

Fatigue Strength of Welded Thin Steel Structures

A PhD Project by Tobias Pawlowitz

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Introduction

The prediction of the fatigue life of a machine part or a steel structure is an essential part of the design work. The fatigue strength is related to a complex system of influencing factors [1]. Therefore the calculation of the fatigue strength always contains some uncertainty. In order to minimise the uncertainty different approaches have been developed to assess the fatigue strength.

This project will concentrate on the nominal stress approach, the hot spot stress approach, and the notch stress approach [2]. The investigated construction detail is a laser welded connection between relatively thin steel plates with a wall thickness less than 5mm.

Methods

The research is divided into two segments: The calculations of the fatigue strength are performed according to the above mentioned approaches. These calculations are supported by extensive finite element simulations, see Figure 1.

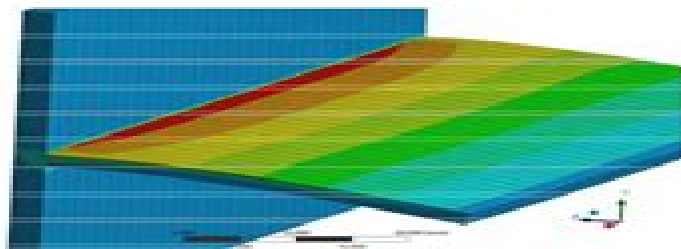


Figure 1: Distribution of maximum principle stresses in a specimen



Figure 2: Test Bench at Kiel UAS

The experiments will be conducted using a test bench for fatigue tests. The tests shall reveal the actual fatigue life of the specimens.

The test results will be compared to the calculation results. The outcome of the comparison will be analysed to verify the approaches chosen.

Objectives

- Investigation of the fatigue strength of welded steel structures with a wall thickness less than 5mm
- Creation of experimental data about a specific weld seam
- Verification of input parameters and settings of finite element calculation of this investigated structure
- Comparison of the calculation results and experimental results and thereby improvement of the prediction accuracy of the notch stress approach for thin-walled steel structure.
- Enhancement of research data base by application of the hot spot stress approach and the nominal stress approach to this specific weld detail

Project Information

Project period:
June 2018 – May 2021

Project partner:
University of Southern Denmark (SDU)
Kiel University of Applied Sciences (Kiel UAS/FH Kiel)

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S J Maddox



Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures:

Fatigue Strength of Welded Structures S J Maddox,1991-01-15 This new edition encompasses the latest research and particularly the recent standards The text will be of value to welding engineers and designers medium to large companies and technical libraries

Fatigue of Welded Structures Timothy Russell Gurney,1979-12-20 *Fatigue Strength of Welded Structures* Stephen John Maddox,Woodhead Publishing,2002

Fatigue Strength of Welded Structures Kenneth George Richards,1969 *Design and Analysis of Fatigue Resistant Welded Structures* Dieter Radaj,1990-01-03 An English version of a successful German book Both traditional and modern concepts are described

Fracture and Fatigue of Welded Joints and Structures K Macdonald,2011-04-19 The failure of any welded joint is at best inconvenient and at worst can lead to catastrophic accidents Fracture and fatigue of welded joints and structures analyses the processes and causes of fracture and fatigue focusing on how the failure of welded joints and structures can be predicted and minimised in the design process Part one concentrates on analysing fracture of welded joints and structures with chapters on constraint based fracture mechanics for predicting joint failure fracture assessment methods and the use of fracture mechanics in the fatigue analysis of welded joints In part two the emphasis shifts to fatigue and chapters focus on a variety of aspects of fatigue analysis including assessment of local stresses in welded joints fatigue design rules for welded structures k nodes for offshore structures and modelling residual stresses in predicting the service life of structures With its distinguished editor and international team of contributors Fracture and fatigue of welded joints and structures is an essential reference for mechanical structural and welding engineers as well as those in the academic sector with a research interest in the field Analyses the processes and causes of fracture and fatigue focusing predicting and minimising the failure of welded joints in the design process Assesses the fracture of welded joints and structure featuring constraint based fracture mechanics for predicting joint failure Explores specific considerations in fatigue analysis including the assessment of local stresses in welded joints and fatigue design rules for welded structures

