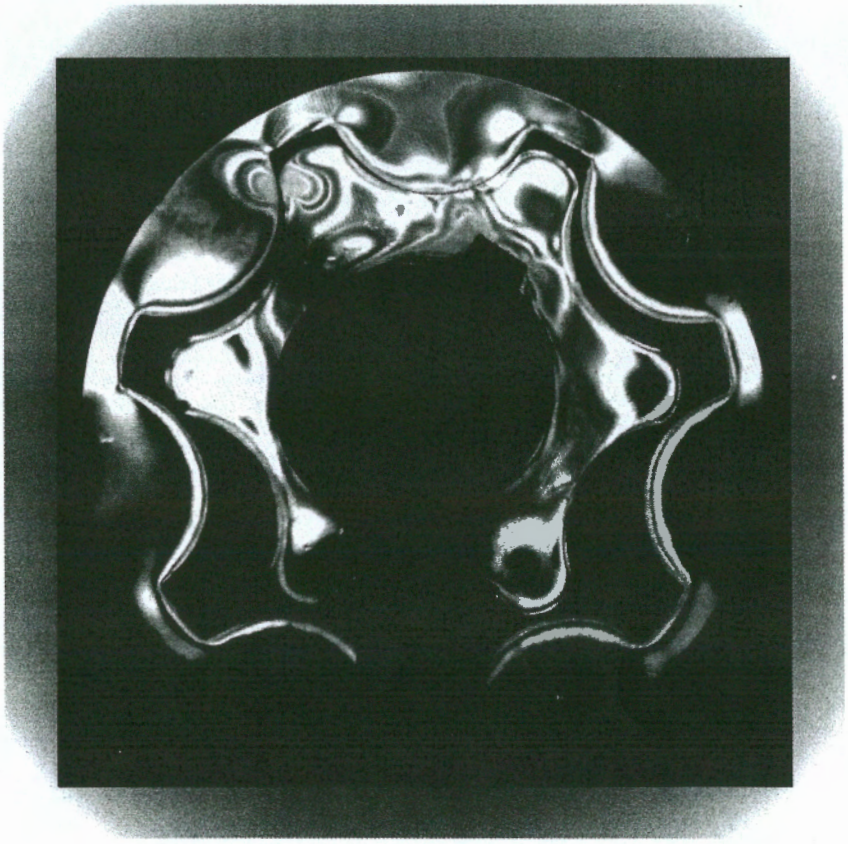
DANUBIA

DRIA

27th Symposium
on Advances in Experimental Mechanics



Wrocław University of Technology

100 YEARS OF TECHNICAL UNIVERSITIES IN WROCŁAW 1910-2010

Committee of Mechanics of Polish Academy of Sciences

SIMP

22nd-25th September 2010
Wrocław, Poland

Wrocław the meeting place

DANUBIA

ADRIA

27th Danubia-Adria Symposium on Advances in Experimental Mechanics

September 22nd-25th, 2010

Wrocław University of Technology

Wrocław / Poland

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SIMP

Polish Society of Mechanical Engineers and Technicians

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Preface

Scientific conferences of Experimental Mechanics in Europe have already a 26-year long tradition. The first Danubia Adria Symposium took place in 1984 in Stubicke Toplice - Croatia. The current Symposium DAS2010 is the second conference organized in Poland. After the 19th DANUBIA-ADRIA symposium on Experimental Methods in Solid Mechanics organized in Polanica Zdrój by the Mechanics Committee Polish Academy of Science, Warsaw University of Technology in 2002, Poland has the privilege of organizing again a scientific meeting of this prestigious international forum – the 27th DA Symposium on Advances in Experimental Methods Organized by Wroclaw University of Technology Faculty of Mechanical Engineering, in cooperation with Committee of Mechanics of Polish Academy of Science and ***Polish Society of Mechanical Engineers and Technicians.***

27st Danubia-Adria Symposium on Experimental Methods in Solid Mechanics (DAS 2010) represents a continuation to the series of fruitful meetings at the previous Danubia-Adria Symposia. The purpose is to provide a forum for engineers, researchers, university teachers and students, scientists and industrial experts to present and discuss the current status and impact of modern technology and development in the field of experimental methods in mechanics. The topics of the DAS 2010 are particularly concerned with recent research and development of experimental and numerical methods for quality enhancing structures, service life and technical safety.

