Residual Stress & Treatment

2018. 04. 18.

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Principle of Residual Stress Generation

Masubuchi, K. (1980). Analysis of Welded Structures: Residual Stress, Distortion, and their Concequences, Pergamon Press Ltd, London.

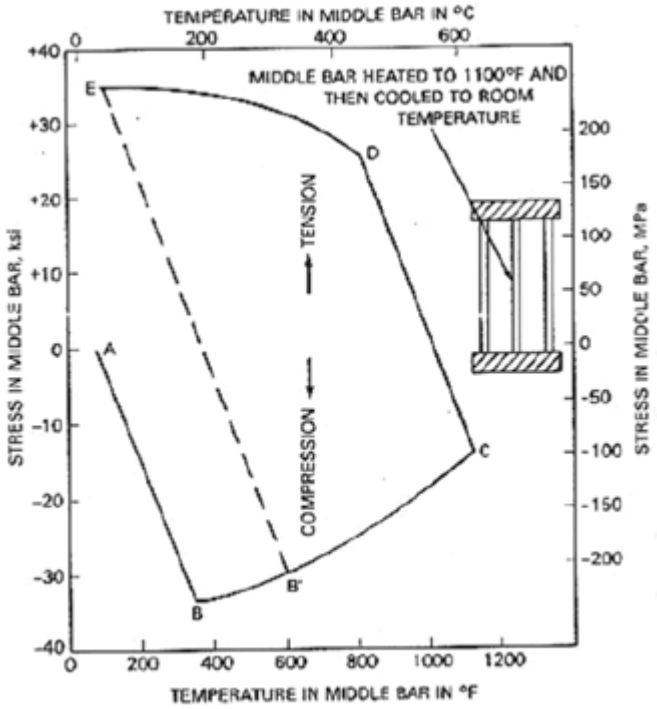

Figure 1. Illustration of residual stress mechanism in welding (source: Masubuchi, 1980)

- AB-curve : Compressive stress increases in linear elastic manner the yield stress of material
- BC curve : Plastic deformation is encountered which affects in decreasing compressive stress.
- CD curve : Cooling stage, the stress sign is dramatically changed from compressive to tension stress, increases in linear elastic way up to the yield stress at point D.
- DE curve : Non-linear plastic behaviour takes place in room temperature resulting in a tensile residual stress in the middle bar and contrary a compressive residual stress in both side bars which are equal to one-half of tensile stress in the middle bar.

Welding Residual Stress

Masubuchi, K. (1980). Analysis of Welded Structures: Residual Stress, Distortion, and their Concequences, Pergamon Press Ltd, London.

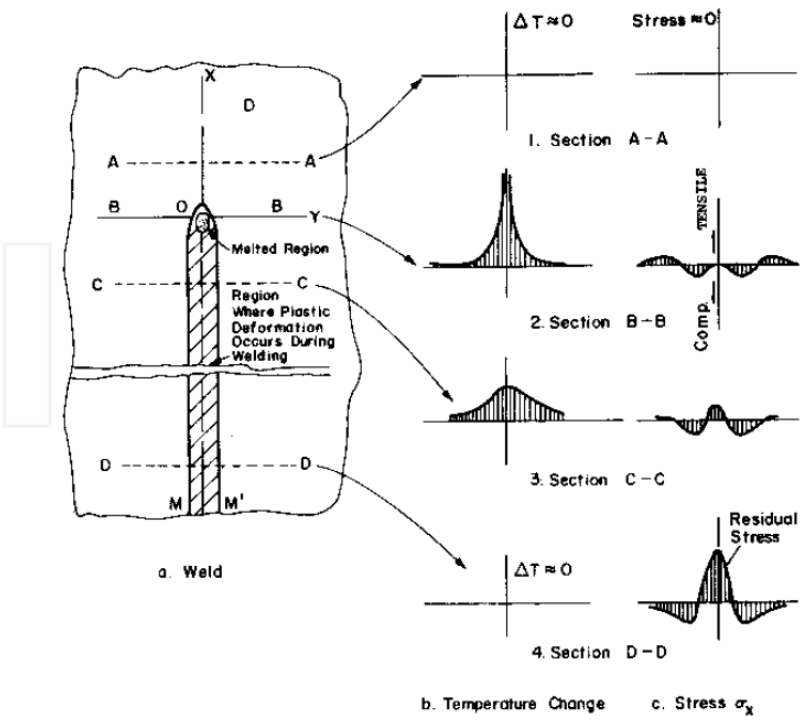

Figure 2. Schematic illustrations of heat cycles in welding and residual stress results (source: Masubuchi, 1980)

