Project ID: lmp_05_blau

Selection of a Wear-Resistant Tractor Drivetrain Material: Success stories at the High Temperature Materials Laboratory (HTML) User Program

DOE 2009 Vehicle Technologies Annual Merit Review and Peer Evaluation Meeting

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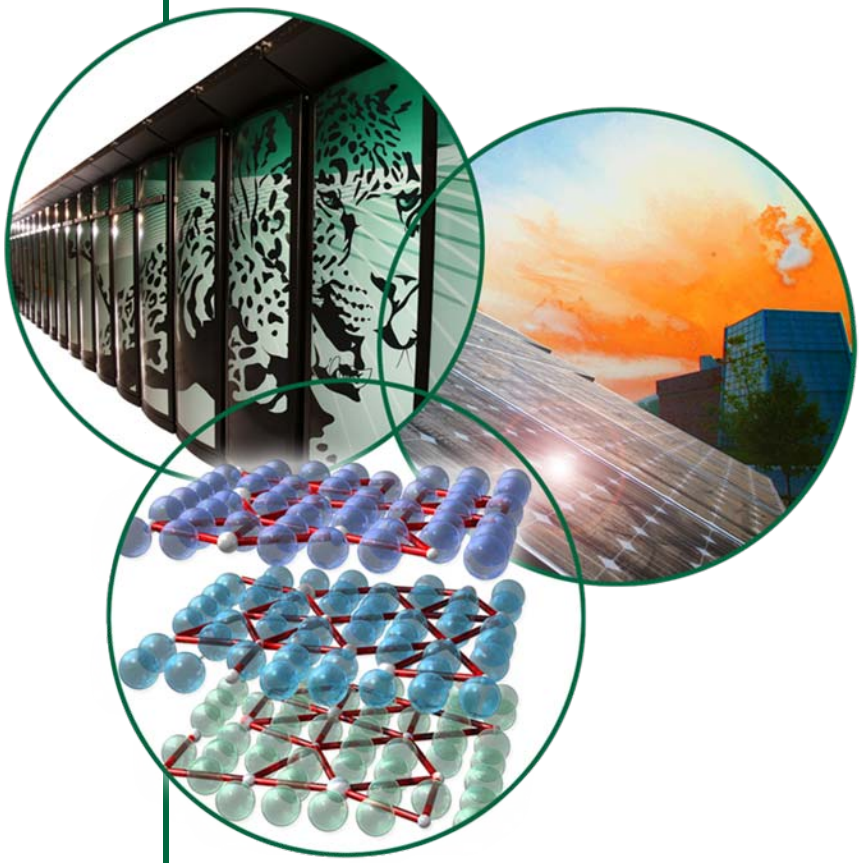
Dr. Peter J. Blau, ORNL



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The HTML User Program - Background

The HTML is a National User Facility that supports the missions of DOE, EERE and the Vehicle Technologies Program in particular, by working with industry, universities and other national laboratories to develop energy efficient technologies that will enable the U.S. to use less petroleum. The HTML is organized into six user centers, which are clusters of highly skilled staff and sophisticated, often one-of-a-kind instruments for materials characterization.

Access to the HTML is provided through the HTML User Program proposal process. Research proposals are reviewed by a committee and approved based on scientific merit, relevance of the proposed research to the mission of DOE's Vehicle Technologies Program, and feasibility. Research is completed within 24 months and normally involves one or more user visits to the HTML.

Both nonproprietary and proprietary research is conducted within the HTML User Program. There are generally no charges for nonproprietary research projects, and users conducting nonproprietary research must agree to submit research results for publication in the open, refereed literature. For proprietary research, the user owns the research data and all costs at the HTML are paid by the user based on DOE guidelines for ORNL costs. A nonproprietary project is complete when the results are published in the open literature and/or presented at a professional conference.

The HTML User Program – FY2008 Activity

During FY2008, the HTML User Program managed 76 user projects from 53 different organizations.

The FY2008 budget for the HTML was $6,072,283 and was allocated as follows:

- $1,567,500 for capital equipment purchases
- $3,879,483 to support staff participation in user projects
- $626,000 for the operation of the user program

Users cost-share user projects through:

1) their direct involvement with HTML staff members during the development of the user project;
2) funding their travel to the HTML to perform research;
3) costs of materials provided by the user or the research performed prior to the user project;
4) their subsequent collaboration with HTML staff members to analyze the data and publish the results.

The HTML also supports the education and preparation of a new generation of scientists and engineers.

