AUTOMOBILE STEEL WHEELS
The Road to Dual Phase

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• Automotive Wheels Have Been Manufactured From Many Materials Throughout The History Of The Automobile:

  • Wood
  • Steel (Casting, Sheet or Wire)
  • Aluminum (Casting, Forging, or Sheet)
  • Magnesium
  • Composites (FRP)
  • Combinations of the Above
From the early days, steel has been a predominant choice for wheel materials:

- Pressed Steel Wheel
  Circa 1910

- Early Wire Wheel
  Circa 1920
The Age of Steel (1935 – 1980s): During This Period Steel Wheels Dominated The Automobile. By 1935 Wheel Diameters Had Decreased From 36” To 16” And Rim Widths Increased From 3” to 6”. The Processes Of Stamping The Center (Disc) And Rolling The Rim Were Well Suited For High Volume Low Cost Production.
Hot Rolled Low Carbon Steel Grades Were Predominant For Wheels Prior To The 1970s And Continue To Be Used Primarily on Rims Today:

- **Discs:**
  - Rimmed 1012/1015 HRLC
    - High Formability – Low Alloyed Outer Surface
    - Converted to Continuous Cast 1012/1015 HRLC

- **Rims:**
  - Mechanically Capped 1008/1010 HRLC
  - Converted to Continuous Cast 1008/1010 HRLC
    - Still the Predominant Steel Alloy for Rims
The Early To Mid 1970s Brought The Need To Reduce Weight And Led To The Introduction Of Higher Strength Steels Into Wheels:

- North America: 955X / 960Y HSLA Grades
  - Precipitation Hardening w/Cb Additions for Grain Refinement
- Europe: Dual Phase Grades
  - DP550 – Initially Si Chemistry
- Japan: SAPH 45 – 60 HSLA Grades
• This Demand For Higher Strength Steels Along With A Need To Maintain Formability Led To The 1st Attempted Use Of Dual Phase Steel For Wheels In North America:

  • Mid 1970s – SAE980X Continuously Annealed Dual Phase
    • Motor Wheel Corporation: AMC Wheel
    • Kelsey Hayes: Cadillac Wheel

  • Both Attempts Discontinued – Production Steel Problems
    • Material Property Inconsistencies
    • Surface Cosmetics due to High Si Levels
The 980X Experience Resulted In North American Wheel Manufacturers And OEMs Reluctant To Pursue Dual Phase Steel For Wheels:

- Micro-Alloyed HSLAs became the Standard for North American Light Weight Steel Wheel Applications
- Dual Phase / Bainitic Steels became the Standard for European Light Weight Steel Wheel Applications
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2002 MY Steel Grade Usage - Automotive Wheels

- Bainitic(HR45-60)
- Dual Phase
- HSLA
- HRLC

Rim Europe  Rim North America  Disc Europe  Disc North America
Renewed Interest in Dual Phase:
- Aluminum Wheel Penetration
  - Advantages of Styling and Weight
- Need for Improved Formability
  - High Vent Wheel Development
- Renewed Need for Weight Reduction
- Dual Phase Development for Ford “Impact” Program
- Development of Cr Based DP Chemistry
  - Increased Availability
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Wheel Material Usage 1980 - Present

1980 - 1995: Steel usage decreases significantly, while aluminum usage increases.
1996 - 2003: Steel and aluminum usage remain relatively stable, with a slight increase in aluminum usage.

Legend:
- %Aluminum
- %Steel
1999: Hayes Lemmerz Began An Investigative Study Into Utilizing Dual Phase In Steel Wheels:

- Trial DP Steels from 7 Global Suppliers:
  - 2 North American
  - 1 South American
  - 2 European
  - 2 Asian

- Chemistry:
  - Si (4 Suppliers)
  - Cr (3 Suppliers)
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- Attributes Evaluated (Dual Phase vs HSLA):
  - Fatigue Strength
    - Higher Base Tensile Strength
      - 87 ksi min. vs 75 ksi min.
    - Greater Work Hardening
    - Paint Bake Hardening
  - Formability
    - Lower Yield to Tensile Ratio
      - 0.60 - 0.70 Typical vs 0.80 – 0.90
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Average Rotary Fatigue Life Comparison
15x6 Drop Center Wheel

Production 060 HSLA
Supplier #1 Si=1.2%
Supplier #2 Si=1.0%
Supplier #3 Si=1.1%
Supplier #4 Si=0.2%
Supplier #5 Si=.02%
Supplier #6 Si=1.1%

Dual Phase Supplier - Si Level
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Average Rotary Fatigue Life Comparison
15x7 Full Face Wheel

- Production - 060 HSLA
- Supplier #4 - Si 0.02%
- Supplier #5 - Si 1.1%

Dual Phase Supplier - Si Level
Wohler Curve Comparison – Dual Phase vs HSLA
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• Evaluation Results: Benefits Confirmed

  • Fatigue Performance Improvement
    • Typically 50% or Greater Increase
      • Allows for 10% Gauge/Mass Reduction

  • Formability
    • Reduced Forming Scrap
    • Reduced Leuder (Strain) Lines
• Evaluation Results: Concerns
  • Cosmetics
    • “Tiger” (Silicon) Stripes
  • Formability
    • Higher Work Hardening (n-values)
    • Redesigned Die Operations
      • More Forming Up Front
  • Consistency
    • Heat to Heat Variation (1970’s Experience)
• Availability and Cost

www.autosteel.org
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• Going Forward:
  • 2006 MY Production Dual Phase Programs
    • Flex Wheel Programs
    • Cr Chemistry Dual Phase Specified
      • 2 Suppliers Identified
  • Additional Steel Suppliers to be Evaluated
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