Heat Treating Society

An Affiliate Society of ASM International

ASM-HTS
1999 Draft R&D PLAN

May 4, 1998

NCMS Annual Technical Conference

U.S. Heat Treating Industry: Achieving the Vision

How Did We Get Here?

- 1995 Heat Treating Industry Needs
- 1996 R&D Plan
- Heat Treating: Vision 2020
  - Metal Treating Institute (MTI)
  - DOE-OIT
- Heat Treating Technology Roadmap Workshop
  - DOE-OIT

Goals from Vision

- Reduce Energy Consumption by 80%
- Reduce Process Time by 50%
- Reduce Production Costs by 75%
- Achieve Zero Distortion and Maximum Uniformity in Heat Treated Parts
- Increase Furnace Life Ten-fold
- Reduce Costs of Furnaces by 50%
- Attain Zero Emissions
- Half the Furnace Insulation for Twice the Capability

What Is It Going to Take to Achieve the Vision?

- Heat Treating Processes With Shorter Cycle Times and Lower Cost Equipment and Materials
- Alternative"environmentally Friendly" Quenching Media
- Improved Process Sensors and More Advanced Controls
- Computer Modeling of Processes Which Include Composition, Microstructure, Dimensional Changes and Final Properties
- Additional Ways to Recycle Heat, Eliminate Re-heating and Reduce Heat Losses
- More Effective Dissemination of Solutions

1999 Draft R&D Plan

- **What Is It?**
  - Definition of the priority research to address vision 2020 goals
  - Groundwork for endorsing cooperation within the heat treating and all thermally oriented industries
- **Purpose**
  - Provide a focus for heat treat research
  - Define specific research and development areas
  - Identify and prioritize immediate research needs
  - Provide a vehicle for ASM to promote the vision

1999 R&D Plan Development Process

- Results of Roadmap Workshop
- Develop Draft Plan
- Input at NCMS Session
- External Review
- Disseminate at ASM Annual Meeting in October

Heat Treating Cross-Cut Industries

- Steel
- Forging
- Aluminum
- Casting
- Glass

1999 R&D Plan
Priority Research Areas

- **Heat Treat Equipment and Hardware Materials**
- **Processes and Heat Treated Materials**
- **Energy and Environment**

Heat Treat Equipment and Hardware Materials

- Improve Furnace and Bath Heat Treating
  - Through hardening, carburizing, nitriding, annealing, etc.
- Develop and Application of Rapid Heating Technologies
  - Induction hardening, laser hardening, etc.
- Integration of Heat Treat With Other Processes
  - Controlled cooling from forging, paint bake aging, etc.

Attain Higher Operating

Current Limitations

-
  temperature
- Material for high temperature heat treat

- **Benefits of Higher Operating Temperature**
  - Reduce process time
  - Reduce production costs

Attain Higher Operating Temperatures

- **R&D Topics**
  - **Ceramic and composite tubes**
    - » **cost, toughness and adaptability**
  - **Alternatives to radiant tube heating**
    - » **increase temperature uniformity**
  - **Advanced insulation**
    - » **efficiency**
  - **(also need advances in material to be carburized)**

Rapid Heating Technologies

- **Current limitations**
  - **High equipment costs**
  - **Geometric limitations**
  - **Component performance**
  - **Cost associated with materials - machining**
- **Benefits**
  - **Short cycle time**
  - **Lower energy consumption**
  - **Low emissions**
  - **Enables synchronous manufacturing**
  - **Lower distortion**

Processes and

- **Integrated Process Models**

Sensors

Integrated Process Models

- **What Are They?**
  - **Numerical models of each step of the heat treat process that predict chemistry, phases, stress-strain state and dimensional changes**
  - **Enabler for Design For Manufacturing**
  - **Enable design and process optimization**

Integrated Process Models

- **Benefits**
  - **Reduced energy consumption**
  - **Reduced process time**
  - **Reduced production costs**
  - **Lower distortion**
  - **Lower process and product development costs**

Integrated Process Models

- **Typical Parts of a Simulation**
  - **Heat-up Behavior**
  - **Carburizing/ Nitriding/ Solutionizing/Aging/Soaking**
  - **Cooling**
  - **Boundary Conditions**
  - **Databases**

Integrated Process Models

- **Priority Research Items**
  - **Quenching**
  - **Electromagnetics (3-D application)**
  - **Mechanical models**
  - **Transformation property databases**

Quenching

- Experimental Quenching
  - 3-D inverse heat transfer calculation
  - Scaling rules for quenching
  - Geometric probe
- Predictive Quenching
  - Advanced CFD
    - large problems
    - boiling

Electromagnetic Models

- 3-D Analysis
  - FEA methods
  - Meshing
- Material Databases
  - Temperature and phase dependent

Mechanical Models

- Stress-strain Databases
  - Phase
  - Strain rate
  - Chemistry
  - Temperature
- Strain Partitioning Theory
- Transformation Plasticity Data

Transformation Databases

- TTT
  - rates)
  - Aging or precipitation
- Transformation Strain Data

Real Time Process Sensors
Predictive Sensors

- **What is it?**
  - **The development of advanced sensors processes.**
- **Benefits**
  - **Reduced production costs**
  - **Better components**
  - **Reduced energy**
  - **Reduced process time**

Real Time Process Sensors Predictive Sensors

- **Priority Research Items**
  - **Sensors controlling a system with multiple physical and chemical inputs**
  - **Controlling algorithms to quantitatively integrate sensor inputs**
  - **Real-time case carbon sensors**

New Materials

- **What is it?**
  - **Development of component materials that enable improvements in processing technology without substantial increase in cost**
- **Benefits**
  - **All the benefits of new processes**

New Materials

- **Priority Research Items**
  - **High temperature processing**
    - » **minimize grain growth**
    - » **stability**
  - **Rapid-heating technology**
    - » **produces desired component performance**
    - » **machinable**
    - » **low-cost**

Energy and Environment

- **Energy Reduction**
- **Zero Emissions**

Energy Reduction

- **What is it?**
  - **Reduce total system energy for heat treatment.**
    - » **improve thermal efficiency of current processes**
    - » **reduce heat treat time**
    - » **change to lower energy processes**
- **Benefit**
  - **Lower energy usage**

Energy Reduction

- **Priority Research Items**
  - **Improve carburizing process**
    - » **low thermal mass fixtures**
    - » **baseline tech performance**
    - » **high temperature carburizing**
  - **Energy map of heat treating**
  - **Rapid heating/cooling systems**
  - **Low-cost heat recovery**

Eliminate emissions from heat treatment that produce a negative impact on the environment

- NO_x
- **Halogenated solvents**
- **Waste oil and salts**

Zero Environmental Impact

- **Priority Research Items**
  - **Alternatives to oil quenchants**
  - **Alternatives to quenching salts**
  - **Alternatives to solvent cleaners**
  - **Reduce CO and NO_x**

What's Next?

- Re-evaluate priorities - session input
- Look for synergy with cross-cutting industries
- Disseminate the plan
- <u>ENCOURAGE ALLIANCES, COLLABORATION, IMPLEMENTATION</u>
- Assess progress - issue updated plans