

# INDUSTRIAL TECHNOLOGIES PROGRAM

## Aging of Graphitic Cast Irons and Machinability

Graphite iron is used to produce automobiles, mass transit, heavy transportation, municipal, energy production and process plant equipment. Given their widespread applications, improving the machinability of these alloys could significantly increase marketability. Further research improves strength by casting compositions into more easily processed compositions, while reducing scrap production due to shrinkage and machinability rejects. The use of higher carbon equivalent iron to achieve the same properties results in lower gating weight per casting (higher yield.) Ductile iron and compacted graphite iron in particular demonstrate the potential enhance energy savings.

In 1999, researchers at the University of Missouri-Rolla demonstrated that age strengthening occurs in gray cast iron. In 2002, these same researchers found that the machinability of cast iron improves with age strengthening,

and have shown evidence of a precipitate formation by neutron scattering. The influence of nitrogen also suggests a nitrogen-containing precipitate. With age strengthening determined in gray cast iron, researchers have begun to look for similar results in ductile iron. Some as-cast grades of ductile iron do show age strengthening and will allow more thorough characterization of the mechanism in terms of strain hardening rate, yield strength and internal friction. Compacted graphite iron, another commercially important family will also be studied to determine whether there is age strengthening to a statistically significant extent.

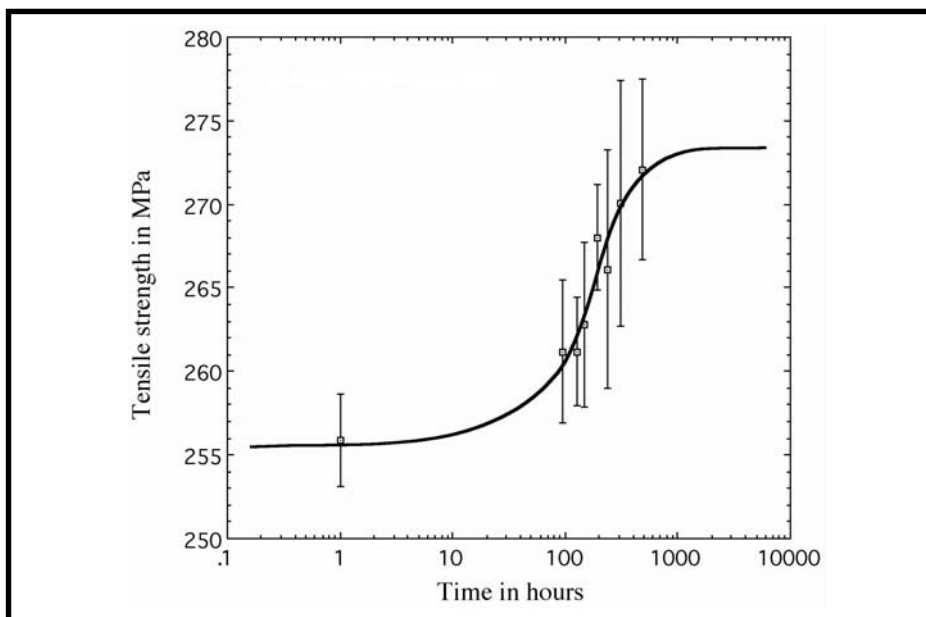


### Benefits for Our Industry and Our Nation

- Yield improvement in iron castings, leading to significant energy savings.
- Reduction in iron casting size.
- Expanded markets for ductile iron and compacted graphite iron.

### Applications in Our Nation's Industry

*This study will determine if age strengthening improves the machinability and the yield rate of ductile iron and compacted graphite iron. The success of this study will significantly increase the marketability of the alloys in the automobiles, mass transit, heavy transportation, municipal, energy production, and process plant equipment industries. For example, machinable compacted graphite iron is necessary for diesel automotive market to improve fuel efficiency.*



Avrami Kinetic Curve for Aging Gray Cast Iron

## Project Description

The goal of this project is to determinate age strengthening will improve machinability of ductile iron and compacted graphite iron. Studies will be conducted to determine whether age strengthening produces a corresponding change in machinability and whether the machinability improves as it does in gray iron.

The objectives of this research are:

- Identify the mechanism by which gray iron age strengthens,
- Identify the mechanism by which age-strengthening improves the machinability of gray cast iron,
- Determine whether ductile iron and compacted graphite iron exhibit age strengthening to a statistically significant extent,
- Determine whether age strengthening improves the machinability of ductile iron and compacted graphite iron alloys and
- Reliable, economical production of age strengthened iron.

## Milestones

### Results to Date

1. Determined the effects of likely alloy factors on age strengthening of gray iron
2. Performed statistical analysis and microstructural characterization to evaluate the age-strengthening of ductile iron

### Future Milestones

1. Understanding increase of strength and machinability in gray cast iron
2. Develop a procedure and run a test of age-strengthening of CG iron using production foundry iron
3. Determine the impact of age-strengthening on machinability of ductile iron
4. Compare ductile iron and compacted graphite iron with gray cast iron age-strengthening and machinability
5. Apply sub-microstructure analysis along with internal friction measurements; quantify time/temperature parameters for accelerated aging processes and laboratory validation experiments
6. Develop improved strength prediction models based on nitrogen and aging, as well as other alloy factors

## Project Partners

*University of Missouri-Rolla*  
Rolla, MO

*American Foundry Society*  
Schaumburg, IL

*Cast Metals Coalition Partnership*  
Charleston, SC

*ASAMA Mfg.*, Coldwater, MI

*Bremen Castings*, Bremen, IN

*Dalton Foundry*, Warsaw, IN

*Federal Mogul*, Southfield, MI

*Metals Technologies Inc.*  
Auburn, IN

*Nicola Consulting*, Warsaw, IN

*Rochester Metal Products*  
Rochester, IN

*St. Louis Precision*, St. Louis, MO

## A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.



**U.S. Department of Energy**  
**Energy Efficiency**  
**and Renewable Energy**

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Last updated: 2005