Temperature change makes stress distribution

- A-A : Before welding
- B-B : When weldment is dropped
- C-C : Cooling stage
- D-D : Room T

Welding Residual Stress Distribution

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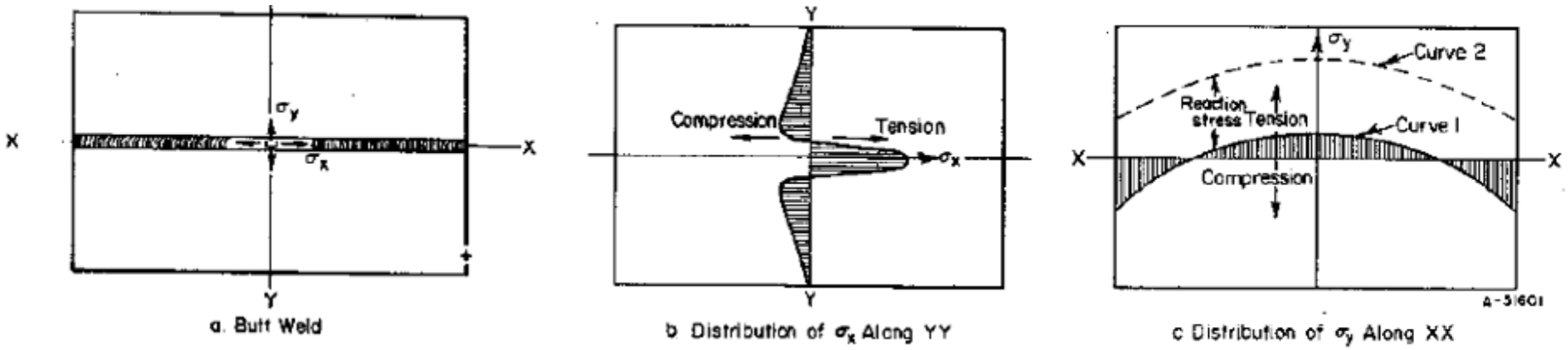


Figure 3. Typical distributions of residual stress in plate butt joints (source: Masubuchi, 1980)

- Tension & Compression both are distributed
  (For force equilibrium)
- The maximum stress of transverse direction is bigger than the maximum stress of longitudinal direction

Residual Stress Effect on Fatigue Life

Fatemi, A., 2011, "Fatigue Tests and Stress-Life (S-N) Approach. Lecture Notes," University of Toledo, OH. Available at: https://www.efatigue. com/

