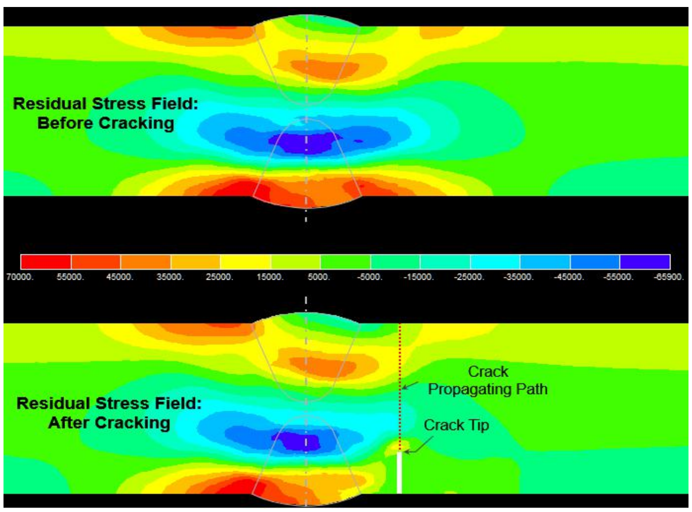
Special Short Course Offering

课程一：残余应力与变形, 结构服役分析方法及应用实例

Residual Stresses, Distortions, and Fitness for Service Assessment



About the Course

It is well known that welding-induced residual stresses and distortions can have significant impact on the manufacturability and structural integrity of welded components. This unique course is designed to:

- Critical assess the "state of art" residual stress modeling, analysis, and measurement techniques
- Demonstrate effective modeling and analysis procedures for various industrial applications
- Guide course participants on how to define and solve day-to- day residual stress/distortion control problems, and fitness-for-service related needs.

A bound volume of course notes will be provided to all registered participants.

About the Instructor

The course will be taught by Prof. Pingsha Dong, Professor of Naval Architecture and Marine Engineering, and Mechanical Engineering, Director of Welded Structures Laboratory at University of Michigan. He has published over 180 peer-reviewed papers in archive journals and major conference proceedings and provided over 20 plenary/keynote lectures at major international conferences. He received numerous prestigious national and international awards, including AWS Fellow Award (2015), IIW Fellow Award (2014), SNAME Helmer L. Hann Award (2012,2007), IIW Evgeny Paton Prize(2008), R&D Magazine's R&D 100 Award(2006), TIME Magazine's Math Innovator(2005), Aviation Week and Space Technology's Aerospace Laurels Award(2004), SAE Henry Ford Award(2003), AWS R.D. Thomas Award, ASME G.E.O Widera Literature Award(2002), among others.

Part I: Residual Stresses and Distortions

- Importance of understanding residual stresses
- Residual stress development mechanisms
  - 1D thermo-plasticity descriptions
  - 3-bar and n-bar models and implications
  - Basic shrinkage modes and distortion types
- Basic finite element modeling requirements
  - Time and length scale considerations
  - Proven residual stress analysis procedures
  - Proven distortion analysis procedures
- Residual stresses in weld repairs
- Comments on residual stress measurements
  - Why measurements can be wrong!
  - How to interpret measurement results?
  - How to plan measurements plan?
- Residual stress and distortion mitigation
  - In-process techniques and examples
  - Post-process techniques and examples

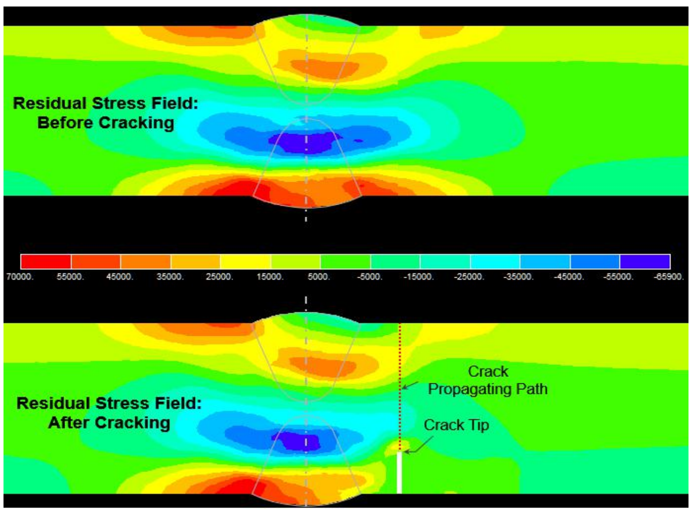
Part II: Fitness for Service (FFS)

