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**FLUIDIZED-BED COMBUSTION PROCESS EVALUATION
AND PROGRAM SUPPORT**

**Quarterly Report
October—December 1979**

by

**Irving Johnson, W. F. Podolski, R. F. Henry,
J. E. Hanway, K. E. Griggs,
E. L. Carls, and A. A. Jonke**



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Chemical Engineering Division

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QUARTERLY REPORT

October-December 1979

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Irving Johnson, W. F. Podolski, R. F. Henry, J. E. Hanway,*
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ABSTRACT

Argonne National Laboratory is undertaking several tasks primarily in support of the pressurized fluidized-bed combustion (PFBC) project management team at Morgantown Energy Technology Center (METC).

The Experimental Program Director of the International Energy Agency pressurized fluidized-bed combustion project was selected.

Work is under way to provide fluidized-bed combustion process evaluation and program support to METC, including development of a planning methodology for PFBC technology development, determination of the state of the art of instrumentation for FBC applications, and evaluation of the performance capability of cyclones for hot-gas cleaning in PFBC systems.

INTRODUCTION

This report is the first in a series of reports describing several tasks which Argonne National Laboratory (ANL) is performing, primarily in support of the DOE pressurized fluidized-bed combustion (PFBC) project management team at Morgantown Energy Technology Center (METC). This activity is an outgrowth of the PFBC Component Test and Integration Unit project at ANL. After the completion of the preliminary design and a portion of the subsequent detailed design in August 1978, DOE decided not to complete the detailed design and construction phases of the facility. The technical director of the CTIU project, E. L. Carls, was subsequently selected as the Experimental Program Director for the International Energy Agency (IEA) PFBC experimental facility under construction at Grimethorpe, U.K. METC, which has been assigned project management responsibility for several DOE-sponsored PFBC projects, also requested ANL assistance in reviewing (1) the Curtiss-Wright PFBC pilot plant program and (2) the experimental program and research instrumentation proposed for the IEA facility.

In the current program, support continues for the Experimental Program Director at the Grimethorpe project and for several additional tasks in assistance to METC. These tasks include the development of a planning methodology for PFBC technology development, determination of the state of

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the art of instrumentation for FBC applications, and evaluation of the performance capability of cyclones for hot-gas cleaning in PFBC systems.

I. EXPERIMENTAL PROGRAM DIRECTION FOR INTERNATIONAL ENERGY AGENCY PRESSURIZED FLUIDIZED-BED COMBUSTION PROJECT

E. L. Carls was appointed Experimental Program Director for the International Energy Agency (IEA) pressurized fluidized-bed combustion (PFBC) project at Grimethorpe, U.K. in December, 1978. In this capacity, Mr. Carls functions as a member of the staff of Argonne National Laboratory on special assignment, secondment to IEA. He is in residence at the project site. Prior to this assignment, Mr. Carls was Technical Director of the PFBC Component Test and Integration Unit project at Argonne.

In his current assignment, Mr. Carls is responsible for preparing the experimental program plans, analyzing data and results from experimental campaigns, and preparing and disseminating reports and other documentation concerning the experimental program at the Grimethorpe experimental facility. Construction of the facility is nearing completion.

II. DEVELOPMENT OF METHODOLOGY FOR PRESSURIZED FLUIDIZED-BED COMBUSTION TECHNOLOGY

A report on development methodology for accomplishing commercialization of PFBC technology in a timely manner has been prepared in draft form and has been transmitted to Morgantown Energy Technology Center (METC) for review and comment. This methodology attempts to correlate and systematize past and ongoing developmental work in PFBC; to define the remaining significant problems in PFBC that adversely impact commercial usage; to evolve reasonable and practicable engineering approaches for solution of these problems in existing, modified, or new experimental facilities of sufficient size and appropriate configuration for reliable extrapolation to commercial units; and lastly, to provide rapid transfer of performance data to prospective users of PFBC technology. The methodology is designed to furnish the greater degree of program integration and coordination necessary during future functionally oriented commercialization efforts.

The proposed methodology for continuation, integration, and coordination of the PFBC development program is outlined in Fig. 1. As shown, it consists of eight major elements.