Fatigue Strength of Welded Structures Kenneth George Richards,1969

Structural Hot-Spot Stress Approach to Fatigue Analysis of Welded Components Erkki Niemi,Wolfgang Fricke,Stephen J. Maddox,2017-08-28 This book provides background and guidance on the use of the structural hot spot stress approach to fatigue analysis The book also offers Design S N curves for use with the structural hot spot stress for a range of weld details and presents parametric formulas for calculating stress increases due to misalignment and structural discontinuities Highlighting the extension to structures fabricated from plates and non tubular sections The structural hot spot stress approach focuses on cases of potential fatigue cracking from the weld toe and it has been in use for many years in tubular joints Following an explanation of the structural hot spot stress its definition and its relevance to fatigue the book describes methods for its determination It considers stress determination from both finite element analysis and strain gauge measurements and emphasizes the use of finite element stress analysis providing guidance on the choice of

element type and size for use with either solid or shell elements Lastly it illustrates the use of the recommendations in four case studies involving the fatigue assessment of welded structures using the structural hot spot stress **IIW**

Recommendations On Methods for Improving the Fatigue Strength of Welded Joints P J Haagenzen,S J

Maddox,2013-01-25 The weld toe is a primary source of fatigue cracking because of the severity of the stress concentration it produces Weld toe improvement can increase the fatigue strength of new structures significantly It can also be used to repair or upgrade existing structures However in practice there have been wide variations in the actual improvements in fatigue strength achieved Based on an extensive testing programme organised by the IIW this report reviews the main methods for weld toe improvement to increase fatigue strength burr grinding TIG dressing and hammer and needle peening The report provides specifications for the practical use of each method including equipment weld preparation and operation It also offers guidance on inspection quality control and training as well as assessments of fatigue strength and thickness effects possible with each technique IIW recommendations on methods for improving the fatigue strength of welded joints will allow a more consistent use of these methods and more predictable increases in fatigue strength Provides specifications for the practical use of each weld toe method including equipment weld preparation and operation Offers guidance on inspection quality control and training as well as assessments of fatigue strength and thickness effects possible with each technique This report will allow a more consistent use of these methods and more predictable increases in fatigue strength **IIW**

Guidelines on Weld Quality in Relationship to Fatigue Strength Bertil Jonsson,G. Dobmann,A. F. Hobbacher,M.

Kassner,G. Marquis,2016-04-13 This book presents guidelines on quantitative and qualitative measures of the geometric features and imperfections of welds to ensure that it meets the fatigue strength requirements laid out in the recommendations of the IIW International Institute of Welding Welds that satisfy these quality criteria can be assessed in accordance with existing IIW recommendations based on nominal stress structural stress notch stress or linear fracture mechanics Further the book defines more restrictive acceptance criteria based on weld geometry features and imperfections with increased fatigue strength Fatigue strength for these welds is defined as S N curves expressed in terms of nominal applied stress or hot spot stress Where appropriate reference is made to existing quality systems for welds In addition to the acceptance criteria and fatigue assessment curves the book also provides guidance on their inspection and quality control The successful implementation of these methods depends on adequate training for operators and inspectors alike As such the publication of the present IIW Recommendations is intended to encourage the production of appropriate training aids and guidelines for educating training and certifying operators and inspectors *Effective means for improving the fatigue*

strength of welded structures, INTERNATIONAL INSTITUTE OF WELDING XIII-1574 Akihiko Ohta,1995 **Fatigue**

