COMPREHENSIVE RESEARCH ON RICE
ANNUAL REPORT
January 1, 1981 - December 31, 1981

PROJECT TITLE: Thermochemical Conversion and Utilization of Energy and Chemical Feedstocks from Rice Straw.

PROJECT LEADER AND PRINCIPAL UC INVESTIGATORS:

John R. Goss, Project Leader
G. E. Miller, Jr., Co-investigator
D. L. Brink (Forest Products Lab., Richmond), Co-investigator
J. J. Mehlschau, Senior Development Engineer
Five Research Assistants, Graduate Students

LEVEL OF 1981 FUNDING: $100,000

OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

Introduction:

The long-term objectives that were proposed for this Project are listed below. Funding was not provided for the third objective. Hence, no work was done on this objective or the specific work objective No. 4 for 1980-81 which is a specialized aspect of the third objective. The development and testing of a 100 kw portable farm power plant to pump irrigation is the first specific goal under Objectives 1 and 2.

1) Development and performance testing of thermochemical processes, such as fixed bed and fluidized bed gasification, direct combustion, and pyrolysis to convert rice straw to low-Btu gas, heat, char, pyrolytic oils and chemical feedstocks.
2) Development and performance testing of systems and processes to utilize low Btu-gas, heat, char, pyrolytic oils and chemical feedstocks produced by the thermochemical conversion of rice straw.
3) Assessment of the potential for the utilization of rice straw as an alternate, renewable energy and chemical resource for agricultural production and processing and industrial operations.

Objectives and Experiments for the 1981 Calendar Year:

Work did not proceed as outlined in Work Objectives 1 through 3 for the 1980-81 proposal because of the delay in receiving funds for this new project and the need to develop facilities and obtain equipment to carry out these objectives. Funding was not provided for the proposed Work Objective No. 4 for '80-'81. The Planned Work Objectives and the tasks accomplished are as follows:

Work Objectives No. 1:

a) Obtain the performance data for a fluidized bed gasifier converting rice straw to producer gas.
b) Obtain the performance and stack emission data for the combustion of producer gas from the fluidized bed gas producer when burned in a fire box that approximates steam boiler operation.
c) Obtain the performance and heated air quality data for the combustion of producer gas from the fluidized bed gas producer when burned in a low-Btu burner system for producing heated air to dry rice or other crop drying application.

The following tasks were completed in preparation for work on the above objectives:

1. Obtain, install, and test special dies to produce high density rice straw cubes in the stationary John Deere Cuber at the Animal Science Feed Mill. The testing revealed that the mill did not have the structural strength required to withstand the cubing pressure loads developed by the special dies. Operation of the Warren and Baerg high density cuber at the Company plant in Dinuba was observed which lead to the decision to repair the Animal Science Cuber for operation with standard dies rather than adapt it to produce high density cubes. This work is reported in more detail in Project RS-5. A reliably operational cuber mill on campus is a necessity for one form of fuel management for the fluidized bed gas producer.
2. Complete the arrangements, receive and set-up the 100 Kw farm power plant from Deere and Co. Put the diesel engine-electric generator and resistor bank into service. Design and order components for metering the producer gas and diesel fuel feed to the engine.
3. Approximately 1000 bales of rice straw provided by the Rice Research Board were moved to the campus, stacked and covered with plastic. A stack of about 500 bales at the Agronomy Rice Research Facility from the 1979 crop year was again covered with plastic.
4. Complete and upgrade (to meet requirements set by the Campus Environmental Health and Safety Office) the 40 x 20 foot temporary shelter which houses the fluidized bed gas producer, 100 Kw farm power plant and resistor bank, 3 fixed bed gas producers and a 1.5 million Btu/hour fire box with exhaust stack. The 2 million Btu/hour air burner will also be set-up under this shelter.
5. After about six-man weeks of study and acquisition of information, a data acquisition-process control system was designed and placed on order. Equipment delivery time for the entire system should be completed in December, 1981, 3 months after the request for the equipment was forwarded from the Department.
6. When rice straw is passed through a hammermill, the fibers in the straw are exposed which intertwine and result in matted globs. This physical characteristic is troublesome in mechanical conveyors and bin storage. It may also be undesirable in the passage of fuel through the fluidized bed. Thus trails were conducted with a field forage chopper with hand-fed slices of baled rice straw to obtain

samples for measurement of the degree of size reduction. The matting problem does not occur with chopped rice straw but about 25 percent by weight is longer than six inches. Re-chopping the straw had little affect on changing the size distribution. The large amount of long straw complicates the handling and conveying of the chopped fuel. Its affect on the efficiency of the fluidized bed gasification process is unknown and therefore will be determined by actual operation of the process.