The 27th Danubia-Adria Symposium has an important significance, honored by its works the 100th Anniversary of Technical Universities in Wrocław .
Today's Wrocław University of Technology is an inheritor of the tangible property of the German Königliche Technische Hochschule Breslau and the intellectual and research traditions of the Lvov Polytechnic. In 2002 we have celebrated 300th anniversary of University of Wroclaw. 2010 is the year to celebrate a special milestone -100th anniversary of Technical Universities in Wroclaw. Today it educates over 30 thousands of them at 12 faculties.

This year's DAS symposium has received 124 accepted submissions from 14 countries. The Program Committee selected 14 papers for oral presentation and 109 papers for the commented poster presentation.

The 27th Danubia-Adria Symposium is the result of an effort of many other people from scientific centers in Poland and Europe. We would like to thank them all.
I believe that the present Symposium, with its aim to exchange ideas concerning the search for new models, construction solutions, and manufacturing technologies, will constitutive the next, very important step in the development of experimental mechanics.

On behalf of the Organizing Committee of the 27th DANUBIA-ADRIA Symposium on Advances in Experimental Methods, organizers wish a warm WELCOME to all the participants in Wrocław - and hope that all the guests will have a pleasant time in Poland.

Chairman of 27th DAS Symposium on Advances in Experimental Mechanics

Romuald BĘDZIŃSKI

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FATIGUE STRENGTH ASSESSMENT OF WELDED JOINTS OF WAGON'S CONSTRUCTIONS

Miroslav ŽIVKOVIĆ, Vladimir MILOVANOVIĆ, Dragan RAKIĆ, Snežana VULOVIĆ, Rodoljub VUJANAC

University of Kragujevac, Faculty of Mechanical Engineering,
S. Janjić 6, 34000 Kragujevac, Serbia

Corresponding author: zile@kg.ac.rs

1. Introduction

The basic requirement that must meet each welded construction is the safety and reliability in the conditions of exploitation. The appearance of the gradual destruction of materials under the influence of periodically varying load is called the fatigue. Experimental methods for fatigue testing are very costly, time consuming and does not provide enough information needed. Finite element method is the most general numerical method for fatigue analysis of welded joints of wagon's constructions, saving time and costs, which are very important in the process of serial production of wagon's construction.

2. The most commonly used European standards

TSI standard [1], Clause 4.2.2.3.1, define all types of loads that wagon's construction have to endure, in accordance with the requirements of a British Standard prEN 12663 [2], Section 3. Calculation of dynamic strength bogie wagon due to the vertical load is carried out in accordance with the TSI standard - Annex CC and the British Standard - prEN 12663, a dynamic load is used in design in the range of ± 30% vertical static loads. In the fatigue analysis of welded joints most commonly used standard wagons is Eurocode 3 - Part 1.9, [3]. The relevant stresses in the welds are (see Figure 1):

$$\sigma_{wf} = \sqrt{\sigma_{\perp f}^2 + \tau_{\perp f}^2} \quad \text{i} \quad \tau_{wf} = \tau_{\square f}$$

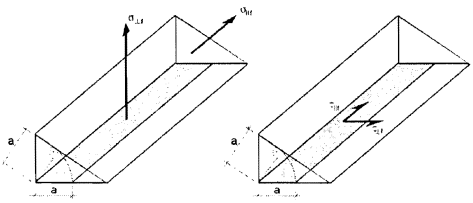

Fig. 1: Relevant stresses in the fillet welds in accordance with Eurocode 3

The curves shown in Figure 2 presents the ratio of direct stress range and the number of cycles to failure and curves are known as Wöhler's curves or S-N curves.

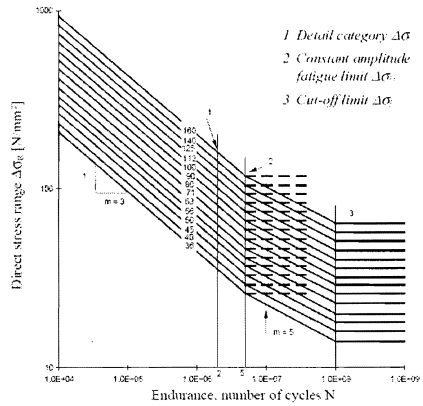

Fig. 2: Wöhler-ove curves (S-N curves)

On Figure 3 is shown pulsating stress in the sinus shape and presents the idealized form of load. Dynamic load is used in the range ± 30% vertical static load. Based on this we can calculate the value of the maximum and minimum stress at dynamic load based on static analysis.

