Weld Challenge III – Exhaust Hanger Weld Fatigue Problem

P. Dong and J.K. Hong/Battelle

P. Ramamohan, H. Agrawal/Ford Motor Company

Battelle

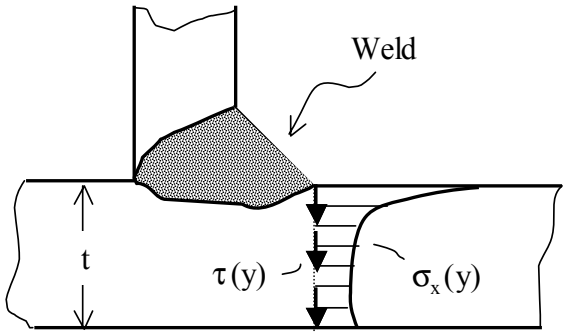
Fatigue Life Prediction Procedures

- Battelle's mesh-insensitive structural stress method
- Master S-N curve based on a large amount of MIG weld S-N data expressed in terms of

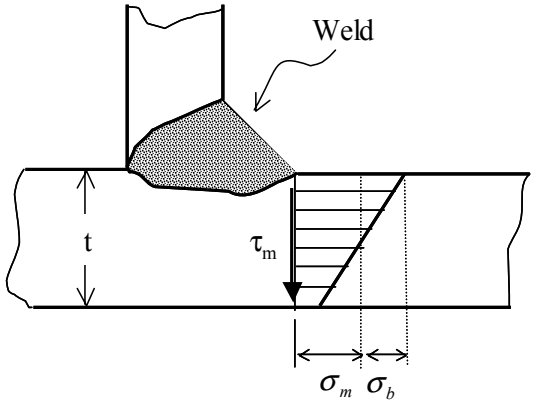
$$\Delta S_s = \frac{\Delta \sigma_s}{t^{[(2-m)/2m]} \cdot I(r)^{1/m}}$$

- FE Mesh was generated based on ArvinMeritor's CAD model from FD&E's website
- Assumptions/simplifications:
  - Failure criterion of the master S-N curve: through-thickness failure
  - Rob modeled using shell elements with t=r
  - Weld element representation: shell thickness = 3mm
  - I(r) for structural joint (i.e., load shielding effects):
    - SS analysis results: weld toe/end failure in pipe and weld metal failure (root or throat failures) not likely
    - Min. 6mm crack length in pipe

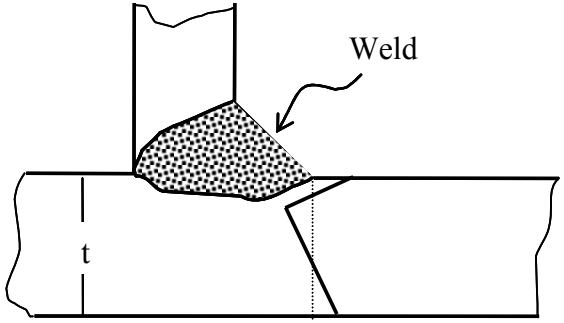
The Structural Stress Definition



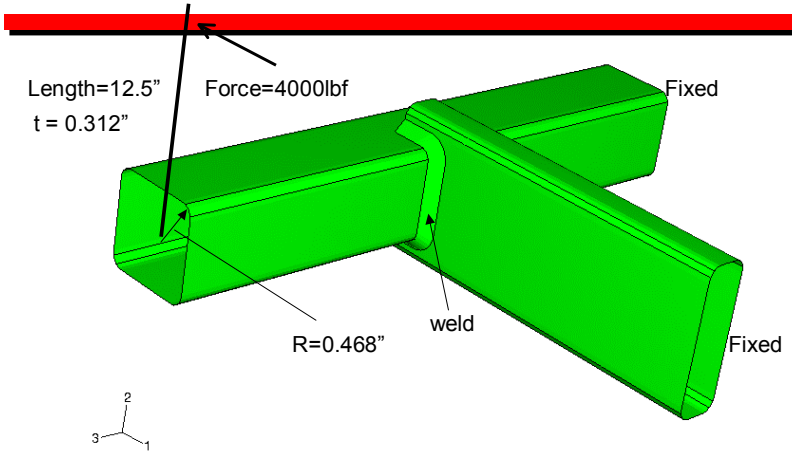
Structural Stress: Equilibrium Equivalent