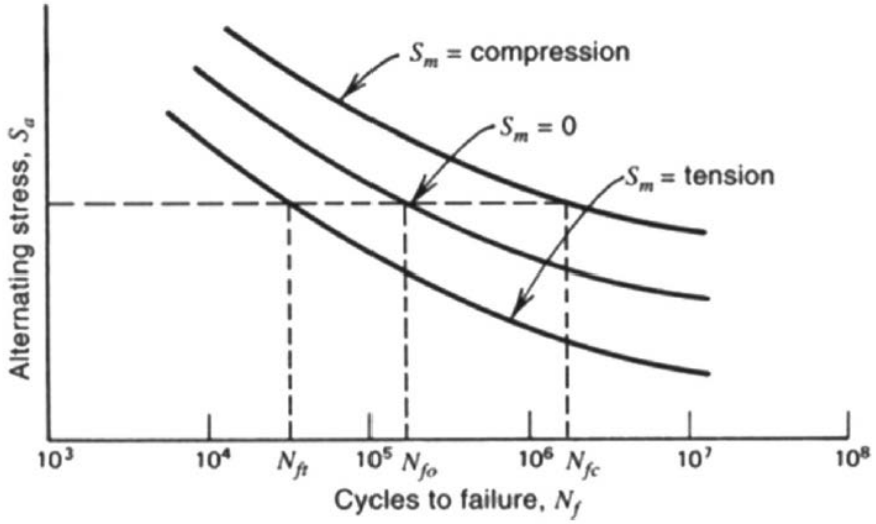
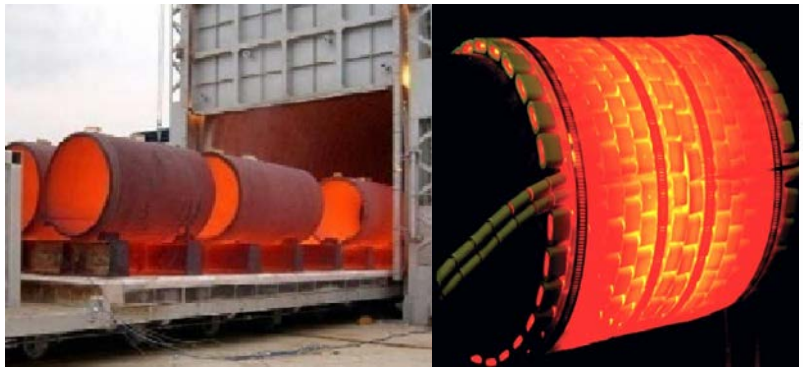


Fig. 4 S-N curves for various mean stress distributions [44]

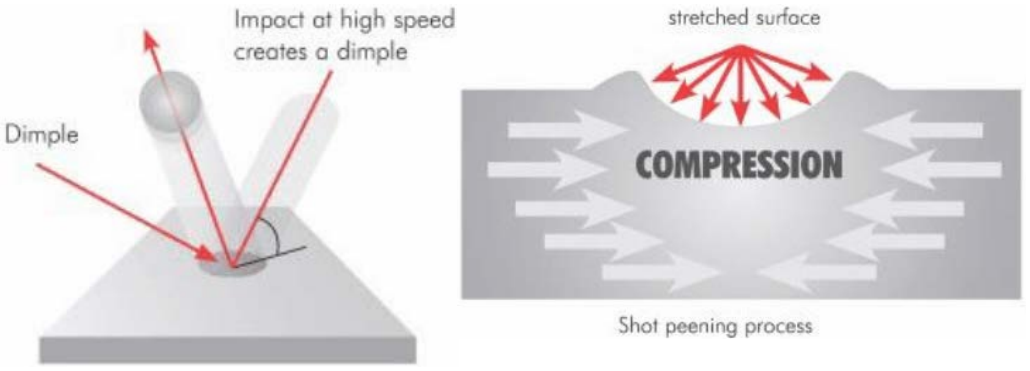
- Tensile mean stresses are the worst since their impact on fa-tigue life is significantly more adverse than that of other stresses.

- Compressive stresses have an effect of closing up the crack and retarding crack propagation, which result in fatigue life extension.