Work Objective No. 2:

Investigate fixed bed gas producers to develop reliable designs to gasify rice straw that has been cubed.

Cubed rice straw has been tested in a downdraft gas producer under two operational conditions. One was normal operation by blowing ambient air. The other was continuously injecting steam with the blown ambient air which is normally expected to reduce reaction zone temperatures and thus has the potential to control slagging of the ash. Neither operational conditions produced a self-sustaining flame of burning hot gas nor did the steam injection prevent slagging. This was an exploratory test and therefore is insufficient to discard steam injection.

Work Objective No. 3:

Performance and wear testing of spark and/or compression ignition engines modified to operate on cool-clean low-Btu gas.

Work on this objective requires completion of performance testing of the fluidized bed gas producer, designing and construction of the gas conditioning system for engine operation.

Work Objective No. 4:

Assess the potential for the utilization of rice straw as an energy source for pumping irrigation water and rice drying in and near the rice growing areas of the State.

This objective was deleted from the project and not funded.

Other work done in support of Objectives 1, 2 and 3:

1. Annotated Reference Bibliography.
   Update and list by automatic data processing the annotated reference bibliography which was developed for an earlier funded project. The initial listing contained 572 references. In the updating process 82 references were added. To cite one important informational item for this project was the identification of advanced fluidized bed gasification projects in Finland and at the University of Brussels. Researchers from both these projects have visited the Project Leader within the past nine months.

Construction drawings of the Brussels unit have been provided and it is anticipated the construction drawings for the components in the gas conditioning system will also be provided.

2. Rice straw ash and slag chemical and thermal characteristics.
   For the operation of any type of air-blown gas producer and design and operation of producer gas conditioning and energy conversion equipment, the complete characterization of the chemical and thermal characteristics are needed of the raw fuel, its ash and any slag formed in the gasification process. The elemental analysis in weight percentages for one rice straw ash sample was determined to be as follows:

SiO_2	Fe	Mg	Ca	Zn	K	Na	S	P
75.2	0.27	0.38	0.52	0.00	9.9	0.03	0.06	3.87

Determination of the deformation and fusion temperatures of rice straw ash and slag samples in a pure N_2 gas is listed as follows:

Sample	Deformation Temp. (°F)	Fusion Temp. (°F)
1. California Rice Straw 1978 Crop	823	1190
2. Agronomy Res. Fac. 1980 crop, straw ash	1190	1200
3. Agronomy Res. Fac. 1980 crop, straw ash	900	1250
4. Agronomy Res. Fac. 1980 crop, straw ash (partially decomposed)	850	1280
5. A mixture of samples 3 and 4.	985	1200
6. Downdraft gas producer slag from cubes made from Sample 2.	1080	1250
7. Replicate of Sample 6.	950	1225
8. Replicate of Sample 6.	900	1255

Deformation temperature is recorded when the tip of a precisely made 3-sided cone starts to melt. Fusion temperature is recorded when the cone has completely lost its granular appearance and slumped down into a liquid droplet. The deformation temperature of SiO_2 ranges from 1460 °F to 1723 °F depending mainly on the actual crystal structure. Since rice straw has significant amounts of K and P, they are responsible for the large reduction in the deformation temperature of the eutectic ash mixture as compared to SiO_2. The relatively low fusion temperature and lower deformation temperatures of rice straw ash in comparison to reaction temperatures in the downdraft gasification process indicate that steam injection by itself holds small promise for satisfactory downdraft gasification of rice straw in any fuel particle form.

SUMMARY OF 1981 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

1. Completion of the temporary shelter to provide an adequate facility in which to conduct the gasification and engine operation work.
2. Storing 1500 bales of rice straw on campus as the initial fuel supply.

3. Rebuilding the stationary cuber mill to produce low density rice cubes which are needed for convenience in fuel handling.
4. Selection and measurement of advanced instrumentation; automated data collection, analyses and process control system, and high temperature furnace for design development of the gasification-engine-generator plant.
5. Long term loan under contract agreement of a fluidized bed gas producer.