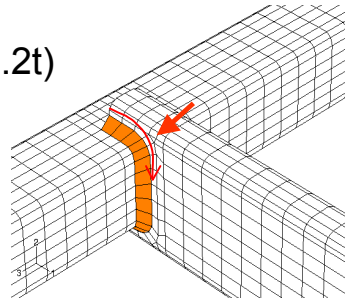
Notch Stress: Self-Equilibrating



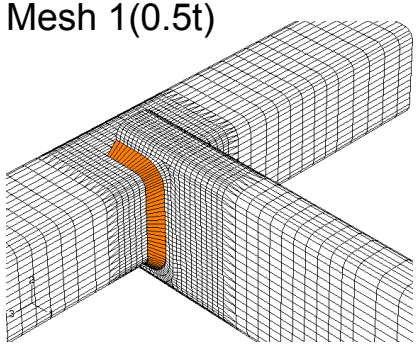
Mesh-Insensitivity Demonstration – The Structural Stress Method



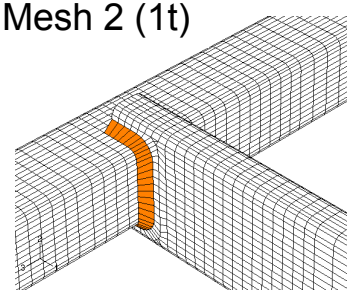
Mesh 3(2.2t)

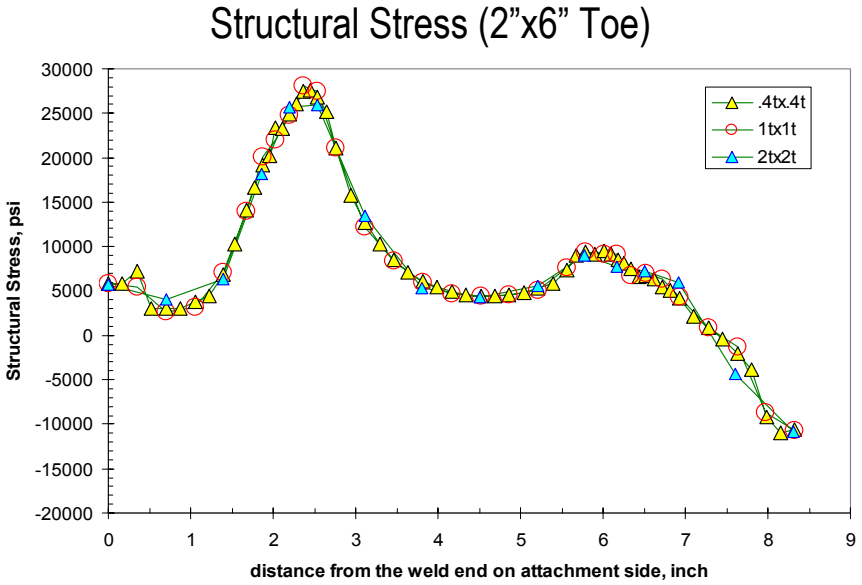


Mesh 1(0.5t)



Mesh 2 (1t)