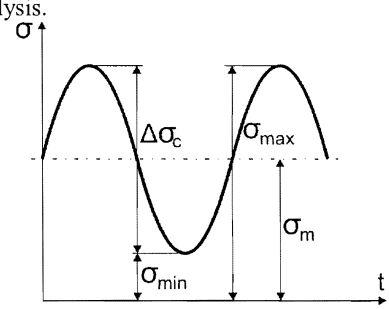

Fig. 3: Pulsating stress

Based on the Figure 3 we can calculate the value of maximum stress due to dynamic load:

$$\sigma_{max} = 2.1667 \Delta\sigma_C$$

In Table 1 are shown the values of permissible stress test for static fatigue testing of welded joints in steel S355J2 + N in accordance with Eurocode 3 Part 1.9. Table 8.2.

Tab. 1: Limit stress values for static test to verify fatigue strength in steel S355J2+N

Direct stress range $\Delta\sigma_C$ [N/mm^2]	Permissible maximim fatigue stress σ_{maxlim} [N/mm^2]	Limit stress for safe life [N/mm^2]	
		Low consequense (γ_{Mf}=1,15)	High consequense (γ_{Mf}=1,35)
160	347	301	257
100	217	188	160
90	195	170	144
80	173	151	128
71	154	134	114
63	136	119	101
56	121	106	90
50	108	94	80

3. Fatigue analysis - example

The task of analysis was to identify the causes of cracks in the middle longitudinal girder of wagon for transportation of containers.

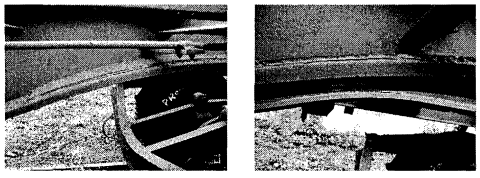

Fig. 4: Crack in the middle longitudinal girder on wagon type Regs-z

Numerical calculations are determined the most critical cases static and dynamic loads [4], which have caused the appearance of cracks in welded joints in the middle longitudinal carrier of wagon type Regs-z.

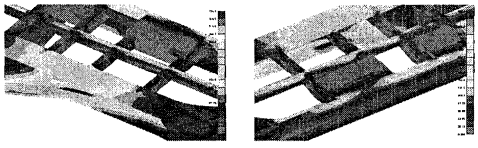

Fig. 5: Von Mises equivalent stress field

From Figure 5 is clear that the position of maximum value of equivalent stress (350.4Mpa) is where the cracks appear in the construction (See Figure 4).

The calculations clearly show that the cause of crack is dynamic load during transportation.

After reconstruction of geometry generated a new mesh of finite elements and repeat all the numerical calculations, in order to verify the proposed solution. Maximal value of equivalent stress is 242.2MPa, located in the parent material, not in the welded joints (See Figure 5), which is considerably below the permissible stress given in Table1.

Fig. 6: Von Mises equivalent stress field after reconstruction

4. Conclusion

This paper is an overview of some of the most common European standard for fatigue evaluation of welded joints wagon's construction. Theoretical basis for calculating fatigue is presented in this paper. Example demonstrates applying of the most common European standards for identification loads that cause the appearance of cracks in welded joints of carrying wagon's elements. Numerical calculations of reconstructed wagon's model [4], show that wagon's construction meet static and dynamic strength according to the following standards.

Acknowledgement: This paper was created under project of Ministry of Science and Technological Development - TR12005: Development of software for explicit nonlinear dynamic analysis.

References

[1] TSI Standard - Freight wagons of the trans-European conventional rail system.

[2] EN 12663 - Railway applications – Structural requirements of railway vehicle bodies, European Standard.

[3] Eurocode 3: Design of steel structures - Part 1.9: Fatigue.

[4] Zivkovic M., Kojic M., Slavkovic R., Grujovic N., PAK – Explicit finite element program for linear and nonlinear structural analysis, Faculty of Mechanical Engineering, University of Kragujevac (2009).