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

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ENCLOSURE (1)

SUMMARY

This is the second Technical Progress Report for DE-AI22-87PC79660 covering the period 1 February to 30 April 1988.

Our main effort during this reporting period is to use the 0.15 MB/H exploratory vortexing combustor hot model as a tool to develop information leading toward the proof-of-concept model design. This 0.15 MB/H model has been operational and performs satisfactorily in firing ultrafine coal. To date, about 50 hours of running time has been logged and about 500 pounds of ultrafine coal has been consumed without incident. The longest uninterrupted, stable running duration was 11 hours. The starting procedure is simple. Once the combustor is started the flame is self sustaining and no supplemental fuel is needed. The fuel to the combustor can be shut off for as long as one-half hour and restarted by simply blowing in the coal. Up to 0.18 MB/H firing rate has been achieved.

Future efforts consist of: Conducting more exploratory experimentation using the 0.15 MB/H model, adding its capability to fire coal water fuel, design of the 0.6 MB/H model, and building up laboratory capability for testing larger models.

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INTRODUCTION

This is the second quarterly technical progress report for the development of vortexing combustion technology under interagency agreement DE-AI22-87PC79660 covering the period between 1 February and 30 April 1988.

The overall effort for this development is described in our first quarterly technical progress report. 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, the 0.15 MB/H model has been constructed and installed in the laboratory. Exploratory experimentations of this model using ultrafine coal are in progress. This report is a summary of the work performed, observations made and thoughts evolved for designing subsequent larger models.

COMBUSTOR DESIGN AND TEST

The 0.15 MB/H Exploratory Model

Hot testing of this model using the ultrafine coal obtained from Energy International began in mid March and is continuing. The setup is schematically shown in Figure 1 and the overall arrangement of the actual hardware is shown in Figure 2. Since the tests are exploratory in nature, the instrumentation used is limited only to measurements for diagnostic purposes. This hot model test is intended for the development of information to:

- Verify performance and operating characteristics of each individual auxiliary equipment and the overall setup as a whole.
- Determine the operating requirements of the combustor such as cold start, hot restart, flame stability, and overall qualitative performance.
- Determine areas for improvement for the design of larger models.

Many test runs have been made. A total of about 50 hours running time on ultrafine coal has been logged and about 500 pounds of coal have been consumed. The largest continuous running duration is 11 hours. No difficulties such as inability to ignite, flame out, and unstable flame have been encountered. We have experienced, however, problems of non-uniformity and poor repeatability in coal feeding using an off-the-shelf screw type feeder as is. A major effort has been devoted to modify this feeder. Although significant improvements have been achieved for the current tests, still better performance is desired.

FIGURE 1. EXPERIMENTAL SETUP FOR 0.15 MB/H VC HOT MODEL

Figure 2. Actual arrangement of the 0.15 MB/II hot model test setup (water-cooled section not insulated).

The cold start and hot restart of the combustor are simple for the ultrafine coal used. The process is depicted in Figure 3. Experience from the tests conducted thus far confirmed that, for burning ultrafine coal, both ignition and self sustained combustion are reasonably simple to achieve without the need for preheated air or supplemental fuel.

The gas temperature T_1 in the adiabatic section should be as high as possible for good combustion efficiency, but for dry ash removal, we would like to keep it below 2000°F. For SO_x and NO_x emission controls, the desired gas temperature T_2 in the water-cooled section should be around 1600°F. A summary of the test conditions that have been run is given in Table 1. As seen in Table 1, we have experienced low values of T_2 which is believed to be the result of a combination of:

High heat transfer rate in the water-cooled section

High excess air

Insufficient particle residence time.

Some simple measures were taken to reduce the heat transfer rate and noticeable improvements could be achieved. No attempt to lower the center tube and stabilizer (the built-in features to change heat transfer area for T_2 adjustments) has been made yet, however. The overall situation is being evaluated. As a result of the low T_2 experienced, experimentation with secondary air has not been started.

FIGURE 3. COLD START AND HOT RESTART CHARACTERISTICS OF THE 0.15 MB/H MODEL USING ULTRAFINE COAL.

Table 1. Ranges of test conditions.

<u>Parameter</u>	<u>Ranges</u>
Coal feed rate, lbs/hr	10 - 12.5
MB/hr	.15 - .18
Air flow rate, SCFM	28 - 32
Gas temperatures, °F	
Adiabatic section, T ₁	1800 - 2000
Water cooled section, T ₂	1250 - 1330
Center tube exit	960 - 1040
Water evaporation rate, lbs/hr,	57 - 70
Excess air at combustor exit, %	40 - 54
Estimated combustion efficiency, %	77

The 0.6 MB/H Experimental Model

Observation from test on the 0.15 MB/H model suggest that the 0.6 MB/H model should be designed substantially the same as the 0.15 MB/H model except with minor modifications to improve the appearance and perhaps less heat transfer surface area in the water cooled section. A conceptual design of the 0.6 MB/H model is being formalized.

INSTRUMENTATION

Three major categories of instrumentation are required for the proof-of-concept model tests:

- Equipment status monitoring,
- Mass balance, and
- Energy balance.

An overall plan of the detailed requirements and material list are being generated.

AUXILIARY SYSTEMS

A baghouse consisting of thirty-six 8'-long filter bags has been delivered to NCEL. Since all the major equipments are now on board, work has begun to develop a system diagram and general laboratory space layout for their installations.

FUTURE PLANS

Subscale Model Test

- Install coal-water fuel firing system.
- Shake down test of the flue gas cleaning facility.
- Expand experimentation with the 0.15 MB/H model.
- Complete design and initiate fabrication of the 0.6 MB/H model.

Proof-of-Concept Model Tests

- Initiate detailed designs for major equipment installation.
- Complete instrumentation planning and initiate hardware procurement.

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