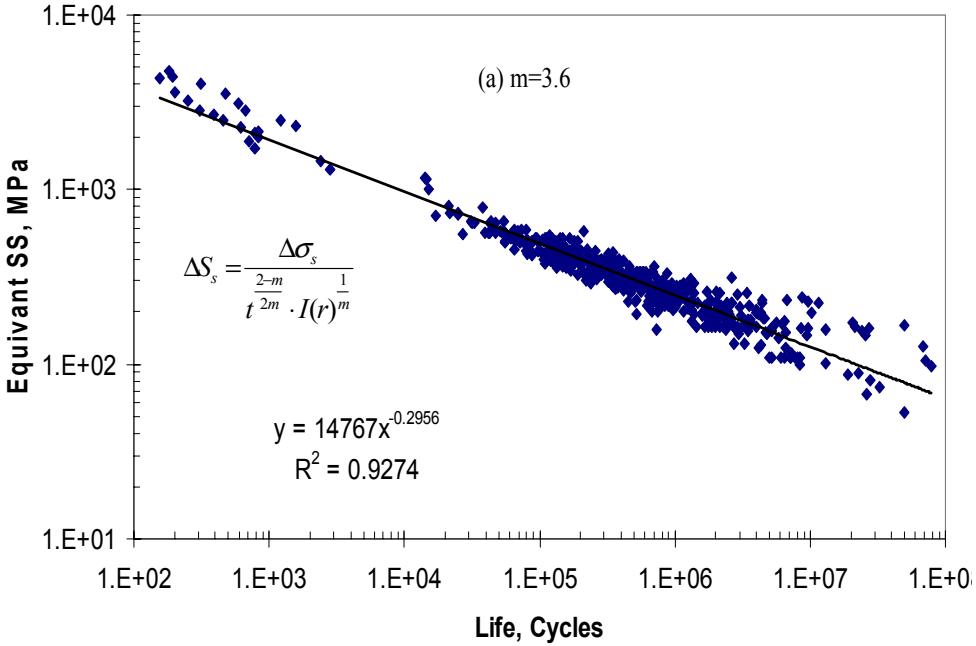


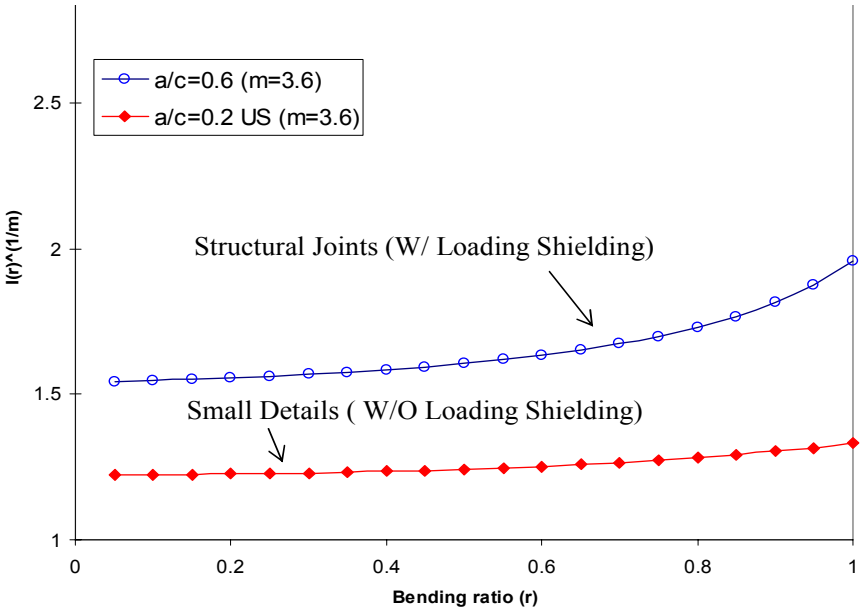


Battelle

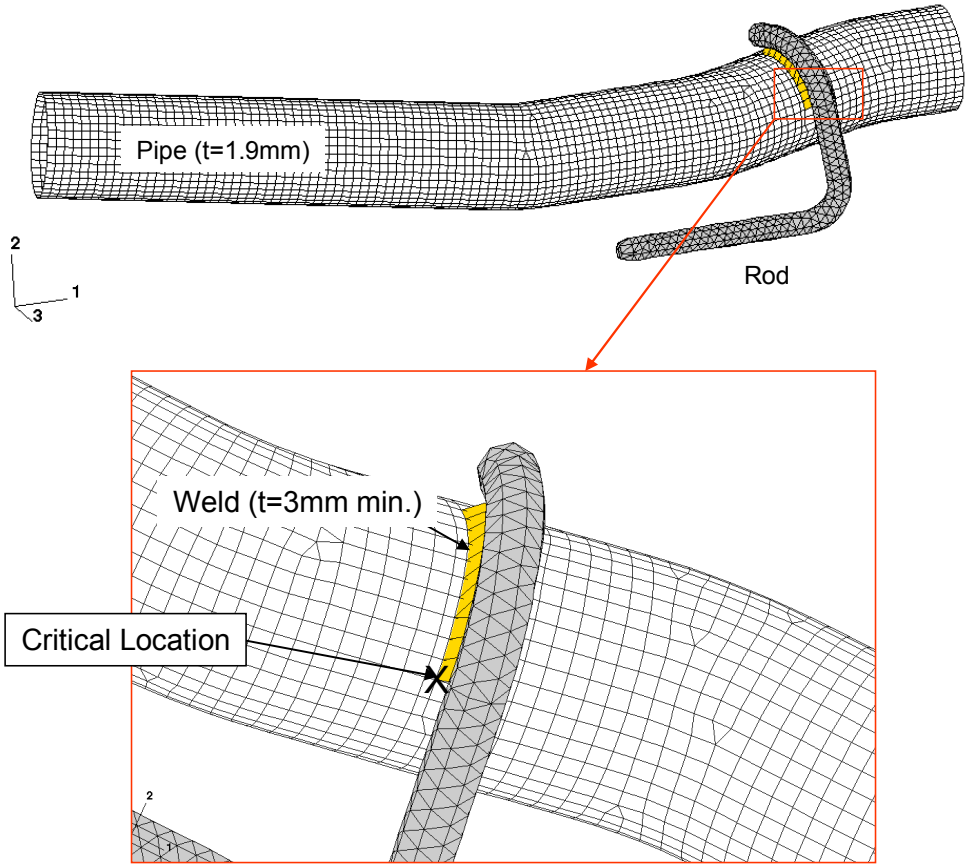
Center for Welded Structures Research