Design of Welded Joints and Components A Hobbacher,1996-10-31 These recommendations present general methods for the assessment of fatigue damage in welded components which may affect the limit states of a structure such as ultimate

limit state and serviceability limited state Fatigue resistance data is given for welded components made of wrought or extruded products of ferritic pearlitic or bainitic structural steels up to f_y 700 Mpa and of aluminium alloys commonly used for welded structures

IIW Recommendations for the Fatigue Assessment of Welded Structures By Notch Stress Analysis W Fricke, 2012-10-22 The notch stress approach for fatigue assessment of welded joints is based on the highest elastic stress at the weld toe or root In order to avoid arbitrary or infinite stress results a rounded shape with a reference radius instead of the actual sharp toe or root is usually assumed IIW recommendations for the fatigue assessment of welded structures by notch stress analysis reviews different proposals for reference radii together with associated S N curves Detailed recommendations are given for the numerical analysis of notch stress by the finite or boundary element method Several aspects are discussed such as the structural weakening by keyhole shaped notches and the consideration of multiaxial stress states Appropriate S N curves are presented for the assessment of the fatigue strength of different materials Finally four examples illustrate the application of the approach as well as the variety of structures which can be analysed and the range of results that can be obtained from different models Provides detailed recommendations for the numerical analysis of notch stress by the finite or boundary element method Discusses structural weakening by keyhole shaped notches and the consideration of multiaxial stress states Provides four comprehensive examples illustrating the variety of structures which can be analysed and the range of results that can be obtained from different models

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Analysis of Welded Structures Koichi Masubuchi, 2013-10-22 Analysis of Welded Structures Residual Stresses Distortion and their Consequences encompasses several topics related to design and fabrication of welded structures particularly residual stresses and distortion as well as their consequences This book first introduces the subject by presenting the advantages and disadvantages of welded structures as well as the historical overview of the topic and predicted trends Then this text considers residual stresses heat flow distortion fracture toughness and brittle and fatigue fractures of weldments This selection concludes by discussing the effects of distortion and residual stresses on buckling strength of welded structures and effects of weld defects on service behavior This book also provides supplementary discussions on some related and selected subjects This text will be invaluable to metallurgists welders and students of metallurgy and welding

Techniques for Improving the Fatigue Strength of Welded Structures J. D. Harrison, 1965

Proceedings of 1st International Conference on Structural Damage Modelling and Assessment Magd Abdel Wahab, 2020-12-12 This book comprises the select proceedings of Structural Damage Modelling and Assessment SDMA 2020 presented online on 4-5 August 2020 It discusses the recent advances in fields related to damage modelling damage detection and assessment non destructive testing and evaluation structure integrity and structural health monitoring The conference covers all research topics and applications relevant to structural damage modelling and assessment using theoretical numerical and experimental techniques This book is useful to scientists and engineers in academia and industry

