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Lightweight Materials for Automotive Applications Final Report CRADA No. TC-296-92-C

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November 17, 2017

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This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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Lightweight Materials for Automotive Applications

Final Report CRADA No. TC-296-92-C

Date: October 27, 2000

Revision: 3

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and General Motors Research and Development Center and General Motors Powertrain.

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General Motors Research and Development Center
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Anil Sachdev
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B. Project Scope

This project was concerned with low cost, metal matrix composites for chassis and powertrain applications. The project had two major components - fatigue and non-destructive evaluation (NDE). The fatigue component of the project studied the fatigue failure mechanisms at elevated temperature (both isothermal and thermo-mechanical fatigue) with the objective of improving material performance. The NDE component of the project developed rapid, high resolution NDE techniques to quantify internal defects in components. All deliverables for the project were met with the exception of transfer of an NDE inspection system. There were no significant changes in either the fatigue or the NDE portions of the project relative to the original proposal.

C. Technical Accomplishments

The project had a number of significant technical achievements including the following.

- Mechanisms of isothermal fatigue were determined and life prediction capability established for metal matrix composites (MMCs) studied.
- Isothermal fatigue testing and characterization completed on 147 samples.
- Theory for the thermal activation of fatigue in MMCs was established.
- Thermo-mechanical fatigue testing and characterization completed on 86 samples.
- Physical basis for thermo-mechanical fatigue in MMCs was established.

- Development of NDE techniques for MMC test samples produced capabilities with 50 μm resolution of defects.
- Development of NDE techniques for MMC components produced capabilities with 200 μm resolution of defects.
- A prototype inspection system for components was developed.

D. Expected Economic Impact

The metal matrix composites studied here have wide application in the automotive industry as lightweight materials. A recent review of the potential automotive applications of MMCs (see paper by Pradeep Rohatji, JOM, 1991) has shown applications in the following systems - engine, suspension, driveline, housings and brakes. The work done under this CRADA was focused on inspection and life prediction. The future economic impact of this work is unknown; however, widespread automotive implementation of MMCs will require utilization of the technologies studied here.

E. Partner Contribution

The partner supplied materials and components for use in the project. For the fatigue studies, the partner also did complementary testing and failure site characterization to the work being done at LLNL. The partner analyzed data and contributed to the documentation of project results. For the NDE studies, the partner did complementary work to LLNL with different (optical) techniques. The partner also analyzed data and studied the implementation of NDE inspection techniques in a production plant. No inventions or patent disclosures were generated during the CRADA.

F. Documents/Reference List

Papers/reports

- Don Lesuer, T.G. Nieh and C.K. Syn, "Fatigue of Metal Matrix Composites"*
- Don Lesuer and Chol Syn, "Isothermal Fatigue of a Metal Matrix Composite"*
- Don Lesuer and Chol Syn, "Thermo-mechanical Fatigue of a Metal Matrix Composite"*
- William J. Baxter, Donald R. Lesuer and Chol K. Syn, "Thermal Activation of Fatigue Damage"*
- Dianne Chinn, Dan Schneberk, Al Brown, Steve Azevedo, Graham Thomas, "Quantitative NDE Methods for Metal Matrix Composite Preforms"*

*CRADA protected information

Lightweight Materials for Automotive Applications

Final Abstract Attachment I CRADA No. TC-296-92-C

Date: October 27, 2000

Revision: 3

This project was concerned with low cost, metal matrix composites for chassis and powertrain applications. Metal matrix composites (MMCs) are lightweight materials in which a metal is reinforced with a ceramic. The fatigue properties and performance are dominated by defects and interfaces. The project had two major components - fatigue and non-destructive evaluation (NDE). The fatigue component of the project studied the fatigue failure mechanisms at elevated temperature (both isothermal and thermo-mechanical fatigue) with the objective of improving material performance.

The NDE component of the project developed rapid, high resolution NDE techniques to quantify internal defects in components. The partner supplied materials and components for use in the project. For the fatigue studies, the partner also did complementary testing and failure site characterization to the work being done at LLNL. The partner analyzed data and contributed to the documentation of project results. For the NDE studies, the partner did complementary work to LLNL with different (optical) techniques. The partner also analyzed data and studied the implementation of NDE inspection techniques in a production plant.