- (1) Definition of significant problems as barriers to commercial utilization by comparing PFBC program objectives with present performance experience and data bases.
- (2) Characterization of existing PFBC developmental facilities and their relevance to the requirements of program objectives and/or problem solving needs.
- (3) Correlation of program objectives and problem-solving needs with existing PFBC facility capabilities (or capabilities of future facilities if required).

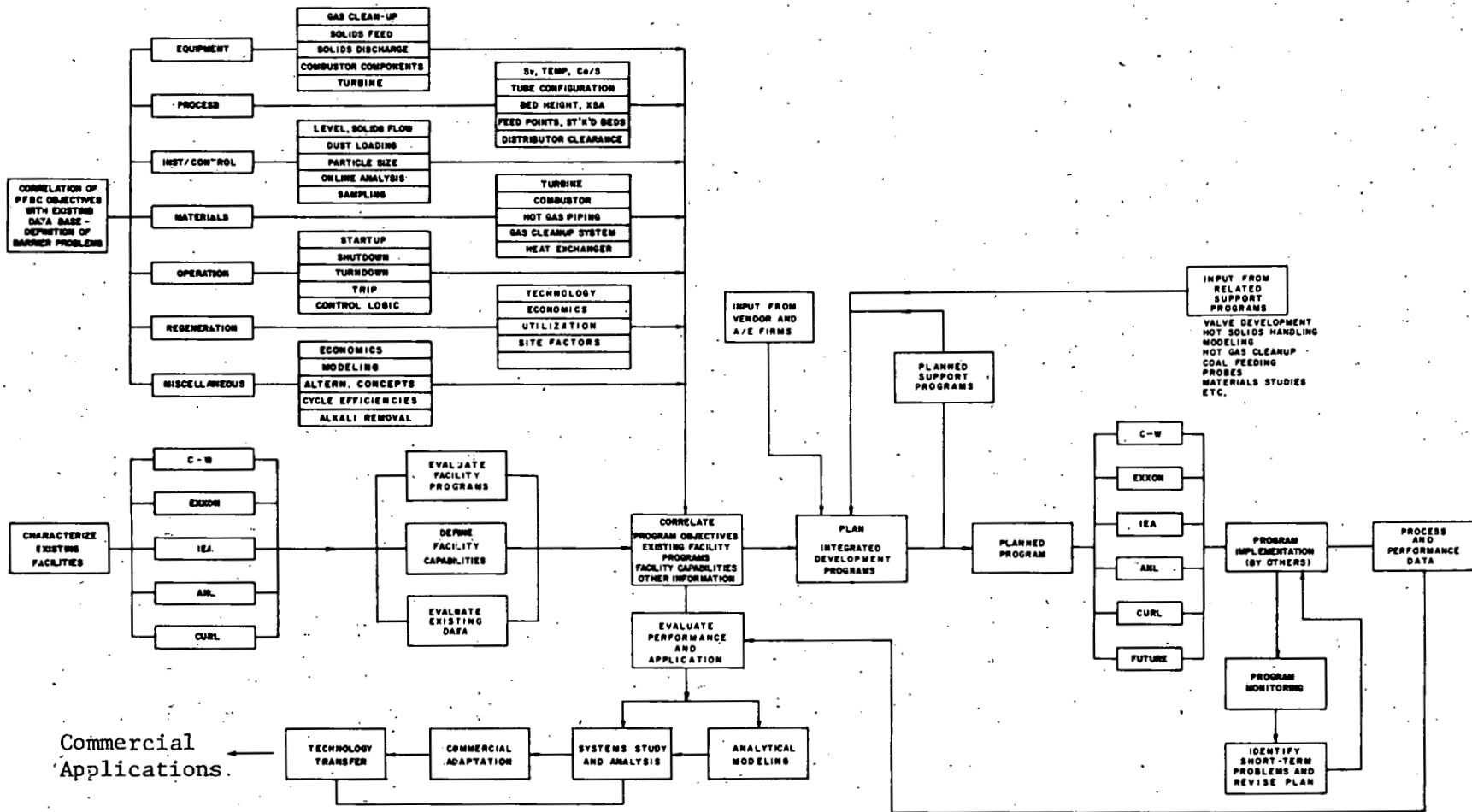


Fig. 1. Strategy for Continuing PFBC Development

- (4) Planning of interrelated programs to accomplish program objectives and the solution of barrier problems, each program designed for specific and appropriate experimental facilities. Planning activities would include the specification of (1) equipment and engineering requirements, (2) testing procedure, and (3) data acquisition capabilities for each developmental study.
- (5) Implementation of experimental programs (by others) in the designated facilities on a dedicated or add-on basis, as appropriate.
- (6) Monitoring of experimental programs to provide detailed knowledge of performance response, to permit identification of short-term operational problems, and to expedite necessary program revisions.
- (7) Evaluation of data and performance factors derived from developmental programs in relation to commercial PFBC usage.
- (8) Conception and detailing of commercial adaptation methods and transfer of technology to prospective users for commercialization.

III. INSTRUMENTATION REVIEW AND DEVELOPMENT

A combined effort of the Chemical Engineering Division (CEN) and the Applied Physics Division (AP) at ANL is under way to assess the state of the art of instrumentation for FBC applications. The purposes of this study are:

1. To update and extend the fluidized-bed portion of the report "A Study of the State-of-the-Art of Instrumentation for Process Control and Safety in Large-Scale Coal Gasification, Liquefaction, and Fluidized-Bed Combustion Systems," Argonne National Laboratory Report, January 1976 (ANL-76-4).
2. To identify instrumentation needs and to serve as a data base for projects to develop instrumentation.

Information for this study is being gathered in a survey of government reports, conference papers, and journal articles. Personnel at individual projects are being contacted directly, with each being supplied one form to describe details of their design and a second form (similar to that used in ANL-76-4) to describe any instrumentation problems or needs encountered. The design details of these projects will define the expected conditions of service for instrumentation in FBC applications.

At this time, approximately 38% of the 27 domestic projects asked to participate have responded. Follow-up telephone calls and, in a few cases, visits are being made to nonresponding organizations to ensure maximum input of information for this survey.