who are interested in the field of structural damage and integrity *Improving the Fatigue Life of High Strength Steel Welded Structures by Post Weld Treatments and Specific Filler Material (FATWELDHSS)* ,2015 The objective of the FATWELDHSS project was to study post weld treatment techniques and their effect on the fatigue life of MAG welded attachments in High Strength Steel HSS Fatigue cracks in steel structures often occur at welded joints where stress concentrations due to the joint geometry and tensile residual stresses are relatively high Fatigue life improvement techniques which rely on improving the stress field and or the surface geometry around the welded joints are generally known to be beneficial Therefore within the framework of this project the following were examined diode laser weld toe re melting High Frequency Mechanical Impact HFMI treatment Low Transformation Temperature LTT filler wires Laser diode re melting was used to improve the surface profile at the weld toe and thus reduce stress concentrations HFMI treatment involving high frequency hammering of the weld toe is another technique that can produce a smooth weld toe profile but more significantly which also can introduce compressive residual stresses Lastly two new LTT filler wires were developed within the project as these can decrease or even remove tensile residual stresses resulting from weld zone shrinkage An extensive fatigue testing programme was set up to establish the levels of improvement in the fatigue lives of the welded attachments achieved by application of the selected improvement techniques Furthermore two industrial demonstrators were selected that could show the project achievements in terms of facilitating the introduction of high strength steels by overcoming the limitations posed by the fatigue properties of the welded joints In addition modelling tools were developed to predict the residual stresses at the welded joint Finally practical guidelines were developed for enhancing the fatigue strength of HSS welded structures *Fatigue Analysis of Welded Components* E. Niemi,W Fricke,S J Maddox,2006-09-27 This report provides background and guidance on the use of the structural hot spot stress approach to the fatigue design of welded components and structures It complements the IIW recommendations for Fatigue Design of Welded Joints and Components and extends the information provided in the IIW recommendations on Stress Determination for Fatigue Analysis of Welded Components This approach is applicable to cases of potential fatigue cracking from the weld toe It has been in use for many years in the context of tubular joints The present report concentrates on its extension to structures fabricated from plates and non tubular sections Following an explanation of the structural hot spot stress its definition and its relevance to fatigue the authors describe methods for its determination Stress determination from both finite element analysis and strain gauge measurements is considered Parametric formulae for calculating stress increases due to misalignment and structural discontinuities are also presented Special attention is paid to the use of finite element stress analysis and guidance is given on the choice of element type and size for use with either solid or shell elements Design S N curves for use with the structural hot spot stress are presented for a range of weld details Finally practical application of the recommendations is illustrated in two case studies involving the fatigue assessment of welded structures using the structural hot spot stress

approach Provides practical guidance on the application of the structural hot spot stress approach Discusses stress determination from both finite element analysis and strain gauge measurements Practical application of the recommendations is illustrated in two case studies *Fatigue of Thin Walled Joints Under Complex Loading* T R Gurney, Timothy Russell Gurney, 1997-07-21 A report containing the results of a TWI Group Sponsored Project beneficial to designers of thin walled structures especially those in the transport industry It serves as a valuable source of reference for a wide range of welding engineers and structural analysts

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Table of Contents Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures

1. Understanding the eBook Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures
 - The Rise of Digital Reading Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures
 - Advantages of eBooks Over Traditional Books
2. Identifying Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures
 - User-Friendly Interface
4. Exploring eBook Recommendations from Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures
 - Personalized Recommendations
 - Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures User Reviews and Ratings
 - Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures and Bestseller Lists
5. Accessing Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures Free and Paid eBooks
 - Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures Public Domain eBooks
 - Fatigue Strength Of Welded Structures Fatigue Strength Of Welded Structures eBook Subscription Services

- Fatigue Strength Of Welded Structures Budget-Friendly Options
- 6. Navigating Fatigue Strength Of Welded Structures eBook Formats
 - ePub, PDF, MOBI, and More
 - Fatigue Strength Of Welded Structures Compatibility with Devices
 - Fatigue Strength Of Welded Structures Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Fatigue Strength Of Welded Structures
 - Highlighting and Note-Taking Fatigue Strength Of Welded Structures
 - Interactive Elements Fatigue Strength Of Welded Structures
- 8. Staying Engaged with Fatigue Strength Of Welded Structures
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Fatigue Strength Of Welded Structures
- 9. Balancing eBooks and Physical Books Fatigue Strength Of Welded Structures
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Fatigue Strength Of Welded Structures
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Fatigue Strength Of Welded Structures
 - Setting Reading Goals Fatigue Strength Of Welded Structures
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Fatigue Strength Of Welded Structures
 - Fact-Checking eBook Content of Fatigue Strength Of Welded Structures
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development

- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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including product managers developers designers and other stakeholders to align on the product s

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web connecting product strategy and the roadmap embracing a top down approach to strategic planning is a popular way to ensure your product roadmap aligns well with both business objectives and long term aspirations for the product it also helps define quantitative goals that not only measure progress but also help inform prioritization

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