**DESIGN OF GASIFIERS TO OPTIMIZE
FUEL CELL SYSTEMS**

DOE/MC/27227--T6

DE92 017675

QUARTERLY TECHNICAL PROGRESS REPORT No. 6

COVERING PERIOD 01/1/92 TO 03/31/92

Submitted by:

ENERGY RESEARCH CORPORATION
3 Great Pasture Road
Danbury, CT 06813
G. Steinfeld, Program Manager

Submitted to:

U.S. Department of Energy
Morgantown Energy Technology Center
3610 Collins Ferry Road
Morgantown, WV 26507-0880
Justin Beeson/COR

Contract No.
DE-AC21-90MC27227

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

TABLE OF CONTENTS

1. Project Summary	1
2. Overview of Activities this Quarter	2
3. Experimental Testing.....	2
3.1 Task 4.1 Experimental Studies Work Plan	2
3.2 Task 4.2 Experimental Studies	5
4.0 Schedule	8

PROJECT SUMMARY

TITLE: DESIGN OF GASIFIERS TO OPTIMIZE FUEL CELL SYSTEMS

CONTRACT NUMBER: DE-AC21-90MC27227

CONTRACTOR: ENERGY RESEARCH CORPORATION
3 Great Pasture Road
Danbury, CT 06813

PERIOD OF PERFORMANCE: September 28, 1990 to September 28, 1992

OBJECTIVE: To configure coal gasification/carbonate fuel cell systems that can significantly improve the economics, performance, and efficiency of electric power generation systems.

CONTRACT TASKS:

Status

as of 3/31/92

TASK 1.	Project work plan	completed
TASK 2.	Gasifier/Fuel Cell System Design Studies	completed
Task 2.1	Design studies	completed
Task 2.2	Technical/Economic analysis	completed
TASK 3.	Program Assessment	completed
TASK 4.	Experimental Studies	in progress

2.0 OVERVIEW OF ACTIVITIES FOR THIS QUARTER

During this quarter the topical report covering Tasks 1, 2, and 3 was submitted. This study evaluates various catalytic gasification/fuel cell power plant configurations. The competitive position of the configurations are assessed in a comparison with present-day as well as emerging alternate coal-based power plant technologies.

The work plan for Task 4, Experimental Studies, was also submitted this quarter. This plan outlines the series of tests which will evaluate the feasibility of using the disposable gasification catalysts recommended in Task 3 of this program.

3.0 EXPERIMENTAL TESTING

3.1 TASK 4.10 WORK PLAN FOR EXPERIMENTAL TESTING

The activities in this task are designed to evaluate experimentally the performance of the alternate disposable gasification catalysts chosen for the system study in the first year of this effort. The objectives of this task have been broken down as follows:

1. To experimentally characterize the performance of the previously recommended gasification catalysts for integrated gasification carbonate fuel cell systems as identified in the system study performed during Tasks 1, 2, and 3. The catalysts which will be tested include limestone and taconite used in dry form as well as coal impregnated with soluble salts of calcium and iron.
2. To evaluate the degree to which SO_2 in a recycled stream, and or sulfur in the feed, can be captured by the selected calcium or iron containing catalyst at the operation conditions in the catalytic gasifier.
3. To carry out tests under simulated conditions approaching the preferred final process design conditions identified in the system study.

Experimental testing will be conducted at the University of North Dakota/Energy & Environmental Research Center with program management and technical input from ERC. The experimental studies approach is shown in Figure 1.

The first phase of experimental testing consists of a cost-effective minimum scale screening by Thermogravimetric Analysis (TGA). The results of these tests will be used to predict the overall reactivity and to recommend conditions for the bench scale (IBG) testing (i.e., temperatures, catalyst loading, residence time) which will be used in the second phase of the experimental testing.

Batch gasification tests with the EERC Integrated Batch Gasifier (IBG) will act as a transition from TGA testing to continuous gasification tests. The IBG is shown in Figure 2. Four series of tests are planned, each will operate at conditions based on the results from the TGA testing of Phase 1 and the system studies conditions for Cases 2 & 3 of the ERC/Fluor study conducted in the first year of this effort. Each test uses 100-200 gm samples of Illinois #6 coal and will operate at pressures ranging from 15-100 psig.

M01042

Figure 1. EXPERIMENTAL STUDIES APPROACH

Figure 2. EERC'S INTEGRATED BENCH-SCALE GASIFIER SYSTEM

The first series of tests (Series A) will be conducted with raw coal and potassium-impregnated coal to provide a baseline performance. The potassium addition rate will be based on the Exxon catalytic gasifier study (15 wt%). This series of tests will also verify agglomeration free operation with Illinois #6 coal.

