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Annual Scientific Report

COMBUSTION OF PULVERIZED COAL IN COUNTER-CURRENT FLOW

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Report Period: from 12.8.88 to 12.7.89

The project objective is to develop and investigate pulverized coal combustors operating in counter-current flow. In the first year of the project our activity was focused on: a) design, calculation and fabrication of a prototype of the combustor for atmospheric pressure operation, b) purchase and fabrication of the measuring instruments and preparation of the facilities for experiments, c) performing the experiments with the combustor firing bituminous coals (including a coal delivered from the U.S.A), and d) theoretical - predictive work.

Favorable aerodynamic conditions for controlled, stabilized pulverized coal burning can be achieved by using an opposed flow combustor. According to initial experimental testing, made in our previous study of a combustor performance, the current research proposes a theoretical/numerical model for predicting the behavior of coal particles in such a combustor. The configuration considered is eight times larger than before by volume and arranged vertically to improve ash separation within the chamber.

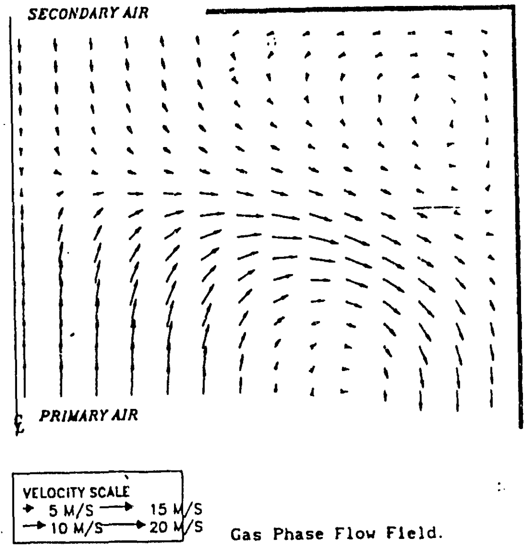
Quantitatively the behavior of both gas and particle phases is found to be similar in the experiments and the prediction. Attention was focused on particle trajectories, burn-out, angle of injection, ash separation by rotational movement, effects of initial particle size and temperature, impingement velocity and gravity.

The results indicate that aerodynamic stability of combustion within such chamber may be achieved in an optimal fashion by appropriate adjustment of the flow and thermal conditions prevalent in the primary, secondary and tertiary jets. Enlargement of the combustor size provides favorable burning conditions for relatively big particles, compared to a smaller chamber. Affects of gravity in the impingement area were negligible even for large particles (500 μm diameter).

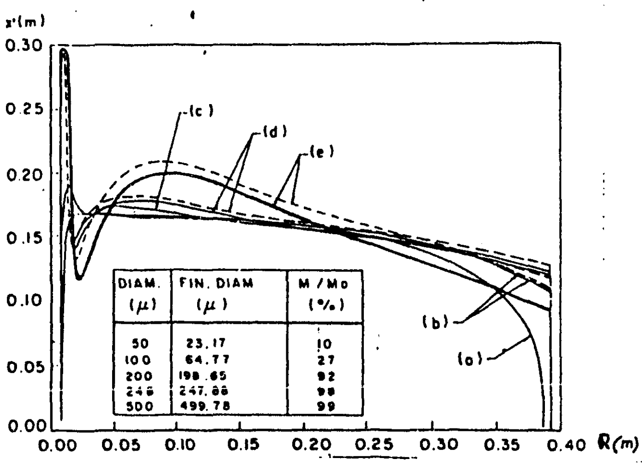
Ash separation within the chamber depends strongly on tangential velocity at the lower level and the rate of scavenging of the aerosol to an ash hopper.

The main quantitative results are: fuel consumption - 300 kg/h; combustion chamber temperature - 1500÷1600°K; chamber volume - 0.70 m^3; maximal ash separation achieved - 70%; fuel burn out - 80÷85% for big particles and about 100% for small particles (less than 120 microns), NO_x concentration in combustion products - 300-400 ppm, SO_2 concentration - 300÷350 ppm. Illustrative results are presented in the figures with brief explanation.

