Y-12

OAK RIDGE Y-12 PLANT

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CRADA Final Report for CRADA Number Y-1292-0111

POWER GENERATION SYSTEMS FOR NO_x
REDUCTION

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FINAL REPORT

POWER GENERATION SYSTEMS FOR NO_x REDUCTION

CRADA NO. Y1292-0111

DOE PROJECT ID: 92-MULT-025-B2-04

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ABSTRACT

The Cooperative Research and Development Agreement (CRADA) No. Y1292-0111, between Allison Gas Turbine Division of General Motors Corporation and Lockheed Martin Energy Systems, under contract to the U. S. Department of Energy, is entitled "Power Generation Systems for NOx Reduction." The objective of this effort was to design, develop, and demonstrate an integrated turbine genset suitable for high efficiency power generation requirements. The result of this effort would have been prototype generator hardware including controllers for testing and evaluation by Allison Gas Turbine Division. The generator would have been coupled to a suitably sized and configured gas turbine engine, which would operate on a laboratory load bank. This effort lead to extensive knowledge and design capability in the most efficient and high power density generator design for mobile power generation and potentially to commercialization of these advanced technologies.

Objective

The goal of this effort was to design, develop, and demonstrate an integrated turbine genset suitable for the power generation requirements of a hybrid automotive propulsion system. The result of this effort would have been prototype generator hardware including controllers for testing and evaluation by Allison Gas Turbine Division of General Motors Corporation (Allison). The generator would have been coupled to a suitably sized and configured gas turbine engine, which would operate on a laboratory load bank. This effort could lead to extensive knowledge and design capability in the most efficient generator design for hybrid electric vehicle power generation and potentially to commercialization of these advanced technologies.

This cooperative research project was to develop a 35-kW generator and associated power controlled regulator for testing and analysis. The axial gap permanent magnet motor/generator development and its associated electronics have been an ongoing effort at Lockheed Martin Energy Systems for the past 25 years. General Motors Corporation (GM) had no experience with the axial gap generator, but was very interested in it because of its high efficiency and its unique packaging advantages for gensets. GM was to contribute the gas turbine hardware, facilities, and manpower to evaluate these advanced generators.

DOE Defense Programs (DP) wanted to respond to key United States competitiveness issues with resident technology, and enhancement of this technology would have yielded intellectual property that improved electric motor efficiency in many applications. This generator and the axial air gap motor are the same technology, and the specific results of improvements would benefit Energy Systems by enhancing Y-12's expertise in developing electric motors for manufacturing applications such as machining system drives.

Status of Objective

The CRADA was executed October 8, 1992, and work began immediately at Energy Systems and Los Alamos National Laboratory (LANL). Hardware was purchased, and work progressed toward the design and prototyping of the generator and the controller. The CRADA was terminated June 30, 1993, by Energy Systems because Allison was unable to participate in the CRADA. Energy Systems held discussions with other potential partners for conducting the project originally planned for this CRADA with Allison. Eventually, DP decided not to pursue this effort and all related work and project partner development activities ceased.

Benefits to DOE-DP

Technology Transfer projects positively impact and improve the vitality of domestic industries that are critical to future weapons production. This cooperative agreement was consistent with the DOE's mission of Technology Transfer to improve U.S. industrial competitiveness through development of improved electric motor efficiencies in machining applications.

The agreement was of particular benefit to DOE's Y-12 Plant by enabling the facility and technical staff to maintain a current state of weapons manufacturing readiness. DOE-DP further benefited from knowledge developed from attempts to define the characteristics of optimum electric generators and motor drives. This technology is useful for a variety of production applications, such as machining systems, and has the potential for dramatically improving manufacturing processes throughout DP production facilities. Considerable resources within the Nuclear Weapons Complex are devoted to assessment of technology applications in pursuit of more efficient and even unattended machining. The participation of a leading industrial company's engineers and the use their facilities afforded the potential for an extensive examination of this technology.

Technical Discussion of Work Accomplished

A team was put in place at Energy Systems for the development of the ultra high-speed generator, power regulator, and its controller. A statement of work was developed for the part of the work to be done at LANL (attached in Appendix A). Detailed work plans were developed for each of the tasks outlined in the project proposal. For the controller, a computer was purchased and a digital signal processor board was bought and installed in the computer. Work progressed in the development of control algorithms for such a high-speed machine and coupling the machine controller to the power regulator. The power electronics controller design was started, with most of the effort directed toward the challenging packaging issues presented by the harsh operating environment presented by the turbine. The power regulator design was initiated, with fabrication of some prototyping hardware to aid in the final design. Preliminary electrical design of the generator was started, as well as the stringent mechanical design requirements for the rotating parts of the machine. During the approximately nine-month duration of the project, \$299,788 was expended by Energy Systems in the conduct of the work. Seventy-eight percent of the effort was expended in staff labor. The project was originally approved at \$1,800,000; therefore, less than 17 percent of the project funds were spent.

