Honeywell

Dubose CRADA

Federal Manufacturing & Technologies

G. L. Schuttler

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Final Report/CRADA Project Accomplishments Summary

CRADA Number 96-KCP-1048

Approved for public release; distribution is unlimited.

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Honeywell

Federal Manufacturing
& Technologies

P. O. Box 419159

Kansas City, Missouri

64141-6159

A prime contractor with the United States

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Date: 8/9/99 Revision:

A. Parties

The project is a relationship between

Honeywell FM&T

2000 E 95th Street

PO Box 419159

Kansas City, MO 64141-6159

Dubose Automotive & Machine

1520 19tth Street

Lubbock, Tx. 79401

Texas Tech. University

Box 41021

Lubbock, Tx. 79409-1021

B. Background

This project involved investigation into two different concepts, both of which are being patented by G. Douglas Dubose. The project was thus divided into two phases, each

dealing with one of the two Dubose concepts.

The first concept under investigation was the Minimal Crevice Volume (MCV) Piston Ring. This concept is intended to reduce internal combustion engine exhaust emissions (automotive and other applications) by lowering the amount of unburned hydrocarbons created in "crevice volumes" in the combustion chamber. Specifically, the MCV ring concept involves the use of a conical top piston ring that angles upward through the top corner of the piston dome to eliminate or minimize the gap around the piston dome (above the top piston ring) typical in conventional piston ring designs (see below).

The second concept under investigation in this project was a refinement of the rotary valve concept that has seen limited use in internal combustion engines since the 1930s. Most four-stroke internal combustion engines utilize poppet valves, typically actuated by a camshaft, to control intake and exhaust events. Rotary valve engines use rotating discs or rings with openings in them to control intake and exhaust events, much like a shutter wheel. Typically, engine performance parameters vary widely as valve event timing, duration, and magnitude are varied (when the valve is opened relative to crankshaft rotation, how long the valve is held open, and how large the opening is when the valve is open). With conventional poppet valves, valve timing is predetermined by the shape of the camshaft and its rotational relationship to the crankshaft, the relative size of the valve, and the geometry of the valve actuation machinery. With a rotary valve arrangement, valve event parameters are controlled by the relative size (length and width) of the openings in the "shutter wheel" and the angular orientation of the valve wheel to the crankshaft. Dubose's idea is to use a rotary valve design that utilizes multiple valve discs which can be rotated relative to each other, to change the effective size of the openings, and relative to the crankshaft, thus changing valve event duration and timing. Further, he proposed to vary the phasing of the valve discs dynamically, using input from the engine's electronic command module (computer) to tailor valve event duration and timing to the engine's current operating conditions. The ability to dynamically alter valve event duration and timing for an internal combustion engine would allow substantial increases in operating efficiency, increases in power, and decreased exhaust emissions.

C. Description

In phase one of this project, Mr. Dubose needed assistance to evaluate his Minimal Crevice Volume (MCV) Piston Ring concept to see if it showed enough technical merit to warrant the expenditure of time and money into patenting the concept and commercializing it. He initially enlisted the help of Texas Tech University, and subsequently Honeywell FM&T, to evaluate the concept for technical feasibility. This evaluation included engineering evaluations of the concept's functionality and manufacturability, along with design analysis and refinement through finite element analysis and other methods. The Principal Investigator at FM&T (Greg Schuttler) and Dr. Maxwell at Texas Tech provided feedback to Mr. Dubose on the functional feasibility of the concept, and the Principal Investigator at FM&T provided manufacturability guidance. Dr. Maxwell had engineering students and a graduate student at Texas Tech conduct static finite element studies to further evaluate the concept; and an extensive dynamic finite element evaluation of the concept, including design refinement, was carried out at FM&T by the Principal Investigator and Jim Mahoney. The results of the FM&T finite element analysis were used as a justification for Mr. Dubose to pursue patent application for this

concept. The dynamic finite element study pushed the state-of-the-art for this type of study at FM&T. It also served as a vehicle to facilitate the familiarization of FM&T associates outside the Finite Elements group in Engineering with finite element techniques and capabilities, a plant goal.

In phase two of this project, Mr. Dubose was attempting to prove the viability of his already patented "Variable Orbital Aperture" concept. All three of the major United States automotive corporations had expressed an interest in Mr. Dubose's multiple valve disc concept, if it could be proven that an effective sealing method could be found, since rotary valve engines have historically been nearly impossible to seal. To accomplish this, Mr. Dubose proposed to build a functional single-disc cylinder head to try different seal designs. Texas Tech had a Kawasaki single cylinder engine that was suitable for this use, and it was decided that a rotary valve cylinder head would be fabricated to fit this engine. To this end, Texas Tech provided assistance in creating the cylinder head design, assisted by Honeywell FM&T. Several design iterations were created, and both wax and stereolithography models were created at FM&T to assist the design process. The wax and stereolithography models were used for conceptual visualization of the designs, fit-up checks of the various components with the actual engine, and even flow testing of the intake and exhaust ports. When the design was finalized, two prototype cylinder head assemblies were machined, from aluminum and steel supplied by Texas Tech and Mr. Dubose, in the FM&T Model Shop. The engine was then to be assembled and tested at Texas Tech. At the time that this project was closed, the engine had not yet been completely assembled and tested.

