Steel Properties & Advanced High Strength Steels

Missouri University of Science and Technology

Founded 1870 | Rolla, Missouri | www.mst.edu
Product oriented research
Success Story: Lightweight Steel P900 Armor

• Need to reduce the logistics cost. Cost of fuel in Afghanistan including delivery, distribution, protection etc. is $600/gal.
• ARL sponsored the program
• New lightweight steel developed to reduce P900 weight by ~15%
• Ballistic properties approaching steel industry standard rolled homogeneous armor
• Ballistic testing successful
Cast Lightweight Steels with Aluminum

- Austenitic steels
- Fe-30Mn-1Si-0.5Mo with Al ranging from 2.7 wt.% to 9 wt.%
- Al lowers the USFE
- Al increases SFE
- Fe-Al-C Short range order
  - Increases ductility
  - Reduces dynamic strain aging
  - Lowers wear resistance
Effect of Si upon $\kappa$-carbide precipitation

- Austenitic, precipitation hardening
- Fe-30Mn-9Al-1Si-0.9C-0.5Mo
- Competes with quench and tempered 4130
- ~15% lighter weight
- Atom probe studies to determine role of Si
3rd Generation Advanced High Strength Steel

Alloy formulation  Casting  Hot rolled product

Modeling
- Thermodynamic
- Density functional theory
- Hypothesis testing by direct experiment
3rd Generation AHSS: TRIP

- Reduce C and increase Mn
  - Reduced stacking fault energy
- No δ-ferrite stringers
- 27% retained austenite; 13% α-martensite; 60% ε-martensite
- Stage I: γ to ε
- Stage II: ε to α
- Stage III: segregated regions TRIP

Fig. 5 — (a) Strain hardening exponent and (b) strain hardening rate varied as a function of engineering strain.
3rd Generation AHSS: Acicular Ferrite

- Fe-13.92Mn - 4.53Al-1.28Si-0.11C
- Duplex (δ+γ) hot rolled
- Acicular ferrite upon cooling
- Low misfit galaxite and MnO₂
- Stability of oxide is temperature dependent
Crystallography of the Peritectic Reaction

- Effected by primary δ-ferrite
- Better castability with < 40% δ-ferrite
- Kurdjumov-Sachs orientation relationship
  - With > 60% δ-ferrite content
  - Slows the solid state peritectic transformation
Effect of Co on Cu precipitation in 17-4PH

Co additions
- Co produces neither solid solution strengthening or softening
- Increase number density of Cu precipitates
- Narrows size distribution of Cu precipitates
- Co is rejected from Cu
  - islands or shell on Cu particle and/or distribute into the Fe matrix
  - Increases cleavage stress if at interface
Potential Topics/Areas of Physical Metallurgy Research

- Thermodynamic Modeling
- Physical Metallurgy
- Density Functional Theory
- Microstructural Characterization
- Performance Testing

Your product