Attempts are also being made to include foreign projects in this study. A review of the literature concerning these projects is under way, and initial contacts have been made.

Computer literature searches are being done periodically to discover additional projects not yet identified. It is anticipated that the state-of-the-art survey will be used as a basis for more critical in-depth assessments of selected instruments and instrument requirements.

IV. EVALUATION OF CYCLONES FOR HOT-GAS CLEANUP

For pressurized fluidized-bed combustion (PFBC) systems to be economically competitive, the hot, dusty flue gas from combustors must be cleaned and expanded through a energy-recovery gas turbine. Cleanup of this hot gas is necessitated by the limited tolerance of turbine blade materials to particulate erosion, corrosion, and deposition caused by carryover of particulate matter and condensed species from fluidized-bed combustors. The required efficiency of gas stream particulate cleanup systems has not been firmly established. Conventional wisdom, based on previous attempts to couple gas turbines to coal-fired boilers, is that cyclones alone would not provide the cleanup efficiency required to ensure adequate turbine lifetime.

Several alternatives are currently being studied and evaluated for this purpose--including cyclones of greater efficiency, precipitators, agglomerators, and filters. Of these, the cyclone is by far the least expensive and most reliable, if only for pretreatment upstream from one of the other types of separators.

Recent data from the Exxon miniplant indicate promising performance with three cyclones in series. Particulate removals averaged near 90% for the third cyclone and 50% cut points of 2.0 μm or less were observed while particulate levels in the exit stream from the third cyclone were less than 0.3 g/m^3 . This experience implies that a series of well-designed cyclones might provide adequate particulate removal for some turbine applications.

A review has been undertaken of these and other data and of supporting literature. A preliminary outline has been prepared for a topical report on cyclone ultimate performance estimates. This report will provide a framework for (1) discussions with knowledgeable individuals and organizations and (2) evaluation of the data and literature being gathered. This report will focus on the best particulate separation attainable with given equipment (such as a cyclone) and inlet gas particulate size in PFBC hot flue gas service. Qualitative estimates of alternatives to simple cyclones are also planned. This summary and evaluation will allow levels attainable for full-size cyclones to be estimated and will indicate whether alternative or supplemental cleanup steps will be required so that particulate loading in the inlet gas to gas turbines will be at levels currently projected to give adequate turbine lifetimes.

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