Heavy Vehicle Propulsion Materials

Walker Process for Accelerated Stress Relief Project (PM_11198)

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Walker Process for Stress Relief

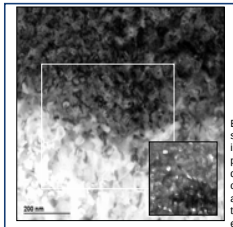
21CTP Technical Goal: **Develop and demonstrate an emissions compliant engine system for Class 7-8 highway trucks that improves the engine system efficiency from ~42% today to 50% by 2010.**

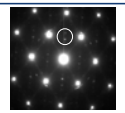
Project Objectives
Develop and demonstrate a new process for accelerated residual stress relief and heat treat processing, resulting in 50% or more savings in energy and efficiency in processing, while enabling reductions in weight and improvements in cycle life.

FY 2005 Focus
Validate process and demonstrate capabilities.

Planned Duration
March 2004 to November 2005

DOE Funding/Industry Cost Share
FY04: $40K





Bright-field TEM image of Al alloy shows oriented second phase, seen in inset dark-field image taken using precipitate spots shown in above diffraction pattern. Area of inset corresponds to white box. TEM is allowing correlation of microstructure to processing and stress-relief effects.

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Accomplishments
Process has been validated for stress relief in 7075-T6 aluminum and in 4340 steel, December 2004.

Process has been validated for weld stress relief in steel truck wheels, resulting in 100% improvement in fatigue life of the parts, March 2005.

Significant Future Milestones
Develop technology for use in casting production and in aging of aluminum alloys for process acceleration and energy use reduction.

Project ID/Agreement ID	Program Structure	Sub-Program Element	R&D Phase	Date
PM_11198	Materials Technology	HV Propulsion Materials	Exploratory R&D	8-15-05

Objectives

- Develop a new process for accelerated residual stress relief and heat treat processing, resulting in 50% or more savings in energy and efficiency in processing, while enabling reductions in weight and improvements in cycle life.
- Verify significant reductions in residual stresses and improvement in corrosion resistance, fatigue life and strength due to the accelerated processing.
- Coordinate with various manufacturing programs to increase efficiency, reduce residual stresses, and reduce production costs.
- Develop estimates of economic impact on production processes and weight improvements with incorporation of the Walker process into current manufacturing environments

Relevance to 21CT Goals

- **Develop and demonstrate an emissions compliant engine system for Class 7-8 highway trucks that improves the engine system efficiency from ~42% today to 50% by 2010.**
- **Successful development of the Walker Process will facilitate improved performance of structural materials and enable more efficient engine designs.**

Technology Transfer

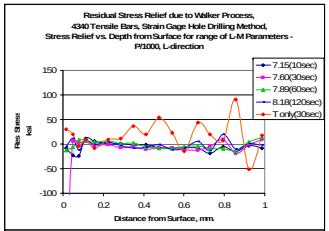
- Acceledyne is a small business which is actively developing new commercial applications for the Walker Process.

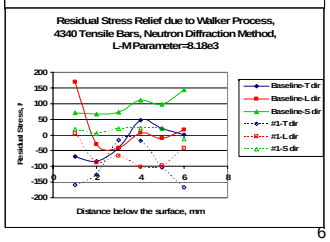
Approach

- Develop methods for application of Walker process to test coupons for residual stress relief and accelerated thermal processing
- Determine Larson-Miller parameters for Walker process for stress relief of 4340 steel and 7075 aluminum and compare to current manufacturing process results. A net reduction of processing flow time, energy, and reduction in weight would be the anticipated result.
- Validate residual stress relief using standardized testing of depth profile.
- Characterize mechanical, microstructural, and corrosion property improvements, resulting in weight reduction of parts.
- Incorporate the Walker process into current production lines at minimal additional cost, reducing energy costs up to 50%, increasing fatigue life of parts, and reducing weight.

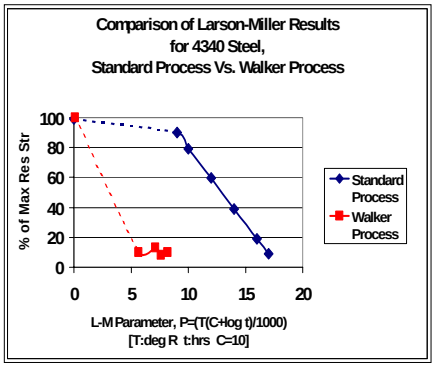
Technical Accomplishments/ Progress/Results

- Demonstrated that the Walker process for accelerated stress relief can be successfully applied to 4340 steel, welded 1040 steel wheels, 7075-T74 and 7055-T7x aluminum and Ti-6-4 sheet specimens and parts.
- Identified key process parameters for scaling to full-scale production applications for steel and aluminum saving 95% processing time and reducing energy costs and weight requirements.
- Obtained comparisons to current Larson-Miller parameter data for 4340 steel and 7075 aluminum
- Verified hole-drilling analysis data using neutron diffraction analysis on 4340 steel and 7055 aluminum
- Observed changes in microstructure of 7055 aluminum using transmission electron microscopy.





Technical Accomplishments/ Progress/Results



- Developed the Walker process to reduce residual stress levels in 4340 steel parts by 95% while reducing energy required by more than 95%. Treatment times were reduced from 100 hours or more to 120 seconds or less. In welded full-face truck wheels, fatigue life increased by more than 200%.
- Similar results were obtained in 7055 and 7075 aluminum and titanium.
- Residual stress results were verified by strain gage hole drilling analysis and neutron diffraction analysis.

Future Work

- Continue refining Walker process and quantify process variables for various materials and applications. Continue to quantify microstructural effects due to the Walker process on materials.
- Develop applications to casting, forming, and welding processes for reductions in process time and improvements in mechanical properties.
- Develop accelerated aging/tempering protocols for commercial aluminum, titanium and steel alloys.
- Conduct tests to determine improvements in mechanical properties, fatigue life and corrosion resistance, leading to weight reduction.
- Conduct cost analysis studies to quantify improvements.