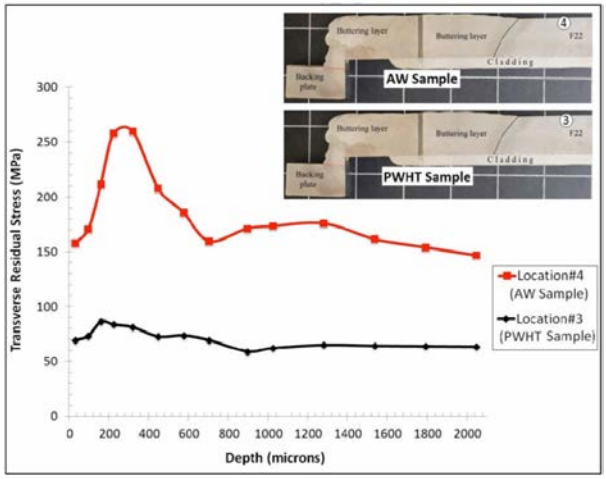
Residual Stress Treatment

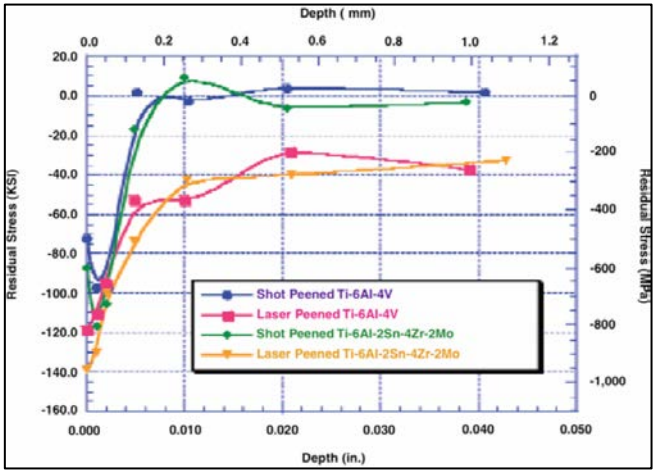


Post Weld Heat Treatment



Peening





- Residual stress could be treated by PWHT & Peening methods

Post Weld Heat Treatment

➢ **Conventional Purpose of PWHT**

- To achieve following two advantages;
  * Reduce the welding residual stress
  * Improve microstructure and mechanical properties

➢ **Recent Issue of PWHT**

- Issue : Degradation of toughness and tensile strength after PWHT was shown in some cases;
  * Several quenched and tempered steels
  * Long PWHT time
- PWHT exemption for quenched and tempered steel is needed in terms of mechanical properties and saving costs of the process.

LTT(Low Transformation Temperature) Welding

- **Definition**

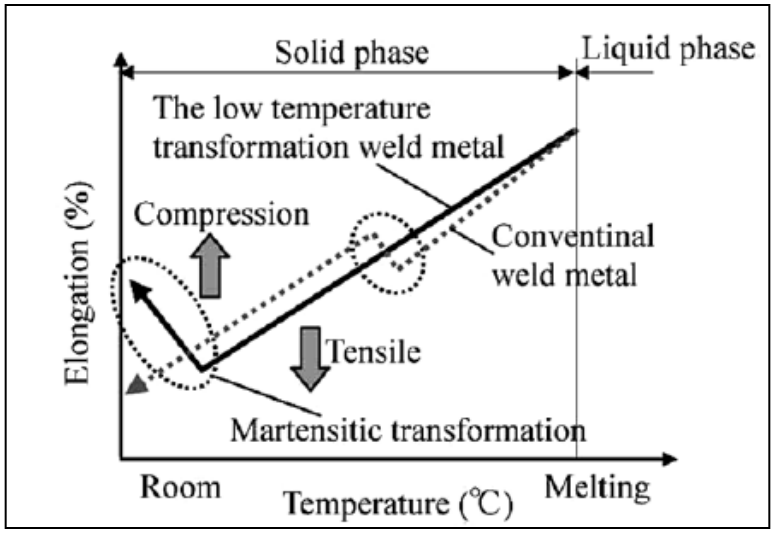
  The novel welding method with relatively low temperature martensitic transformation of welding filler

- **Purpose**

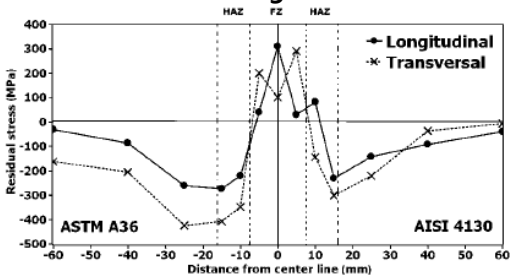
  Reducing tensile residual stress or inducing compressive residual stress in weld material

- **Basic Principle**

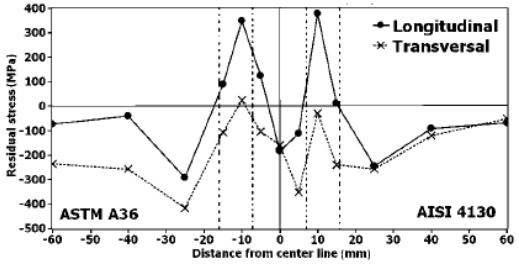
Strain by Phase Transformation → Compressive Residual stress/strain



(a) Conventional welding



(b) LTT welding



(Application of low Ms temperature consumable to dissimilar welded joint, 2014)