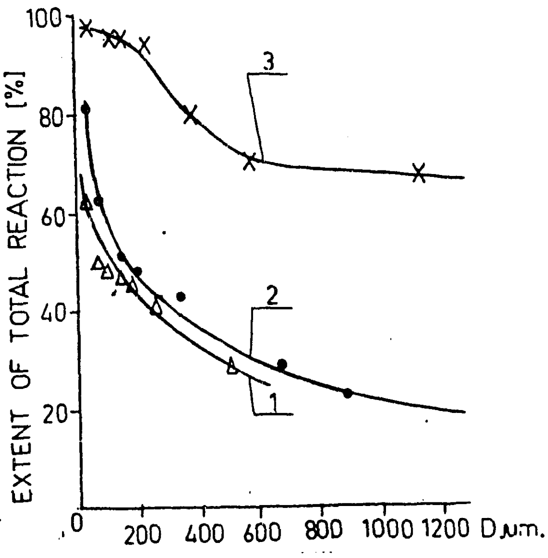
Counter-Current Combustor and Experimental Facility.



Gas Phase Flow Field.



Coal Particle Trajectories in Larger Vertical Chamber.
Key: Unbroken line - without gravitational force;
Broken line - with gravitational force.
Particle Sizes: (a) 50 μm, (b) 100 μm, (c) 200 μm, (d) 250 μm, (e) 500 μm. Computed Data



Extent of Total Reaction. Experimental Data.
1 - impingement point, 2 - mid-point,
3 - combustor exit.

Second Year Plan

During the second year of the activity we will concentrate our efforts on operation of the combustor under high pressure.

The first task will be to calculate, design and fabricate a high pressure prototype of the combustor; the second task includes purchasing additional measuring instruments and preparing the facilities for high pressure experiments.

The third task will be to perform experiments at pressure levels corresponding to an available turbocharger BBC-VTR-320, for air supply. The experimental results will be compared with the theoretical prediction obtained for high pressure conditions.

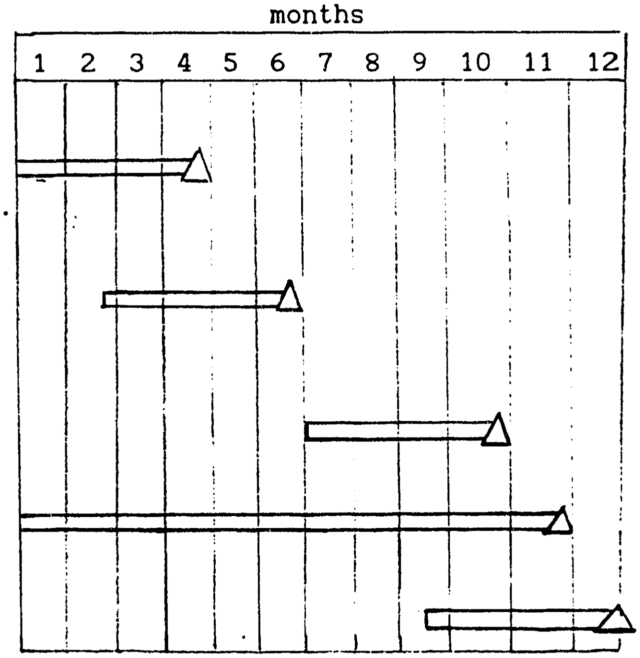
The final task will be the preparation of the concluding scientific report.

Time Schedule

Name of Activity

2nd Year
months

1. Calculation, design and fabrication of the second prototype of the coal combustor (pressurized).
2. Purchasing and fabrication of the measuring instruments and preparation of the system for experiments.
3. Experiments with the second prototype of the combustor.
4. Theoretical-predictive work.
5. Preparation of the concluding scientific report.



Deliverables

These will include:

i. A concluding 2-year report on the experiments performed in the counter-current combustion facility (atmospheric and pressurized) and comparison of experimental data with theoretical predictions.

ii. Computer codes - as described in the statement of work.

iii. Recommendations for work at ambient and high pressure.

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