Low Cost Manufacturing of Precision Diesel Engine Components Project (PM 9111)

Peter J. Blau, Principal Investigator
with
Jun Qu and T.W. Liao*

Oak Ridge National Laboratory
September 14, 2005

Louisiana State University

This poster does not contain any proprietary or confidential information

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

UT-BATTELLE

Low Cost Manufacturing of Precision Diesel Engine Components

21CTP

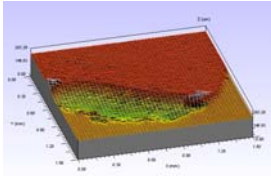
21CTP Technical Goal: **Develop and demonstrate an emissions compliant engine system for Class 7-8 highway trucks that improves the engine system efficiency from ~42% today to 50% by 2010.**

Project Objectives
Through experiments and modeling, advance cost-effective machining technology for diesel engine materials.

FY 2005 Focus
- Participate in the Third Wave Systems (TWS) consortium to develop software for high-speed Ti machining.
- Develop new ceramic-based cutting tool materials.
- Investigate grinding characteristics of advanced cermets.

Planned Duration
October 2001 to September 2005

DOE Funding/Industry Cost Share
FY04: $165K; FY05: $150K



Wear of a TiB_2 coated tool used to cut Ti alloys (3D laser topographic map)

Principal Investigator(s)
Peter Blau, Oak Ridge National Laboratory/UT-Battelle
(865) 574-5377; blaupj@ornl.gov
(with J. Qu, ORNL, and T.W. Liao, Louisiana State U.)

Technology Development Manager
Sid Diamond, DOE/OFCVT
(202) 586-8032; sid.diamond@ee.doe.gov

Accomplishments
- Prepared and characterized new ceramic composites for possible use in machining titanium alloys. (6/2005)
- Conducted instrumented grinding experiments and microscopy studies on cermets for diesel engine structural components. (9/2005)

Significant Future Milestones
This project is ending in FY 2005. A new effort is planned for FY 2006. It will develop new synergistic process-enhanced grinding technology to enhance cost-effectiveness and improve material removal rates on hard materials.

Project ID/Agreement ID	Program Structure	Sub-Program Element	R&D Phase	Date
PM_9111	Materials Technology	HV Propulsion Materials	Applied Research	8-11-05

Objectives

- To advance cost-effective machining technology for diesel engine components by experiments and process modeling.
  - Investigate and characterize the machining characteristics of advanced candidate structural materials such as ceramics, cermets, and titanium alloys.
  - Develop new, ceramic-based cutting tool materials for high-speed titanium machining.
  - Working with a small business (Third Wave Systems), assist in the development of software for optimizing high-speed titanium machining.

Relevance and Technology Transfer

Relevance

- Specific goal: "To advance cost-effective machining technology for diesel engine materials"
- Enabling commercialization and use of new materials for fuel-efficient engines to meet 21CTP Technical Goal.
- Understanding the materials science that affects machining processes.

Technology Transfer

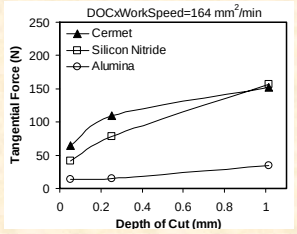
- Participate in a Third Wave Systems, Inc., industry consortium to develop software for modeling high-speed titanium machining processes.
- Collaborate with Kennametal, Inc. to commercialize new cutting tool materials

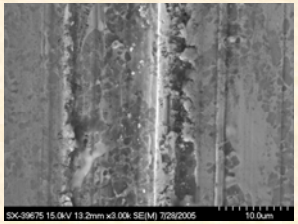
Approach

- Quantify the grindability of TiC / Ni_3Al matrix cermets that are promising candidates for diesel engine fuel injector plungers and wear parts.
  - Using superabrasives, determine the effects of grit size, grit concentration, and the state of wheel wear on grinding behavior and resultant surface quality.
  - Compare grindability of cermets with that of Al_2O_3 and Si_3N_4.
- Investigate the possibility of using cermets as cutting tool materials for high-speed titanium machining.
  - Measure tool life and identify wear mechanisms of cermet tools.
  - Compare performance with traditional WC-Co tools
  - Participate in a High-Speed Titanium Machining Consortium to share the latest technology in machining of Ti alloys.
- Participate with Third Wave Systems, Inc., in developing FEA-based machining modeling software, *AdvantEdge*^{TM}, and acquire new machining process modeling capabilities at ORNL.

Accomplishments: Grinding of Advanced Cermets

- Creep feed and conventional surface grinding characteristics of TiC-Ni_3Al (50 and 25 vol%) composites were studied on an instrumented grinder with resin-bonded diamond wheels.
  - Cermets required higher grinding forces and power compared with alumina and silicon nitride ceramics.
  - Better surface finish was obtained on cermets than on the two ceramics.
- Microscopy of ground surfaces revealed how the surfaces of intermetallic alloy-bonded TiC composites responded to different degrees of grinding severity ('aggressiveness').

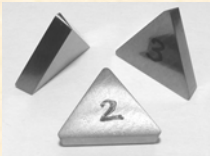




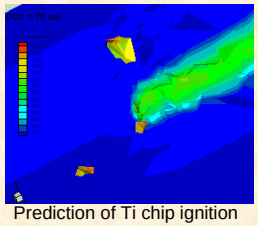
Ground cermet surface

Accomplishments: High-Speed Titanium Machining

- **New cutting tool materials**
  - TiC-Ni_3Al (5 and 9 vol%) cermets were synthesized at ORNL.
  - TiC-Ni_3Al (9 vol%) has hardness and toughness comparable to commercial WC-Co (6 vol%) tool inserts.
  - Encouraging results obtained on manually-polished TiC-Ni_3Al tools.
  - TiC-Ni_3Al tools are being professionally shaped by Kennametal.
- **Process modeling and verification**
  - Good correlations between TWS *AdvantEdge™* software models run at ORNL and turning experiments on Ti at U. of Michigan.
  - New drilling software is being tested.



Experimental TiC-Ni_3Al inserts



Prediction of Ti chip ignition

Peak chip temp > 1200° C

Future Work

- This project is ending in FY 2005.
- A new effort is planned for FY 2006. Its aim is to explore new opportunities in the use of synergistic process-enhanced grinding (SPEG) methods to improve cost-effectiveness and material removal rates – especially on hard materials like ceramics. Examples include laser-assisted and chemically-enhanced machining where several processes can be combined to produce better results than a single process alone.

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY