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Project Accomplishment Summary
for
Project Number 92-MULT-017-B2-0

LIGHTWEIGHT MATERIALS FOR AUTOMOTIVE
APPLICATIONS/TOPIC 2: WEAR RESISTANT
ALUMINUM ALLOY

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PROJECT ACCOMPLISHMENT SUMMARY

Title: Lightweight Materials for Automotive Applications/
Topic 2: Wear Resistant Aluminum Alloy
CRADA Number: ORNL92-0113
DOE TTI Number: 92-MULT-017-B2-0
Partner: General Motors Corporation

BACKGROUND

The replacement of cast iron by aluminum alloys in automotive engine blocks and heads represents a significant weight reduction in automobiles. The primary hurdle to the widespread use of aluminum alloy engine blocks in the North American automobile industry was high cost. The lack of wear resistance in most aluminum alloys added to manufacturing cost, since expensive procedures such as the incorporation of cast iron liners or special coatings were needed to achieve the required wear properties. The project targeted the development of a wear resistant aluminum alloy, as well as tools and the knowledge-base required to design the casting process, to allow it to be cast economically into engine blocks without the use of a cast iron liner or special coating, thereby providing benefits to both the material and manufacturing aspects of the process. The project combined the alloy development, wear and microstructural characterization, and casting modeling capabilities of the laboratory with the partners extensive alloy and casting process development and manufacturing experience to develop a suitable wear resistant aluminum alloy and casting process.

DESCRIPTION

The objective of the project was the development, characterization, and testing of a wear resistant aluminum alloy, as well as tools and the knowledge-base required to design the casting process, to allow it to be cast economically into engine blocks without the use of a cast iron liner or special coating. The selection and development of candidate alloys was conducted by the industrial partner with the support of the laboratory. Once the selection of candidate alloys was complete, test specimens were cast by the industrial partner for characterization and wear testing by the laboratory. The laboratory also developed procedures and test methods for the development of quality criteria for the prediction of microporosity, to be used in the design of the casting process; test castings used for the analysis, casting procedures, and alloy and mold materials used in the analysis were provided by the industrial partner. Upon development, alloy performance and design tools were verified on castings made under quasi-production conditions by the industrial partner. The project resulted in the identification of a class of wear resistant aluminum alloys that potentially could meet the performance requirements specified by the industrial partner, and the development of tools and a database that could be useful in the design of a casting process.

BENEFITS TO DOE

The project enhanced the skills of the laboratory in alloy development, microstructural characterization, and mechanical properties of cast alloys, and in predictive modeling and experimental capabilities related to casting, heat and fluid flow, and manufacturing. The skills and capabilities gained in the project have improved the prospects of deploying advanced materials and near-net-shape castings in DP and energy related applications, and the use of casting modeling codes for the design of critical cast components without the need for extensive manufacturing lead times and trial and error approaches.

ECONOMIC IMPACT

The results of the project are currently being applied by the industrial partner in the development of cast aluminum alloy engine blocks and in the conversion of its cast iron casting facilities for the casting of aluminum alloy. The use of monolithic cast aluminum engine blocks without the use of cast iron liners will result in significant fuel savings, since the elimination of six cast iron liners (assuming a 6-cylinder family car) will result in a weight savings of 12 lb per automobile, and the resulting head and block size reduction will yield additional savings, for a total weight savings of 25 lb per automobile. The resulting energy savings may be calculated as following:

Total weight savings per automobile = 25 lb

Fuel economy gains per automobile = $25 \text{ lb}/100 \text{ lb} * 2\% * 26.3 \text{ MPG} = 0.13 \text{ MPG}$
(based on 26.3 MPG for average vehicle, and gains of 2% fuel economy/100 lb saved)

Total gasoline saved per automobile/yr = 2.24 Gal
(based on 26.43 MPG vs. 26.3 MPG, and 12,000 miles driven/yr.)

Total gasoline saved per million vehicles = $2.24 * 10^6 \text{ Gal}$

Gasoline BTUs saved per year = $2.24 * 10^6 * 110,000 = 246 * 10^9 \text{ BTUs}$ (246 Billion BTUs)

This clearly demonstrates that there is significant potential for energy savings by the use of aluminum engine blocks in automobiles. The eventual savings will be higher as several million vehicles are likely to be impacted. The use of aluminum will also provide other environmental benefits as the process of melting and casting aluminum is cleaner and generates fewer pollutants.

The development of the alloy and casting technology will also save jobs as General Motors casts its own blocks, and the conversion of its existing cast iron facilities to aluminum will preserve its work force. The consumer/taxpayer also serves to benefit by the job savings and preservation of U.S. manufacturing and the development and implementation of U.S. technology in future automobiles.

PROJECT STATUS

This project has been completed.

COMPANY SIZE

General Motors is one of the largest corporations in the world with over 600,000 employees worldwide.

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PROJECT EXAMPLES

Due to the proprietary nature of the project, test components and other information will be provided by the industrial partner at their discretion.

TECHNOLOGY COMMERCIALIZATION

General Motors Corporation is currently optimizing a wear resistant aluminum alloy composition and developing a casting process for the production of cast aluminum alloy engine blocks at its facilities. General Motors Corporation continues the research to develop and test potentially wear resistant alloy candidates and match those to the foundry process capabilities.

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