- Basic elements of FFS
- Stress categories and modern interpretation
  - Primary and secondary stresses (P,Q)
  - Treatment of residual stresses
- Basic *K* solutions and structural applications
- Basic limit solutions and structural applications
- Failure assessment diagram (FAD)
- Fracture ratio (K_r) and load ratio (L_r)
- Critical defect size determination
- Remaining life assessment
  - S-N curve based method
  - Crack growth method
- Similarities/differences: BS 7910 versus PI 579
- Industrial application examples
  - Weld quality definition in aluminum spot welds
  - Riser pipe weld defect evaluation
  - Storage tank remaining life assessment
  - FFS of super heater header repair
- Summary and Q/A

Special Short Course Offering

课程一：焊接结构残余应力，变形, 服役分析方法及实例

Residual Stresses, Distortions, and Fitness for Service Assessment



About the Course/课程介绍

焊接残余应力与变形影响焊接构件的制造性能及服役安全性，本课程即解决此类问题，培训内容要点如下：

- 残余应力与变形评价
- 残余应力产生基本原理及分析方法
- 讲解已应用工业界的各种应用实例
- 引导学员定义和解决所在行业的残余应力与变形控制问题，焊接接头设计，结构服役相关需求.

About the Instructor/主讲人

董平沙： 美国密歇根大学 船舶与海洋工程系、机械系教授，焊接结构研究室主任，哈尔滨工业大学(威海)特聘教授，发表学术论文 180 余篇，国际特邀报告 20 余场次，个人所获奖项如下： AWS Fellow Award (2015), IIW Fellow Award (2014), SNAME Helmer L. Hann Award (2012,2007), IIW Evgeny Paton Prize(2008), R&D Magazine's R&D 100 Award(2006), TIME Magazine's Math Innovator(2005), Aviation Week and Space Technology's Aerospace Laurels Award(2004), SAE Henry Ford Award(2003), AWS R.D. Thomas Award, ASME G.E.O Widera Literature Award(2002), among others.

Part I:残余应力与变形

- 理解残余应力的重要性
- 残余应力的产生过程与机理
  - 一维杆热-塑性分析模型
  - 3-bar and n-bar 分析模型与应用
  - 熔池收缩模式及基本变形方式
- 有限元建模基本要求
  - 时间与尺度效应考虑
  - 被证实的残余应力分析程序
  - 被证实的焊接变形分析程序
- 补焊中残余应力的演变分析
- 残余应力测试方法评价
  - 测试中的错误认知与不当操作!
  - 如何解释测试数据?
  - 如何制定残余应力测试方案?
- 残余应力与变形的消除措施
  - 随焊控制措施及案例
  - 焊后消除措施及案例