Master S-N Curve (Over 800 Tests): Load Controlled Conditions

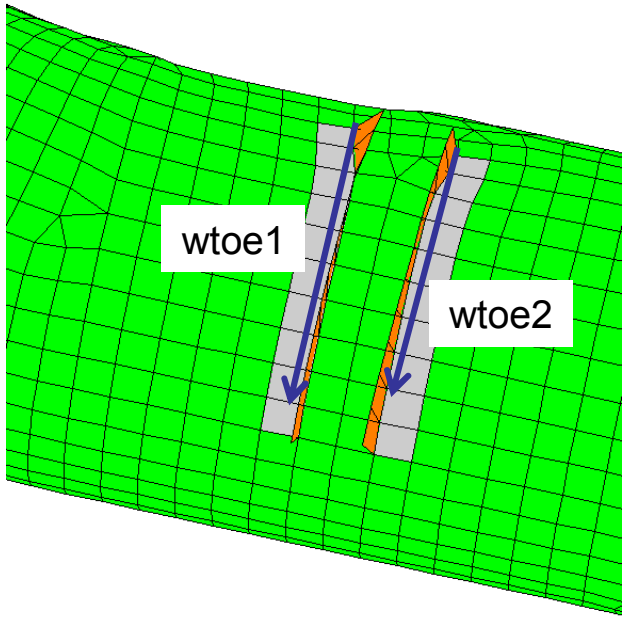




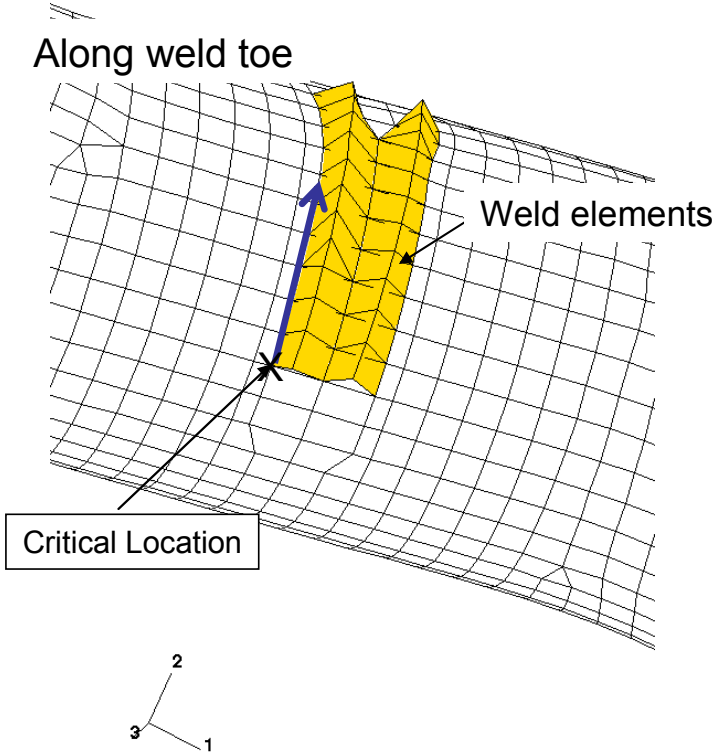
Model 1: A Simplified Weld Presentation to Check Potential Weld Failure - Unlikely

