0015 Development Of A Standard Methodology For The Quantitative Measurement Of Steel Phase Transformation Kinetics And Dilation Strains Using Dilatometric Methods

Benefits

- Estimated annual benefit of $9.1 million per year based on the elimination of the heat-treating step for just 10 percent of the total amount of domestic bar and rod product produced annually in the U.S., which is approximately seven million tons per year
- Reduced usage of natural gas conservatively estimated at an energy savings of 0.33 billion cubic feet per year when 90 percent penetration into the normalization heat treatment market place is achieved
- Reduced CO, CO2, SO2, NOX, and other greenhouse gas emissions
- Reduced material rejection as a result of not meeting property requirements
- Replacement of annealed products with hot-rolled products
- Minimization of scale formation and decarburization
- Increased utilization of new sensors and control systems currently being developed

Applications

Accurate transformation data will enable the steel industry to predict the structure, residual stresses, and dimensions of finished components as a function of process and alloy selected, thereby enhancing the manufacturing process and alloy selection method. In turn, this enables virtual product and process development, and provides input to durability analysis for product design, helping integrate design with manufacturing to reduce product development time.

Better Characterization Of Phase Transformation Kinetics And Thermal Strains For Steel May Define More Precise Bar And Rod Processing Parameters

The steel producing industry, forging, heat treating, and component user industries are under increasing demands for higher quality, better performing materials and components at lower costs. These demands require tighter process control, as well as product and process optimization to minimize energy use, scrap, materials and processing cost, while simultaneously improving component performance. These goals are being addressed with improved materials and processes and computational tools to study and optimize processes and designs. The development for the predictive tools for the steelmaking, forging, heat treating, and component user industries is significantly lagging, compared to many other areas (such as casting and sheet forming). This results from the complexity of the steel manufacturing processes, a lack of accurate data for the models, and the daunting and expensive task of acquiring these data -- issues that justify a common approach in the steel industry.

Data on steel transformations has been collected using a variety of techniques, such as metallography, dilatometry, magnetic permeability, and differential thermal analysis. Dilatometry is a common method of measurement, yet many key steps in data acquisition and reduction used in constructing phase transformation diagrams remain non-standardized, thus subject to high variability in practice.

The purpose of this project is to develop standard procedures for obtaining quantitative steel transformation kinetic and thermal strain data using two dilatometric methods. The initial focus is on bar and rod product forms for two steel grades, 8620 and 1050.

Project Description

Goal: To develop a standard practice for obtaining and archiving quantitative steel transformation kinetic and thermal strain data. The initial thrust is focused on bar and rod product.

Standard measurement, data interpretation, and data reporting methods are being developed and defined, upon which a quantitative database for process modeling can be developed and electronically archived. A key goal in establishing standard practices will be to provide the steel phase transformation data in an appropriate format so as to maximize and accelerate their utility in state-of-the-art material and process modeling computer simulation software.

Parallel standard development paths are being pursued in four technical tasks to cover the two families of dilatometric equipment currently used in practice in the steel industry. These systems are: (1) high-speed quenching and deformation dilatometers, and (2) Gleeble thermo-mechanical processing equipment. The standard practiced methodologies are being developed for three distinct austenite transformation scenarios. These include: (a) transformation of the austenite under no applied elastic stress or plastic deformation, (b) transformation while a static elastic stress is applied to the austenite, and (c) transformation of the austenite while it is undergoing plastic deformation. Recommended standards for the QMST standard will be documented and published.

Progress and Milestones

- ❖ Project Start Date: January 2001
- ❖ 0 - 6 Months: TASK 1: Definition and Terms of Parameters
  - Test Matrix
  - Standardized Nomenclature
  - Defined Benchmark for Accuracy
- ❖ 3 - 15 Months: TASK 2: Development of a Procedure for Determination of Transformation Data (without Austenite Deformation)
  - Data Collection Procedure; Data Collected; "Best" Collection Technique
  - Transformation Process; Identification Standard
  - Percentage Transformed Definition; Standard
- o 3 - 15 Months: TASK 3: Development of a Procedure for Determination of Transformation Data (with Austenite Deformation)
  - Data Collection Procedure; Data Collected; "Best" Collection Technique
  - Transformation Process; Identification Standard
  - Percentage Transformed Definition; Standard
- ❖ 16 - 24 Months: TASK 4: Development of a Standard Method for Data Analysis and Reporting
  - Standard for Data Analysis and Report
  - Final Report
- ❖ Project End Date: January 2003

Total Project Cost/Duration
$1,051,000/2 years

Research Organization

Technologies Research Corporation - National Center for Manufacturing Sciences
Ann Arbor, MI (Dr. Manish Mehta)

Colorado School of Mines
Golden, CO

National Institute of Standards
Gaithersburg, MD

Oak Ridge National Laboratory
Oak Ridge, TN

Sandia National Laboratories
Albuquerque, NM

Industry Participants

American Axle & Manufacturing, Rochester Hills, MI
Caterpillar Inc., Peoria, IL
DCT, Inc., Cleveland, OH
Daimler Chrysler, Auburn Hills, MI
Deere & Co., Moline, IL
Dynamic Systems, Poestenkill, NY
Ford Motor Co., Redford, MI
GKN Automotive, Auburn Hills, IL
Ispat Inland, East Chicago, IN
MAC Steel, Jackson, MI
North Star Steel, Edina, MN
Timken Co., Canton, OH
Torrington Co., Torrington, CT
Thyssen Krupp, Duisburg, Germany

For additional information, Please Contact:

Peter Salmon-Cox
Office of Industrial Technologies
Phone: (202) 586-2380
Fax: (202) 586-9234
peter.salmon-cox@ee.doe.gov
http://www.oit.doe.gov/steel

Dr. Manish Mehta
Technologies Research Corporation - National Center for Manufacturing Sciences
manishm@ncms.org

Joseph R. Vehec
American Iron and Steel Institute
aisiap@aol.com