D. Expected Economic Impact

Since his company is small, it is unlikely that Mr. Dubose could have afforded to fabricate a working prototype of the VOA assembly in accordance with phase two of this project. Additionally, he would have had to hire consultants to provide the engineering evaluations and finite element analysis evaluations required for both phases of the project, and this may have been prohibitively expensive for him. If his ideas are put into practice by the U.S. automotive industry, royalty payments to Mr. Dubose would be sizable, and the technological advantage to companies incorporating these concepts into their products would be immense. Both Dubose inventions focus on increasing internal combustion engine efficiency and reducing pollution, so the environmental impact of this project is very high as well.

E. Benefits to DOE

In phase one of the project, plant-wide understanding of finite element methods was enhanced by having the Principal Investigator actually perform part of the finite element study. Expanding usage and understanding of finite element techniques and capabilities beyond the finite element analysis engineering group is an ongoing plant goal. Additionally, the difficulty and complexity of the dynamic FEA study conducted for this

project helped to advance the state-of-the-art in finite element analysis at FM&T.

In phase two of the project, electronic part definition files (3D part models and drawing files) were transferred directly from Texas Tech to the Principal Investigator via the internet, a practice which was relatively new to FM&T at the time. This practice has now become commonplace, as the FM&T Model Shop deals with a variety of customers both within the weapons complex and outside the weapons complex. Additionally, due to Texas Tech's limited drafting capabilities, the machining of the cylinder head components quickly became an experiment in manufacturing product directly from 3D part models, without the benefit of detailed engineering drawings (electronic or paper). This exercise gave the Model Shop first-hand experience in manufacturing product to electronic models only, exposing the problems and advantages of this practice. This activity was very timely and valuable, as many customers throughout the weapons complex had been expressing the desire to manufacture prototype parts directly from electronic part models, circumventing the time-consuming task of preparing detailed engineering designs. Finally, the complex geometry of the cylinder head's intake and exhaust ports provided an ideal application for the Model Shop to expand its use of MasterCam CAM software in the area of multi-axis complex surface milling. This capability has since been used on several weapons-related projects.

F. Industry Area

Both phases of this project focused on the automotive industry.

G. Project Status

The project was terminated due to a lack of further DOE benefit. The majority of FM&T's planned involvement has been completed.

H. Point of Contact for Project Information

Ken Bauer

US Department of Energy

Kansas City Area Office

PO Box 410202

Greg Schuttler

Honeywell FM&T

PO Box 419159

Kansas City, MO 64141-6159

Kansas City, MO 64141-0202 Telephone: (816) 997-4051

Telephone: (816) 997-3917 Fax: (816) 997-4518

Fax: (816) 997-5059

I. Company Size and Point of Contact

Dubose Automotive is an automotive machine shop that employs two or three people. Doug Dubose is the contact and the proprietor of the company. Because additional work on the project was cancelled without his concurrence (due to lack of additional DOE benefit), Mr. Dubose may or may not be willing to provide feedback regarding project success. His telephone number is (806) 765-8429.

Texas Tech University, the other partner in this CRADA, is not a typical profit-oriented company, and thus does not have annual sales, etc. The contact at Texas Tech is Dr. Timothy Maxwell, and he can be reached at (806) 742-0972. Again, due to the nature of the cancellation of the project, he may or may not be willing to provide feedback regarding project success.

J. Project Examples

Photographs were taken of two of the design iterations of the cylinder head designed for phase two of this project before they were shipped to Mr. Dubose and Dr. Maxwell for trial fitting and design review. These models were created in wax on the 3D office modeler by the Principal Investigator. Also available is the FM&T final report documenting the results of the Finite Element Study for phase one of the project. Contact Greg Schuttler for a copy of the report, if it is desired.

Wax models of two iterations of the Dubose VOA assembly. These were made at FM&T and sent to Dubose for design review and trial fit-up.

K. Technology Commercialization

Dr. Maxwell of Texas Tech and Mr. Dubose have now partnered with a private investor to commercialize these concepts. They intend to develop and demonstrate the concepts to the point where they can convince the major U.S. automotive companies of the concepts' merit, at which time the automotive manufacturers would refine the concepts and incorporate them into their products.

L. Release of Information

I have reviewed the attached Project Accomplishment Summary prepared by Honeywell FM&T and agree that the information about our CRADA may be released for external distribution.

Original signed by 3/1/00

Name: Timothy M. Maxwell Date

Organization: Associate Professor

Title: Texas Tech Univeristy