



Cairo University

# **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**



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**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° 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.



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