The second series of tests (Series B) will be conducted with dry taconite to determine the catalytic and sulfur capture effect. The third series of tests (Series C) will determine the catalytic effect of impregnated calcium with dry taconite added for sulfur capture. In the last series of tests (Series D) the catalytic effect of iron impregnated Illinois #6 with dry taconite added for sulfur capture will be analyzed.

The IBG test results will be compared and used to assess the design assumptions of the system study. Based on the data that best supports the system study, test recommendations will be made for the third phase of experimental testing using the continuous pilot unit (CPU).

Continuous gasifier testing will use the CPU shown in Figure 3. In the 4 lb/hr CPU reactor, coal and catalysts are continuously fed into a fluidized reaction zone. This reactor closely simulates large-scale gasifiers. Operating pressure will range from 50-100 psig. Two one-week-long test runs are planned for which the operating conditions will be based on the IBG test results and the system study.

The results from the experimental testing will be used to compare the reactivity of calcium and iron based catalysts to the original estimates made in the system study and to the baseline potassium catalyst. The potential of disposable catalysts and the impact on future integrated gasification carbonate fuel cell systems will also be assessed.

3.2 TASK 4.20 EXPERIMENTAL STUDIES

Phase 1 of Task 4.2 began this quarter with TGA testing of limestone, taconite and K_2CO_3 as a gasification catalysts with Illinois No. 6 coal. These tests are designed to compare the reactivities of these catalysts using Illinois No 6 coal. In all cases the molar equivalent ratio of catalyst to fixed carbon was 0.12, so that for K^+ the molar ratio was $K/FC = 0.12$, for $Ca^{++} = 0.06$, and for $Fe^{+++} = 0.04$ mols/mol. In this way the active sites on the coal structure ($-COO^-$) are exposed to the same number of possible connections with mobile cations regardless of the choice of metallic element. The proximate analyses of the catalyzed samples and raw coal are shown in Table 1.

The TGA tests used a dry form of each catalyst at temperatures ranging from 700° to 800°C. Analysis of the data, shown in Table 2 and Figure 4, reveals that dry taconite alone provides essentially no catalytic activity. Dry limestone provides a slight improvement in reactivity; however this improvement is insignificant in comparison to the high reactivities obtained with a potassium catalyst. An impregnated potassium catalyst, introduced as a wood ash leachate, was also tested. The negligible difference in reactivities of wood ash leachate and K_2CO_3 indicate that the potassium is as mobile dry as it is impregnated, and therefore its chemical form is not a crucial issue.

Further TGA testing is being conducted using Illinois No. 6 coal char impregnated with soluble Ca^{++} and Fe^{+++} . By using soluble forms of the catalysts, more intimate contact between the coal and catalyst is expected, which may increase apparent reactivity.

Figure 3. EERC'S CONTINUOUS PROCESS UNIT

Table 1. ILLINOIS #6 RAW COAL AND CATALYZED COAL PROXIMATE ANALYSIS

Wt. %	Raw Coal	Catalyst and Illinois No. 6 Coal			
		Limestone (Dry)	Taconite (Dry)	K ₂ CO ₃ (Dry)	Wood Ash Leachate (Impregnated)
Volatiles	36.26	37.64	30.81	35.79	39.03
Fixed Carbon	52.99	37.99	38.07	35.07	28.83
Ash	10.70	24.39	31.11	29.15	31.14

Table 2 REACTIVITIES DETERMINED BY TGA ANALYSIS

Catalyst	Temperature, °C	k, 1/hr	H ₂ , %
Limestone	700	0.09	32.35
	750	0.23	60.34
	800	0.47	60.68
Taconite	700	0.07, 0.07	72.41
	750	0.14, 0.25	82.19
	800	0.38, 0.44	69.57
K ₂ CO ₃	700	7.33	68.64
	750	15.32	66.41
	800	27.93	64.15
Wood Ash Leachate	600	0.88, 0.93	53.24
	650	2.78, 2.87	66.18
	700	8.25, 8.85	67.80
	750	16.47, 17.27	64.96
	800	23.14, 27.00	62.97

JF0029r

Figure 4. REACTIVITY OF ILLINOIS NO. 6 CHAR DETERMINED BY TGA:

The Taconite and Limestone in Dry Form Do Not Appreciably Improve the Reactivity of Illinois No. 6 Coal Char

4.0 SCHEDULE

The schedule is shown in Figure 5 and the milestones are defined in the following table. During this quarter Task 330 and Task 410 were completed. Work continues on Task 420, Experimental Studies.

END

**DATE
FILMED**

9 / 3 / 92