During FY2008, students and professors from 32 universities participated in the HTML User Program. Four of those students received their Ph.D. degree in FY2008 based in part on research performed through the HTML User Program.

Deere and Company (John Deere)

"Wear Comparison Test – Tracks Tractor Rear Axle Spool"

This poster highlights one of the 76 user projects managed by the HTML User Program during FY2008.

Timeline

- Start date: 3/7/07
- End date: 3/6/09
- % complete: 100%

Budget

- Included in the user center allocations from the annual budget of the HTML User Program; users cost-share as previously noted.

Barriers

- parasitic losses and durability of drivetrains in ground vehicles

Collaborators

- User: Mark Beltowski
- HTML staff: Peter Blau

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User Project with Deere and Company

Research problem:

- To identify which of three candidate alloys for transmission spools (used to couple the differential ring gear to the axles in a rubber-tracked tractor) represent the most cost-effective means to enhance the wear-life of the drivetrain.

Relevance to the VT Program:

- The Vehicle Technologies Program supports the HTML User Program and provides an annual budget to address a wide range of materials-related issues in ground transportation systems arising from R&D needs in U.S. industry. In this case, the problem concerns reducing parasitic losses and material wastage in drivetrains.

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Milestones

Year	Milestone
2007	Experimental work: **Complete on-site friction and wear study of candidate cast irons for use in the transmission of a tractor. (Feb 28 – Mar 1)**
2008	Data analysis: **Analyze experimental results and prepare draft publication; submit to the journal *Wear.***
2009	Publish results: **Mark F. Beltowksi, Peter J. Blau, and Jun Qu (2009) "Wear of Spheroidal Graphite Cast Irons for Tractor Drive Train Components," accepted for publication in the journal *Wear*.**

Overall Approach

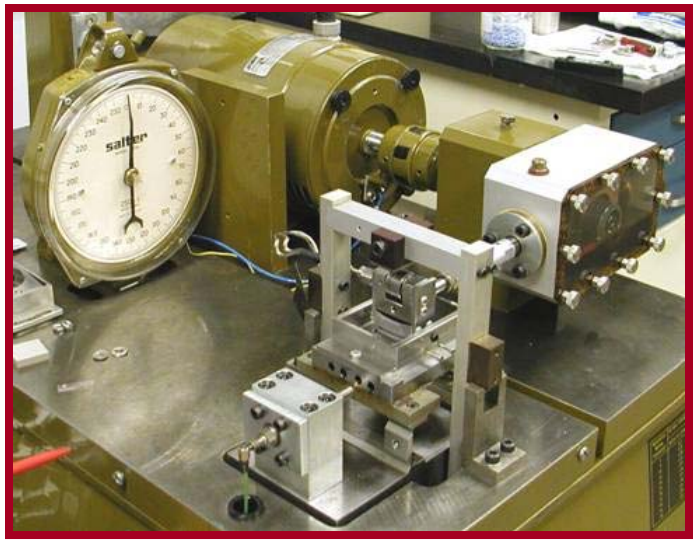
Photo courtesy of Deere and Company.

- **Jointly develop an HTML User Program proposal that includes a wear test plan for candidate spool materials under lubricated conditions.**
- **Select an appropriate contact stress, sliding speed, type of motion, test duration, and lubricant type to enable an adequate simulation of the contact conditions.**

- **Conduct wear tests, analyze data, and correlate results with material properties**
- **Select the most promising alloy**

User Project with Deere and Company
Accomplishments

Test Selection

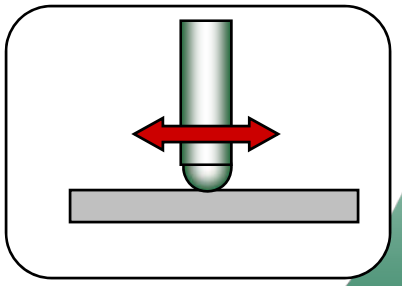


- Wear and friction test based on ASTM Standard G 133 (reciprocating pin-on-flat, developed at ORNL)
- Pin material: Cr-Mo alloy steel
- Applied load: 25 N (when dry), 200 N (when lubricated)
- 10 mm stroke, 10 cyc/s
- Lubricant: JDM-J20C (formulated lubricant)

Candidate Materials

Specimen	Material Designation	Tensile Strength (MPa)	Tensile Elongation (%)	HV (kg/mm^2)	HB (kg/mm^2)
Pin	42CrMoS4/ 41CrS4	-	-	327.	266-325
Flat	ISO 1083/GGG450	450	10	271.	142.2*
Flat	ISO 1083/GGG600	600	3	310.	187.6*
Flat	ISO 1083/GGG700	700	2	290.	214.1*

