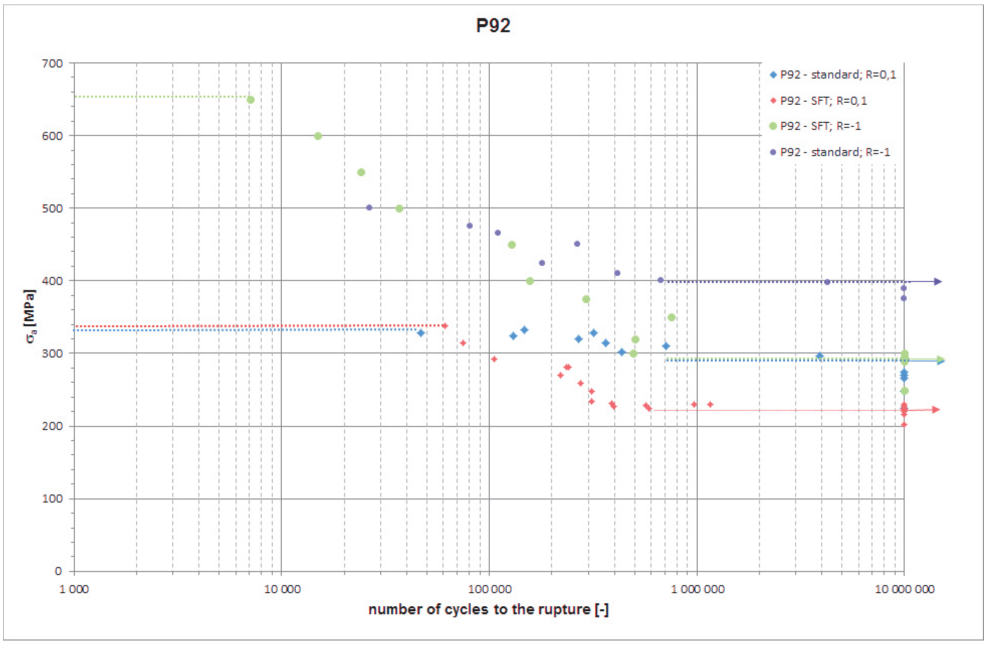

Fig. 10 Summarizing graph (Fig 7, **Fig. 8**), influence of cycle asymmetry comparison

CONCLUSION

When considering the stress concentration 1.33 at SFT samples neck (this concentration is already included in **Fig. 7**), the results are shifted in both low cycle and high cycle fatigue lower than the results of conventional tests. This is the material property, e.g. for aluminum alloys the fatigue results were almost identical when considering stress concentration for SFT specimens and nominal stress for standard specimens.

Despite the dispersion of results (especially in low-cycle fatigue) the evaluated fatigue limits vary by less than 5 MPa and impact of the tested production types in the standard way or by water jet to determine the fatigue limit is thus negligible (**Fig. 8**).

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