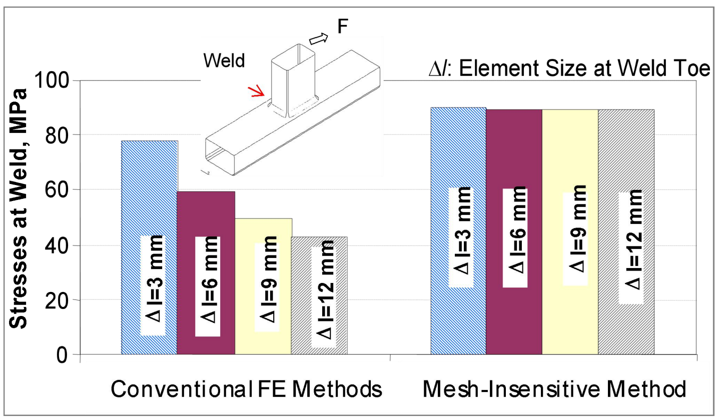
Part II:服役安全性分析

- 服役安全分析的基本要素
- 应力的分类及全新解读
  - 一次应力与二次应力定义(P,Q)
  - 残余应力的角色定义
- 常见的 K 计算公式与结构应用
- 常见的极限值求解与应用
- 失效评定图解读(FAD)
- 断裂比 (Kr) 与载荷比(Lr)
- 临界缺陷尺寸的确定
- 剩余寿命评估
  - 基于 S-N 曲线的方法
  - 基于裂纹扩展速率的方法
- BS 7910 versus API 579 的异同之处剖析
- 工业界应用案例
  - 铝合金点焊质量定义
  - 深海立管的焊接缺陷评估
  - 储油罐剩余寿命评估
  - 补修后 super heater header 服役安全分析
- 总结与答疑

Special Joint Short Course Offering

课程二：焊接结构抗疲劳设计及寿命分析方法

Advances in Fatigue Design and Life Prediction Methods for Welded Structures



About the Course

This special course will provide a unique opportunity for attendees to learn the basic principles of structural fatigue design and life valuation procedures, including most recent developments in finite element based fatigue lifing methodologies, particularly on welded structures. Effective fatigue testing procedures for lab-scale specimens and large-scale components will also be discussed, including methods for data interpretation. Through this training course, participants should be able to:

- Solve basic fatigue design problems
- Effectively design fatigue test plan and interpret fatigue test data
- Perform computer-based fatigue life estimations for basic fatigue problems

About the Instructor

The course will be taught by Prof. Pingsha Dong of University of Michigan, the inventor of the mesh-insensitive structural stress method (also referred to as the Master S-N Curve Method) adopted by the 2007 ASME Div 2 and API 579/ASME FFS-1 Codes and Standards mandated by over 50 countries worldwide. Over the past 10 years, Prof. Dong has taught this course in over 10 countries. Prof. Dong has published more than 180 peer-reviewed papers in archive journals and major conference proceedings, including over 20 plenary/keynote lectures at major international conferences. He has received numerous prestigious national and international awards/recognitions, including AWS Fellow Award (2015), IIW Fellow Award (2014), SNAME Helmer L. Hann Award (2012 and 2007), IIW Evgeny Paton Prize (2008), *R&D Magazine*'s R&D 100 Award (2006), *TIME Magazine*'s Math Innovator (2005), *Aviation Week and Space Technology*'s Aerospace Laurels Award (2004), SAE Henry Ford Award (2003), AWS R.D. Thomas Award, and ASME G.E.O Widera Literature Award (2002), among others.

Part I: Fundamental Concepts

<u>Fundamental aspects of structural fatigue</u>

- Initiation versus propagation and failure criteria
- Unique fatigue issues associated with welded joints

<u>Conventional fatigue evaluation procedures</u>

- Key assumptions
- Stress definitions and calculation procedures
- Code-recommended S-N curves and assumptions
- Why they don't work well for structural applications?

<u>Traction structural stress method – I</u>

- The traction structural stress definition
- Numerical implementation
- Simple calculation procedures
- Measurement techniques and validations
- Comparison with other stress definitions

Part II: Generalization and Applications

<u>Traction structural stress method – II</u>

- Generalized calculation procedure
- Mesh-insensitivity validations
- Multi-axial stress state
- Weld root cracking versus weld toe cracking
- Worked examples

<u>The master S-N curve approach</u>

- Fracture mechanics consideration
- Master S-N curve formulation and validation
- Load- versus displacement-controlled

<u>Finite element based structural life prediction procedure</u>

- Plug, resistance spot, laser, and FSW welds
- Do's and don'ts
- Recent developments

