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MONTHLY PROGRESS REPORT
WEAR MECHANISM AND WEAR PREVENTION IN
COAL-FUELED DIESEL ENGINES

U.S. DOE Contract DE-AC21-88MC26044
SwRI Project No. 02-2681

Reporting Period
February 1, 1989 to March 3, 1989

Submitted to
U.S. Department of Energy
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March 20, 1989

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INTRODUCTION

Cylinder bore and ring wear in a coal-fueled diesel engine is due to contamination of the ring-liner interface by unburned coal, partial combustion products of the coal, and the noncombustible ash contained within the coal. These contaminants can contribute to the wear through direct interference between the moving parts leading to abrasive wear, or indirectly through disruption of the formation of the boundary layer leading to retarded formation of the hydrodynamic mode of lubrication. The magnitude of the wear depends on the concentration of the particles in the film, the form of the particles (i.e., unburned coal, soot, or ash), the properties of the particles, including the particle-size distribution and the hardness of the particles, and the size of the asperities in the surfaces of the rings and liner.

Solution of the wear problem in coal-fueled diesel engines must include concepts that:

- o Maximize the combustion efficiency
- o Minimize the contact of the unburned coal with the cylinder liner
- o Prevent inclusion of the ash particles in the lubricant film
- o Prevent contamination of the lubricant in the crankcase.

The ultimate scope of the problems associated with implementing these requirements depends heavily on determining the mechanism of wear in coal-fueled engines and the contributions of the various possible lubricant contaminants introduced with the use of coal fuels.

OBJECTIVES

The overall objective of this program is to develop the engine and lubricant system design approach that has the highest probability for commercial acceptance. Several specific objectives can also be identified. These objectives include:

- Definition of the dominant wear mechanisms prevailing in coal-fueled diesel engines.
- Definition of the specific effect of each coal-related lube oil contaminant.

- Determination of the potential of traditional engine lubrication design approaches to either solve or mitigate the effects of the coal related lube oil contaminants.
- Evaluation of several different engine design approaches aimed specifically at preventing lube oil contamination or preventing damage due to lube oil contamination.
- Presentation of the engine/lubricant system design determined to have the most potential

APPROACH

The approach which is being followed in this project is one in which the wear mechanism is examined in two different bench apparatus. These devices provide much more controlled wear environments than an actual engine, while simulating the ring-liner interface in an actual engine. The two apparatus, a Cameron-Plint Machine and a Engine Friction and Wear Rig, will be used to determine the effects of the composition and the concentrations of lube oil contaminants on the wear occurring at the interface of a piston ring and a cylinder liner. The contaminants will include raw coal, cleaned coal, ash, and combustion products from coal. The goal is to define lubrication solutions to the ring and liner wear problem. In addition, novel engine designs will be examined in a effort to select a design approach which will both reduce the wear problem and be practical to implement in a commercial coal-fueled engine.

PROGRESS THIS PERIOD

Work during this reporting period was devoted to accomplishment of the following items:

1. Development of the work plan for the project;
2. Selection of components and materials for use as wear specimens in the two rigs;
3. Acquisition of the components for contamination of the lube oils;
4. Preparation of the coal-powder combustor to be used for generation of the combustion product contaminations of the lube oil.

The work plan was prepared and submitted for approval by the COTR during this reporting period.

Cylinder liners and rings must be selected for use in both apparatus. The Engine Friction and Wear Rig is equipped with the liner and ring set used in a standardized lubricant evaluation engine, or a CLR engine. The liners in this engine, as with most diesel engines, are cast iron. The rings are also cast iron or cast iron with chrome plating. Liners and both types of rings have been obtained for use on this project.

The liners and rings will fit directly into the Engine Rig, although a new piston has been designed for the engine rig used on this project. In the original configuration designed to study ring-liner friction, the piston crown was removed to prevent the development of compression pressure. The piston which will be used in this project will have a crown, and compression will occur as in an actual engine.

Segments of the rings and liners are used in the Cameron-Plint Machine. In this apparatus a segment of the liner, approximately 3 cm x 6 cm, is mounted as the stationary element, and a segment of the ring, approximately 3 cm long, is used as the moving element of the controlled wear couple. The rings and liners are currently being sectioned for use in this apparatus. In addition, a literature search has been started to determine the most appropriate ring loadings to use in both the engine and the Cameron-Plint rigs. In the engine the ring loading can be adjusted by varying the air pressure supplied to the back side of the ring through the ring groove. The ring loading in the Cameron-Plint machine is adjusted by changing the spring force acting on the reciprocating element which holds the ring segment.

The contaminants which will be added to the lubricant in both apparatus will include raw coal, cleaned coal, the removed ash, and combustion products from coal. The goal is to obtain the raw coals, the cleaned coals, and the ash from the same coal. Both AMAX ER&D and Otisca were contacted during this reporting period to determine the availability of these materials. Both companies indicated that these materials could be provided. A specification is currently being prepared and will be sent to the companies for bid. It is envisioned that the raw coals will be readily available. The initial work will be done with these raw coals as the other contaminants are being prepared.

Work was started on preparation of the coal-powder combustor that will be used to generate the combustion product contaminants. A new burner assembly has been designed that will reduce the complexity of collecting the combustion products. The original design incorporated a furnace and flue, the new design is basically a Bunsen burner design, with no flue.

WORK PLANNED FOR NEXT PERIOD

The preparations of the Engine Rig and the Cameron-Plint machine will be completed. The lube oil and contaminant specifications will be prepared and sent to the potential suppliers for bid. Preparation of the coal-powder combustor will be completed and preliminary runs performed to determine the appropriate operating and sampling conditions for collection of the required contaminants.

FINANCIAL

As of March 3, 1989, total expenditures on this project are \$8665. Cost, labor, and management data are provide in the attached reporting forms 1332.9, 1332.3, and 1332.2.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

U.S. DEPARTMENT OF ENERGY
MILESTONE SCHEDULE ☐ PLAN ☐ STATUS REPORT

FORM APPROVED
OMB NO. 1901-1400

DOE F1332.3
(11-84)

1. TITLE Wear Mechanism and Wear Prevention in Coal-Fueled Diesel Engines		2. REPORTING PERIOD Jan. 31, 1989 - Feb. 28, 1989												3. IDENTIFICATION NUMBER DE-AC21-89MC26044											
4. PARTICIPANT NAME AND ADDRESS Southwest Research Institute 6220 Culebra Road San Antonio, Texas 78284		5. START DATE Jan. 31, 1989												6. COMPLETION DATE Jan. 31, 1991											
7. ELEMENT CODE	8. REPORTING ELEMENT	9. DURATION FY 89												10. PER-CENT COMPLETE a. Plan b. Actual											
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