PUBLICATIONS OR REPORTS:

Updated computer listing of an annotated reference bibliography on gasification containing 652 selected references. The listing is in three volumes. One volume is by alphabetized title, one by alphabetized authorship, and one by alphabetized titles under ten key words.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

The first long-term goal is to assemble and test a 100 Kw portable farm power plant with its main fuel supply being producer gas generated from rice straw. The major components of the plant are a trailer-mounted, dual-fueled, diesel engine-generator; a fluidized bed gas producer, and a collection of conveyors, live-bottom cattle feeding wagons, and ash handling system.

The 100 Kw portable farm power plant was designed and built by the Department for Deere and Company in 1977 and was returned to the campus in May, 1981 as a gift from Deere and Company. A contract has been entered into with Minturn Huller Cooperative, Inc., Chowchilla, California, for the completion, testing and long-term loan of a fluidized bed gas producer. Thus, the two major components needed to assemble and test the power plant have been acquired. It is intended to use campus equipment for the fuel processing and handling at the power plant test location. This location has been provided by completing the construction of a 40 x 20 foot temporary shelter for protection from inclement weather while testing the system.

An initial supply of 1500 bales of rice straw has been stored on campus, the stationary cuber mill rebuilt so that the baled straw can be cubed. Advanced instrumentation, automated data acquisition-analyses and process control system have been acquired. Some laboratory data have been obtained on the chemistry and melting temperatures of rice straw ash and slag. Tests have been conducted on chopping baled rice straw as one means of preparing it for fueling the fluidized bed gas producer. The foregoing equipment and information is needed to design and develop the power plant system.

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COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION

DEPARTMENT OF ENVIRONMENTAL TOXICOLOGY
DAVIS, CALIFORNIA 95616

July 13, 1981

Mr. Mel D. Androus, Manager
Rice Research Board
P.O. Box 507
Yuba City, CA 95991

Dear Mr. Androus:

This is to request changes in (A) contingencies, (B) budget appropriations between categories, and (C) ending date for the project: Characterization of Hazardous Constituents in Smoke From Rice Straw Burning submitted by Dr. Dennis Hsieh and I in Fall, 1980.

A. Contingency

The Rice Research Board approved $15,000 in funding for this project contingent on additional funds being supplied by the Air Resources Board. ARB chose not to fund the project, however. We have examined the project objectives, and the extent to which existing Agricultural Experiment Station support can substitute for ARB, and now feel that several of the principal objectives of the project can be achieved without the ARB contribution. This will necessitate the following changes in objectives:

Objective 1.

No cytotoxicity tests will be done and all Ames assay evaluations will be on particulate fractions only. Otherwise, objective 1 will remain intact.

Objective 2.

No essential changes. A new fractionation method currently under development will allow us to save considerably on expenditures in this category.

Objective 3.

No essential changes, except that the extent of environmental sampling will be less than originally planned. We wish to emphasize that this objective addresses a major gap in our present knowledge on potential health effects from exposure to rice straw smoke.

Objective 4.

This objective will be deleted, although some work may be attempted at a later date.

Objective 5.

We will place our findings in the context of health significance, but the extensive compilation originally planned will be deleted. We understand that a project funded by ARB at another institution will address this objective.

C. Ending Date

We propose that the present project run from July 1, 1981 to December 31, 1982, rather than January 1, 1981 to December 31, 1981 as originally proposed. This recognizes that the project is approximately 6 months behind schedule at present, and that our principal experimentalist, Ms. Terry Mast, wishes to devote the summer and fall of 1982 to completing the parts of the project dealing with environmental fate. It will allow, for example, for some sample collections during the fall of 1982 to fulfill the environmental fate objective.

Thank you, for your consideration, of these requests. We look forward to working with the Rice Research Board on this important project.

Sincerely,

James N. Seiber
Professor

Dennis P.H. Hsieh
Professor

JNS/DPHH/lo
cc: Terry Mast
James Woodrow

OPERATING UNDER THE AUTHORITY OF THE
DIRECTOR OF FOOD & AGRICULTURE, STATE OF CALIFORNIA

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RICE RESEARCH BOARD
P. O. BOX 507
YUBA CITY, CALIFORNIA 95991

September 10, 1981

Dr. James Sieber
Dept. of Environmental Toxicology
University of California
Davis, CA 95616

Dear Jim:

This is to advise you the Rice Research Board removed its contingency of your receiving funds from the Air Resources Board for the project you submitted. In other words, you now have the $15,000.00 you requested.

For your information, this amount was included in the 1980-1981 contract with the University and we have been paying on it so that the funds should be available to you now.

If you have any questions, please contact me.

Very truly yours,

Melvin D. Androus
Manager

MDA/dl