<u>Summary and Q/A</u>

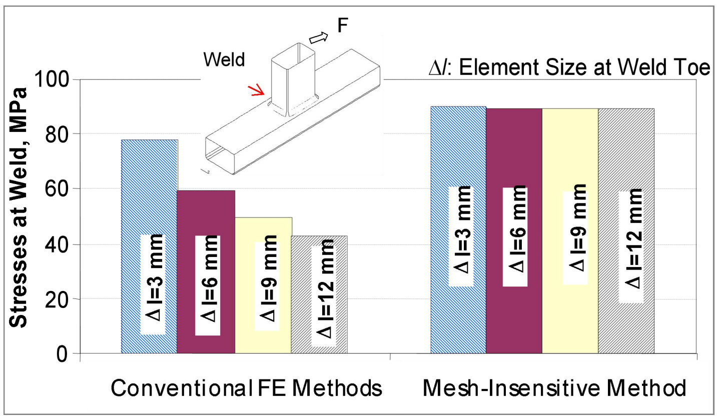
<u>Part III: Comments on pre-submitted problems</u>

- Problems on residual stress and distortions
- Problems on FFS
- Problems on fatigue

Special Joint Short Course Offering

课程二：焊接结构抗疲劳设计及寿命分析方法

Advances in Fatigue Design and Life Prediction Methods for Welded Structures



About the Course/课程介绍

本培训为学员讲解既先进又简洁的焊接结构疲劳设计与寿命评估方法，内容涵盖：传统焊接结构抗疲劳方法及优缺点，焊接接头疲劳损伤特征，结构应力力学模型，有限元分析的疲劳寿命计算方法及应用，焊接接头疲劳测试要求及疲劳数据分析方法。借此培训，学员将理解并掌握：

- 真正解决疲劳设计的根本所在
- 有效设计疲劳试验及解读疲劳测试数据
- 快速开展常见结构疲劳的寿命估算

About the Instructor/主讲人

董平沙：结构应力法/Master S-N 曲线的发明人，美国密歇根大学 船舶与海洋工程系、机械系教授，焊接结构研究室主任，哈尔滨工业大学(威海)特聘教授，该方法已被 2007 ASME Div 2 and API 579/ASME FFS-1 Codes and Standards 标准委员会采纳，在全世界 50 多个国家推广应用，近几年受邀在十几个国家开展专场培训. 发表学术论文 180 余篇，国际特邀报告 20 余场次，个人所获奖项如下：AWS Fellow Award (2015), IIW Fellow Award (2014), SNAME Helmer L. Hann Award (2012,2007), IIW Evgeny Paton Prize(2008), R&D Magazine's R&D 100 Award(2006), TIME Magazine's Math Innovator(2005), Aviation Week and Space Technology's Aerospace Laurels Award(2004), SAE Henry Ford Award(2003), AWS R.D. Thomas Award, ASME G.E.O Widera Literature Award(2002), among others.

Part I:基本疲劳概念

<u>结构疲劳基本概念</u>

- 裂纹萌生 versus 裂纹扩展及失效判据定义
- 焊接接头的疲劳特征

<u>常规的疲劳寿命分析方法</u>

- 重要假设
- 应力定义与计算过程
- 国际标准推荐的 S-N 曲线与假设
- 常规方法不适用于结构疲劳分析的原因剖析

<u>Traction structural stress method – I</u>

- The traction structural stress 定义
- 数值求解过程
- 简单计算流程
- 应力测试技术及验证
- 不同应力计算方法对比

Part II:通式与应用

<u>Traction structural stress method – II</u>

- 通式化的计算流程
- 网格不敏感性验证
- 多轴应力状态分析
- 焊根失效 versus 焊趾失效
- 实例分析

<u>Master S-N 曲线方法</u>

- 断裂力学基础讲解
- Master S-N 曲线的公式与验证
- 载荷控制 versus 位移控制

<u>基于有限元分析的结构疲劳寿命预测实例</u>

- 塞焊，电阻点焊，激光焊，搅拌摩擦焊
- Do's and don'ts
- Recent developments

<u>总结与答疑</u>

Part III:点评来自学员的技术问题

- Problems on residual stress and distortions/残余应力与变形相关
- Problems on FFS/服役安全分析相关
- Problems on fatigue/疲劳相关