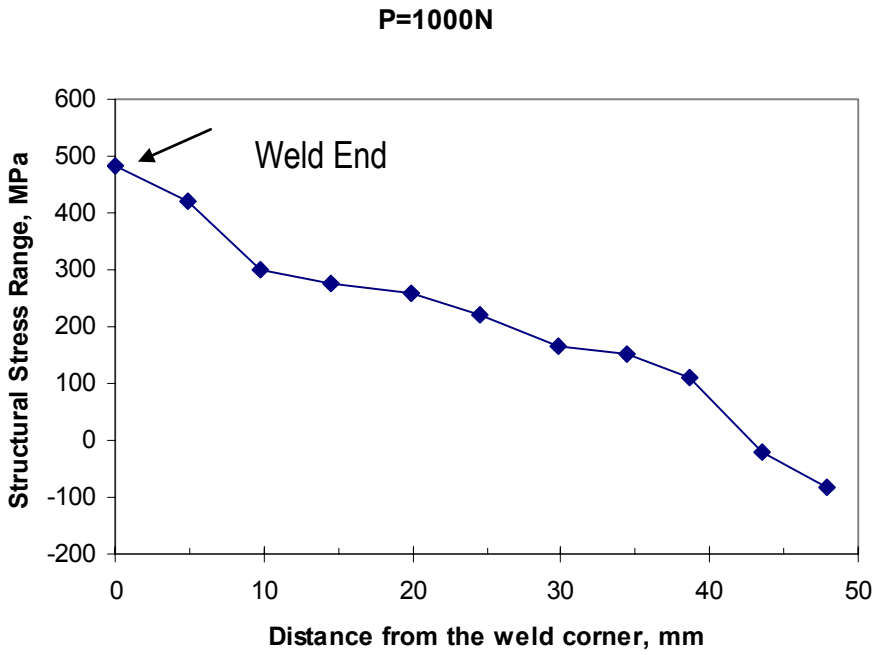


Weld represented by one row elements



Model 2: Weld Toe Failure Into Pipe Wall

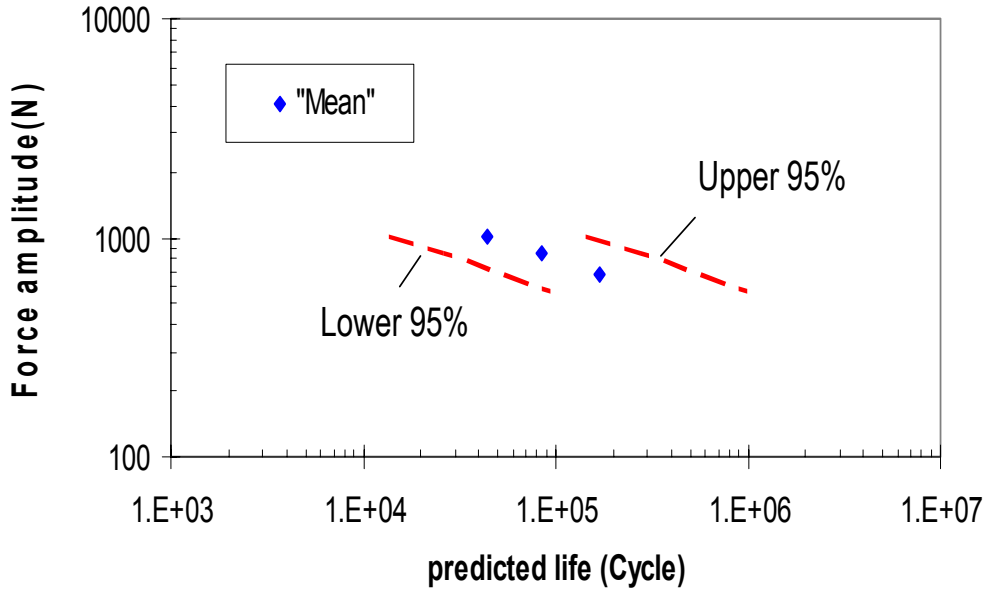




Life Predictions: Weld Toe Failure Along the Left Weld Originating From End

Force amplitudes: 1023N, 845N, 689N

Load ratio: R=-1



Some Concluding Remarks

- Highly localized stress concentration at one weld end
  - Highly rigidity of rod
  - Flexible thin pipe wall
  - The specific loading mode
- Minimum 6mm crack length as failure criterion is too large to maintain load-controlled conditions
- The present mean predictions should be on the conservative side