SHAKEDOWN BOUNDARIES OF LOCALLY THINNED-WALL 90 DEGREE PIPE BENDS SUBJECTED TO STEADY INTERNAL PRESSURE AND CYCLIC IN-PLANE BENDING LOADS

By
Amr Ahmed Foad Fahmy Oda

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
MECHANICAL DESIGN AND PRODUCTION ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT

2015

SHAKEDOWN BOUNDARIES OF LOCALLY THINNED-WALL 90 DEGREE PIPE BENDS SUBJECTED TO STEADY INTERNAL PRESSURE AND CYCLIC IN-PLANE BENDING LOADS

By
Amr Ahmed Foad Fahmy Oda

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
MECHANICAL DESIGN AND PRODUCTION ENGINEERING

Under the Supervision of

Mohammad M. Megahed

Professor of Solid Mechanics
Dept. of Mechanical Design and Production
Faculty of Engineering,
Cairo University, Egypt

Hany F. Abdalla

Assistant Professor of Mechanical Design and Solid Mechanics
Dept. of Mechanical Engineering
Faculty of Engineering
The British University in Egypt

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT

2015

SHAKEDOWN BOUNDARIES OF LOCALLY THINNED-WALL 90 DEGREE PIPE BENDS SUBJECTED TO STEADY INTERNAL PRESSURE AND CYCLIC IN-PLANE BENDING LOADS

By
Amr Ahmed Foad Fahmy Oda

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
MECHANICAL DESIGN AND PRODUCTION ENGINEERING

Approved by the Examining Committee:

_____
Prof. Dr. Mohammad M. Megahed, Thesis Main Advisor

_____
Prof. Dr. Abdalla S. Wifi, Internal Examiner

_____
Prof. Dr. Maher Y. A. Younan, External Examiner
Professor of Mechanics and Design, Associate Dean for Undergraduate Studies,
School of Science and Engineering, The American University in Cairo

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT

2015

Engineer's Name: Amr Ahmed Foad Fahmy Oda
Date of Birth: 15/09/1984
Nationality: Egyptian
E-mail: eng_oda@yahoo.com
Phone: (+2)01000408468
Address: Gesr El Suez, Cairo, Egypt
Registration Date: 01/10/2009
Awarding Date: / /2015
Degree: Master of Science
Department: Mechanical Design and Production Engineering

Supervisors:

Prof. Dr. Mohammad M. Megahed

Ass. Prof. Dr. Hany F. Abdalla
Assistant Professor of Mechanical Design and Solid Mechanics,
Dept. of Mechanical Engineering, Faculty of Engineering,
The British University in Egypt

Examiners:

Prof. Dr. Mohammad M. Megahed (Thesis main advisor)

Prof. Dr. Abdalla S. Wifi (Internal examiner)

Prof. Dr. Maher Y. A. Younan (External examiner)
Professor of Mechanics and Design, Associate Dean for
Undergraduate Studies, School of Science and Engineering,
The American University in Cairo

Title of Thesis:

Shakedown Boundaries of Locally Thinned-Wall 90 Degree Pipe Bends Subjected to Steady Internal Pressure and Cyclic In-plane Bending Loads

Key Words:
Pipe bend; Thinning; Shakedown; Ratcheting; Reversed plasticity

Summary:

The current research utilizes a direct non-cyclic technique to generate elastic shakedown boundaries for locally thinned-wall long radius 90^o pipe bends. Wall thinning is located once at intrados, once at extrados and once at crown. The pipe bend is subjected to the simultaneous effect of steady internal pressure spectrum and cyclic in-plane bending moments. A parametric study is conducted to investigate the effect of thinning depth and thinning location under both cyclic in-plane closing and opening modes of bending on shakedown boundaries. Assessment procedures adopted in the well-known Fitness-for-Service standard, API 579-1/ASME FFS-1, to assess structural integrity of defective pipe bends against fatigue and ratcheting failures are compared with the results of the direct non-cyclic technique.

Acknowledgments

First and foremost, I am extremely grateful for **ALLAH** for showing blessing in completion of this thesis. In reality, no words can express my gratitude for **ALLAH** for supporting me and being on my side all the time.

Great thanks to my supervisors and my second family Prof. Dr. **Mohammad M. Megahed** and Ass. Prof. Dr. **Hany F. Abdalla,** for their guidance during the course of this thesis. I consider myself very lucky to have worked with my supervisors in my first research endeavor. This experience has taught me considerably innovative ways of problem solving.

I would also like to appreciate the continuous help of all of my friends and colleagues, especially engineers **Mohamed Abdel-Aal, Ahmed Gaber** and **Youssef Hafiz**.

Thanks to the unwavering support of my **parents**, **brother** and **sister**. Special thanks to my **wife** and son **Mohamed** who have been a great source of motivation for me. I know that I have been heavily preoccupied in the last period, but all members of my family know how much I love all of them, and I hope they will be proud of me.

Thanks and appreciation to all who supported me.

Table of Contents

List of Tables