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Rapid Tooling for Functional Prototype of Metal Mold Processes Final Report CRADA No. TC-1032-98

G. Heestand, T. Jaskolski

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Rapid Tooling for Functional Prototype of Metal Mold Processes

Project Accomplishments Summary
CRADA No. TC-1032-98
Date Technical Work Ended: June 1996

Date: November 14, 2001 Revision: 5

A. Parties

This project was a relationship between Lawrence Livermore National Laboratory (LLNL) and United States Automotive Partnership (Ford Motor Company).

The Regents of The University of California
Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94550
Glenn Heestand
Principal Investigator
Telephone: (925) 423-4370
Fax: (925) 424-3412

United States Automotive Material Partnership
Ford Motor Corporation
P.O. Box 2053
Dearborn, MI 48121-2053
One Parklane Boulevard
Parklane Tower East, Suite 804
Dearborn, Michigan 48126
Attn: Tom Jaskolski
Phone: (313) 594-7150
FAX: (313) 390-2350

B. Background

Production inserts for die-casting were generally fabricated from materials with sufficient strength and good wear properties at casting temperatures for long life. Frequently tool steels were used and machining was done with a combination of conventional and Electric Discharge Machining (EDM) with some handwork, an expensive and time consuming process, particularly for prototype work.

We proposed electron beam physical vapor deposition (EBPVD) as a process for rapid fabrication of dies. Metals, ranging from low melting point to refractory metals (Ta, Mo, etc.), would be evaporated and deposited at high rates (~2mm/hr.). Alloys could be easily evaporated and deposited if their constituent vapor pressures were similar and with more difficulty if they were not. Of course, layering of different materials was possible if required for a specific application. For example, a hard surface layer followed by a tough steel and backed by a high thermal conductivity (possibly cooled) copper layer could be fabricated.

Electron-beam deposits exhibited 100% density and full strength when deposited at a substrate (mandrel) temperature that was a substantial fraction of the deposited material's melting point. There were several materials that could have the required high temperature properties and ease of fabrication required for such a mandrel. We had successfully used graphite, machined from free formed objects with a replicator, to produce aluminum-bronze test molds. There were several parting layer materials of interest, but the ideal material depended upon the specific application.

C. Description

At the time of the CRADA, production inserts for die-casting were generally fabricated from materials with sufficient strength and good wear properties at casting temperatures for long life. Frequently, tool steels were used and machining was done with a combination of conventional and Electric Discharge Machining (EDM) with some handwork — an expensive and time-consuming process — particularly for prototype work.

The overall objective of this project was to develop and commercialize the Electron Beam Vapor Deposition (EBPVD) process for producing die inserts for rapid prototyping of light metal automotive components.

We attempted to vaporize maraging steel by EBPVD but were unable to do so because the molybdenum component would not vaporize and was left behind. Since we could not produce the material even in its simplest form, there was no way we could produce the mold. The industrial partners agreed to terminate the project when it was halfway completed.

Deliverables

The major deliverable for the first year was a mold made out of maraging steel. Unfortunately, as noted in previous paragraph, we could not produce the material even in its simplest form, and there was no way we could produce the mold.

D. Expected Economic Impact

Benefits to Industry
Beam processing applications influence a significant portion of the worldwide economy. The area of microelectronics, a sub-field of beam processing applications, is currently a multi-trillion dollar per year worldwide market. It was widely anticipated that major new technologies and applications would significantly expand this field in the coming years. The Europeans recognize the potential and have already instituted significant programs in an attempt to gain technological and market superiority in beam processing applications.

The National Center for Manufacturing Science (NCMS), which considers the LLNL electron-beam facilities and capabilities to be unique in the world, estimated that a market of $7B will be created by the year 2005 primarily in the electron beam coating technologies for metal and ceramic bonded coatings, metal matrix composites and multi-layer coatings. Studies show that net shape forming of tooling (molds and dies) by high rate electron-beam deposition should have a strong impact on the $38 billion tooling industry by bringing back to this country the 30% of the business now going to foreign suppliers as well as for rapid prototyping applications.

Unfortunately, as noted in this report the project did not work out as intended and it was terminated.

E. Benefits to DOE

Net shape forming by high rate vapor deposition has applications in rapid prototyping of injection molds as well as the potential for an environmentally benign, cost-effective means for fabricating or re-manufacturing nuclear weapons components for Stockpile Maintenance Programs. LLNL had the unique national capability to utilize the NEPA approved uranium facilities to advance the state of the art in uranium manufacturing.

Unfortunately, as noted in this report the project did not work out as intended and it was terminated.

F. Industry Area

The automotive industry would have benefited from the project.

G. Project Status

This project was terminated.

H. LLNL Point of Contact for Project Information

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Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94550
Glenn Heestand
Principal Investigator
Telephone: (925) 423-4370
Fax: (925) 424-3412

I. Company Size and Point(s) of Contact

United States Automotive Material Partnership
Ford Motor Corporation
P.O. Box 2053
Dearborn, MI 48121-2053
One Parklane Boulevard
Parklane Tower East, Suite 804
Dearborn, Michigan 48126
Attn: Tom Jaskowski
Phone: (313) 594-7150
FAX: (313) 390-2350

J. Project Examples

There are no project examples.

K. Subject Inventions

This contractual mechanism did not anticipate any generation of Intellectual Property (IP) including subject inventions. The LLNL contributors and the company participants both indicate that no new intellectual property was generated.

Documents/Reference List

Reports

CRADA Final Report for CRADA 94-MULTI-AMP-0318 (with United States Automotive Materials Partnership [USAMP])
ORNL Report Number: C/ORNL 94-MULTI-AMP-0318
Title: "Rapid Tooling for Functional Prototyping of Metal Mold Processes,"
Authors: T. Zacharia, G. M. Ludtka, M.A, Bjerke, and W. H. Gray,
Published: December, 1997.

Copyright Activity

None

Generated Information

None

Background Intellectual Property

None

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 — Date: 1/15/02

Release of Information

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

Tom Jaskowski
Ford Motor Company for USAMP — Date: 12/6/01

Glenn Heestand, Principal Investigator
Lawrence Livermore National Laboratory — Date: 1/7/02