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Lightweight Materials for Automotive Applications

Project Accomplishments Summary (Attachment II) CRADA No. TC-296-92-C

Date: October 27, 2000

Revision: 3

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and General Motors Research and Development Center and General Motors Powertrain.

of California

University

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Anil Sachdev
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B. Background

This project was concerned with low cost, metal matrix composites for chassis and powertrain applications. Metal matrix composites (MMCs) are lightweight materials in which a metal is reinforced with a ceramic. The properties and performance are dominated by defects and interfaces. This project developed non-destructive evaluation (NDE) techniques for imaging these defects as well as fatigue testing and theory to understand mechanisms of fatigue failure and the prediction of life. Thus the project was concerned with inspection and reliability of these MMCs.

C. Description

The project had two major components - fatigue and non-destructive evaluation (NDE). The fatigue component of the project studied the fatigue failure mechanisms at elevated temperature (both isothermal and thermo-mechanical fatigue) with the objective of improving material performance. The NDE component of the project developed rapid, high resolution NDE techniques to quantify internal defects in components. The partner supplied materials and components for use in the project. For the fatigue studies, the partner also did complementary testing and failure site characterization to

the work being done at LLNL. The partner analyzed data and contributed to the documentation of project results. For the NDE studies, the partner did complementary work to LLNL with different (optical) techniques. The partner also analyzed data and studied the implementation of NDE inspection techniques in a production plant.

D. Expected Economic Impact

The metal matrix composites studied here have wide application in the automotive industry as lightweight materials. A recent review of the potential automotive applications of MMCs (see paper by Pradeep Rohatji, JOM, 1991) has shown applications in the following systems - engine, suspension, driveline, housings and brakes. The work done under this CRADA was focused on inspection and life prediction. The future economic impact of this work is unknown; however, widespread automotive implementation of MMCs will require utilization of the technologies studied here.

E. Benefits to DOE

The NDE techniques developed in this project for imaging defects, voids and interface failures represent technology needs that are common to industry as well as DOE (including Defense Programs). Specifically, advances in signal processing and transducer development are needed by both DOE and industry. In addition the fatigue study evaluated the influence of fatigue loading and thermal cycling on the life of metal matrix composites (MMCs). The defects that determine the life of MMC parts are also found in parts of interest to DOE applications. Thus the methodologies developed for predicting life of MMC components can be used for DOE applications.

F. Industry Area

The metal matrix composites studied here have wide application in the automotive industry as lightweight materials. A recent review of the potential automotive applications of MMCs (see paper by Pradeep Rohatji, JOM, 1991) has shown applications in the following systems - engine, suspension, driveline, housings and brakes.

G. Project Status

Complete.

H. LLNL Point of Contact for Project Information

University of California
Lawrence Livermore National Laboratory
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Don Lesuer
(925) 422-9633
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I. Company Size and Point(s) of Contact

The industrial partner was General Motors Research and Development Center and General Motors Powertrain. General Motors corporation is the world's largest industrial corporation and a full-line vehicle manufacturer which employs 647, 000 people (1996 figure). The two divisions that were our industrial partners in this project are part of General Motors - North American Operations, which had sales of \$100 billion in 1996. The responsible individual at General Motors Research and Development Center was:

General Motors Research and Development Center
30500 Mound Rd.
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J. Project Examples

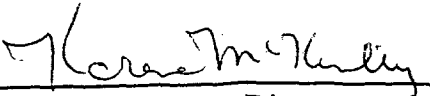
The metal matrix composites studied here have wide application in the automotive industry as lightweight materials. A recent review of the potential automotive applications of MMCs (see paper by Pradeep Rohatji, JOM, 1991) has shown applications in the following systems - engine, suspension, driveline, housings and brakes. The work done under this CRADA was focused on inspection and life prediction. The future economic impact of this work is unknown; however, widespread automotive implementation of MMCs will require utilization of the technologies studied here.

K. Intellectual Property

No patentable inventions were made by either party under this CRADA. No copyrightable computer software was developed under this CRADA.

L. Release of Information

I certify that all information contained in this report is accurate and releasable to the best of my knowledge.



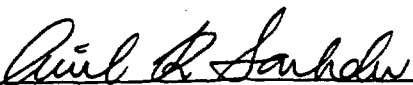
Karena McKinley, Director
Industrial Partnerships
and Commercialization

12/7/00
Date

RELEASE OF INFORMATION

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that only the information about our CRADA may be released for external distribution.

1. Final report document dated October 27, 2000 exclusive of the reports identified as "CRADA Protected". These reports are not releasable until five (5) years after the date of the report (i.e. the date the report was produced).



Anil Sachdev
General Motors Research and
Development Center

11/2/00
Date

Note: General Motors has requested that a final quarterly report be excluded from this final close-out report.