* measured on the surfaces of unworn test specimens



User Project with Deere and Company
Accomplishments

Wear Resistance (WR)

WR = - *log* (*V* / *P x*)

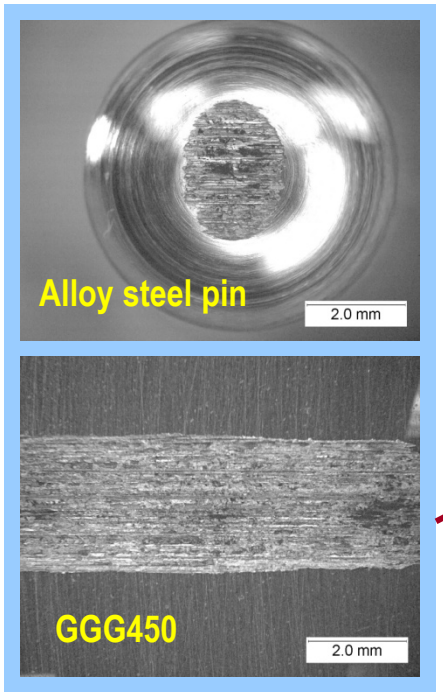
V = wear volume (mm^3)

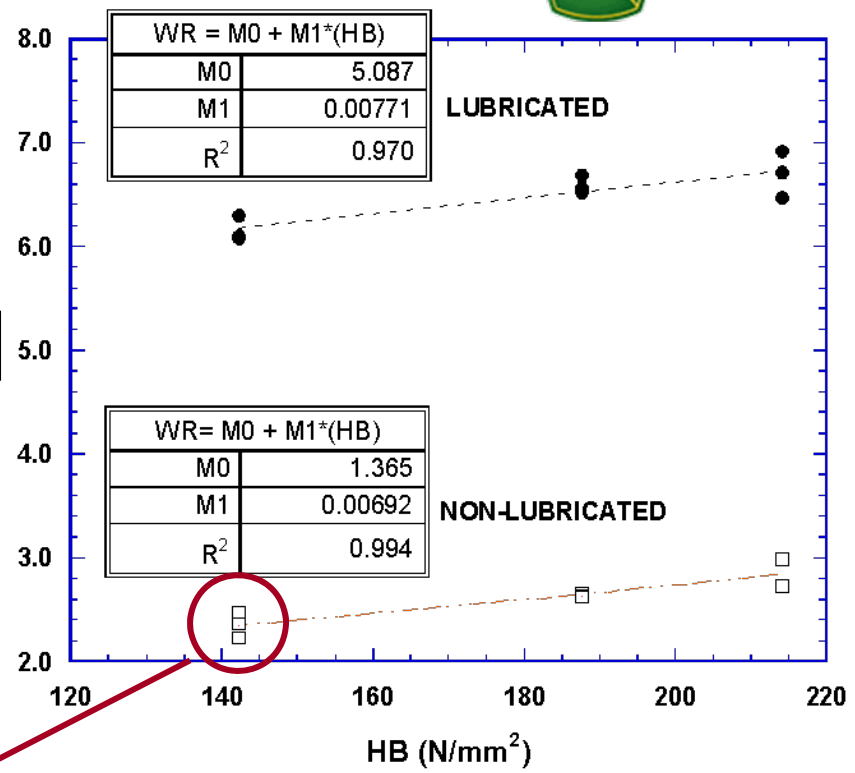
P = applied load (N)

x = total distance slid (m)

WR

Flat Spec





Correlation between Brinell hardness and the wear resistance of both lubricated and non-lubricated material combinations.

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Future Work

None

(This HTML user project has been completed.)

Summary

John Deere worked with the ORNL under the High Temperature Materials Laboratory User Program to conduct laboratory-scale wear tests of candidate cast irons for a tractor drivetrain. The following conclusions were obtained:

- Wear rates were about four orders of magnitude lower for lubricated tests than non-lubricated tests. The trend in wear resistance with the increasing strength of the cast iron was similar.
- There was a linear relationship between the Brinell hardness number of the cast iron specimens and the negative logarithm of the wear rate.
- There was a larger incremental benefit in wear resistance between the GGG450 and GGG600 material than between the GGG600 and GGG700 material, but there was no difference in the friction coefficient under lubricated conditions.
- The better-wearing GGG600 can be substituted for GGG450 without any effects on drivetrain friction.