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Technical Progress Report No. 3

DEVELOPMENT OF A VORTEXING COMBUSTOR
(VC) FOR SPACE/WATER HEATING APPLICATIONS
(PROOF-OF-CONCEPT MODEL DEVELOPMENT)

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ENCLOSURE (2)

SUMMARY

This is the third quarterly technical progress report for DE-AI22-87PC79660 covering the period between 1 May and 31 July 1988.

During this reporting period, the firing test of Dry Ultrafine Coal (DUC) in the 0.15 MB/H exploratory model has continued. Sufficient experience and insight have been accumulated to help finalize the design of the 0.6 MB/H experimental model. Fabrication of the 0.6 MB/H model is 33% complete. A Coal-Water Fuel (CWF) loop for firing tests and an apparatus for testing CWF nozzle spray patterns are also 33% complete. A new test facility which includes the flue gas cleaning facility (described in our first quarterly progress report) is operational. We are now able to conduct independent tests on both the 0.15 and 0.6 MB/H models without disruption to either model. Current efforts have been concentrated in permanently installing test apparatus/equipment in the new test facility area.

CWF tests in the 0.15 MB/H model and DUC tests in the 0.6 MB/H model are expected to begin in September 1988.

TABLE OF CONTENTS

	PAGE
SUMMARY	i
LIST OF FIGURES	iii
INTRODUCTION.	1
COMBUSTOR DESIGN AND TESTS.	2
The 0.15 MB/H Exploratory Model.	2
1. Dry Ultrafine Coal Firing Tests.	2
2. Coal-Water Fuel Firing Tests	3
The 0.6 MB/H Experimental Model.	3
INSTRUMENTATION	5
AUXILIARY SYSTEMS	5
FUTURE PLANS.	7

LIST FIGURES

	PAGE
1. 0.6 MB/H experimental VC hot model.	4
2. Preimninary flow diagram for Vortex Combustor experimental facility	6

INTRODUCTION

This is the third quarterly technical progress report for the development of vortexing combustion technology under interagency agreement DE-AI22-87PC79660 covering the period between 1 May and 31 July 1988.

The overall effort for this development is described in our first quarterly technical progress report. In summary, it consists of three major steps, the design, construction, and test of:

1. A 0.15 MB/H exploratory model,
2. A 0.6 MB/H experimental model, and
3. A 2-4 MB/H proof-of-concept model.

During this reporting period, our efforts have been to conduct further dry ultrafine coal (DUC) firing tests using the 0.15 MB/H exploratory model, preparation for coal-water fuel (CWF) tests, installation of test apparatus/equipment in our new test facility (a sheltered outdoor test area) just completed, and fabrication of the 0.6 MB/H experimental model.

COMBUSTOR DESIGN AND TESTS

The 0.15 MB/H Exploratory Model

1. Dry Ultrafine Coal Firing Tests.

Our experimental focus during this reporting period has been to: (1) determine the combustor's primary to secondary air ratio; and (2) evaluate the merits of swirling vanes in the center tube. These efforts were directed towards raising T_2 , the gas temperature in the water-cooled combustor annular space, to the desired 1650°F level. Cold secondary air has the effect of lowering T_2 but it is counteracted by the increased combustion activity due to the fresh supply of oxygen. Results thus far shows that its net effect on T_2 is small and ambiguous.

Swirling vanes in the center tube cause the incompletely burned coal particles to fly toward the "hot" tube wall thereby accelerating the combustion process. This effect was observed from the resulting higher center tube gas temperature and higher estimated combustion efficiency (an increase from 0.77 to 0.83). Current efforts have succeeded in raising T_2 to as high as 1500°F but it is still below what is needed for efficient combustion.

Lower T_2 is due to the excessive cooling in the water-cooled section. Corrective measures and further experimentations have been planned for the next quarter. Among the several measures under consideration, one is to locate the water-cooled surfaces at the center tube.

2. Coal-Water Fuel Firing Tests.

The required modifications to the adiabatic section of the combustor for CWF firing have been completed. A CWF loop for both firing and nozzle spray pattern tests is 33% installed. CWF firing tests will begin next quarter.

The 0.6 MB/H Experimental Model

Experience gained from the exploratory model tests suggest the need for effectively reducing the heat transfer rate in the water-cooled section. After careful study and in conjunction with the results of theoretical work performed at Catholic University, a logical location for heat removal surfaces for combustion gas temperature control is at the center tube. Based on this reasoning, the 0.6 MB/H has been designed as shown in Figure 1. Basically, it consists of a refractory lined combustor enclosure and a water-cooled, movable center tube assembly. The center tube assembly itself consists of a water jacket connected at the top and bottom with pipes to two headers for water inlet and outlet. For heat transfer rate adjustment, the water jacket position in the combustor enclosure may be moved up or down by adjusting screws located on the outside. Combustion air and fuel are fed tangentially from the openings in the refractory wall. Fabrication of this model is 33% complete. We expect to begin testing this model next quarter.

Figure 1. 0.6 MB/H experimental VC hot model.

INSTRUMENTATION

The primary instrumentation for testing the proof-of-concept model is shown in Figure 2, the flow diagram of the overall experimental facility. A detailed list of items to be procured has been prepared and about 33% of the items are now on order. Instrumentation/ equipment procurement will be a continuing effort.

AUXILIARY SYSTEMS

An overall plan for testing the proof-of-concept model has been developed as shown in Figure 2. All components are sized based on the requirements for a 3 MB/H combustor output. With the exception of the Pulverized Coal (PC) feeding system and some sensors, all items are now on board. Equipment installation is planned to begin next fiscal year. Our current efforts focus on insuring the success of our subscale model tests and on the design of the proof-of-concept model.

A new test facility (a sheltered test area of approximately 26' x 60' size) intended for conducting all subscale hot model tests is operational. Efforts have been concentrated on moving and permanently installing all test apparatus/equipment in this new test facility. The flue gas cleaning facility described in our first quarterly report is being calibrated. With all these operational, we will be able to test both the 0.15 and 0.6 MB/H models without disturbing each other.

6

FUTURE PLANS

- Expand experimentation with the 0.15 MB/H model to fire CWF and to increase T_2
- Complete calibration of the flue gas cleaning facility
- Conduct tests on the 0.6 MB/H model
- Initiate detailed design of proof-of-concept model
- Install all test equipment in preparation for the proof-of-concept model tests.
- Invite sponsors and guest to visit our new test facility.

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