Considerable effort was expended to work with Allison and other divisions of GM to get their participation in this CRADA. Although Allison and another division of GM were extremely interested in this project, funding was never made available from GM to these organizations to support the project. Consequently, Energy Systems sought another potential partner for the CRADA. Discussions were held with several companies, and a statement of work was developed jointly with Unique Mobility of Golden, Colorado. Ultimately, DP decided to cancel funding to Energy Systems for the CRADA, and all work was stopped.

Inventions

No invention disclosures or patents were developed in this CRADA.

Commercialization

Since the Industrial Partner never actively participated in this project, there are no reasonable plans for commercialization as a result of this effort.

Future Collaboration

There are presently no plans for collaboration with Allison on projects related to this technology.

Conclusions

Work was started by Energy Systems to design and prototype a generator and its related controller and power regulator to operate at high speeds in a harsh environment. This work helped DOE in the effort to establish extensive knowledge and design capability in the most efficient generator design for hybrid electric vehicle power generation and potentially to commercialize these advanced technologies. The specific results benefit DOE by enhancing Y-12's expertise in developing electric motors for manufacturing applications such as machining system drives.

Unfortunately, the industrial partner was unable to participate in the CRADA, so the project could not be completed.

Appendix A
STATEMENT OF WORK (SOW)
for
LOS ALAMOS NATIONAL LABORATORY
UNDER CRADA NO. Y1292-0111
TURBINE GENERATOR SET DEVELOPMENT FOR POWER GENERATION

Martin Marietta Energy Systems (MMES) at ORNL and Y-12 has established a CRADA with General Motors Corporation (GM) to design, develop, and demonstrate an integrated turbine-generator set suitable for high efficiency power generation. The result of this effort will be prototype generator hardware, including controllers for testing and evaluation by GM. The generator will be coupled to a suitably sized and configured gas turbine engine, which will be operated on a laboratory load bank.

LANL will perform work under the CRADA terms and conditions with funding that DOE has authorized LANL to spend on this project (\$100K in FY-93 and \$100K in FY-94).

LANL will assist MMES by providing testing support in the various tasks as described in more detail below. Emphasis will be on diagnostics and sensor research and development, creation of test plans, setup and instrumentation of test facilities, and participation in the testing as a member of the test team.

TASK 1. DEFINITION OF GENERATOR-ROTOR AERODYNAMICS AND HEATING LOSSES

An existing rotor will be evaluated at various levels of vacuum to investigate aerodynamic heating effects on efficiency. Testing is necessary to help resolve issues of aerodynamic heating, losses, efficiency, cooling requirements, and ambient temperatures.

LANL will be a prominent participant in the rotor spin tests, will help define the instrumentation, and will be part of the team supporting any testing done at GM as required. LANL will work with MMES and GM personnel to determine the nature and range of the test parameters and the type of instrumentation needed. LANL will assist in acquiring the instrumentation that is not already in place, setting up and calibrating it, and acquiring data by directly participating in the testing.

TASK 2. DEVELOPMENT OF HIGH-SPEED GENERATOR

MMES will design a generator to match the power output curves of the turbine engine. Testing is required to verify the various design and development elements. The principal issues include temperature effects caused by aerodynamic heating, water cooling, rotor inertia, power density, and temperature. LANL will work with the designers during the design and development phases to help establish the test parameters.

A test stand will be modified at MMES to do the initial generator testing. LANL will assist in the test stand modification. LANL will be a prominent participant in the tests and will help define the instrumentation, based on input from the designers, to be obtained during the design and development phases. LANL will help MMES personnel to determine the nature and range of the test parameters, and the type of instrumentation needed. LANL will assist in acquiring the instrumentation that is not already in place, setting up and calibrating it, and acquiring data by directly participating in the testing.

The generator will be mated to the turbine at GM to form a genset. GM will do initial testing of the genset. LANL will be a part of the team from MMES supporting the installation and testing of the genset at GM, and will help to resolve issues of temperature effects, inertia effects, and power density.

TASK 3. POWER CONTROLLED REGULATOR FOR THE GENSET

MMES will design, build, and test a proof-of-principle 35-kW power controlled regulator. LANL will work with the designers during the design and development phases to help establish the test parameters. Some of the issues to be resolved are ambient temperature, cooling, voltage/current regulation, EMC, and acoustic noise. As appropriate, LANL will write test plans and conduct testing of modules, subassemblies, and the completed assembly. Items to be tested may include electronics PC boards, modules, final assemblies of boards and modules, and subassemblies, as well as the completed regulator.

TASK 4. ASSEMBLY AND PREPARATION OF TURBINE ENGINE

This task will be carried out by GM. No MMES or LANL participation is currently planned.

TASK 5. TEST CELL EVALUATION OF THE GENSET

GM will reconfigure its engine test facilities as needed for the genset testing. GM will conduct the tests with significant input from, and cooperation by, MMES. LANL will be part of the MMES team supporting the testing. Experimental parameters and test conditions will be established by GM, with input from the MMES team as requested.

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