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16 December 1986
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TECHNIQUES OF DIRECT COAL LIQUEFACTION (PHASE II)

DP/CPR/83/002

Technical report: Coal Liquefaction Technical Adviser *

Prepared for the Government of China
by the United Nations Industrial Development Organization (UNIDO)
acting as executing agency for the United Nations Development Programme

Based on the work of James J. Lacey,
Expert in the Construction of Process Development Units (PDU's)
and Coal Liquefaction Process Technology

United Nations Industrial Development Organization
Vienna, Austria

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December 16, 1986
English

LIQUEFACTION OF COAL
DP/CPR/83/002/11-01/32.1.I
CHINA

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TRIP REPORT - CHINA

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ABSTRACT

Project DP/CPR/83/002/11-01/32.1.I
December 1-7, 1986

This report covers a trip which included seven (7) days in Beijing, China for the purpose of strengthening and supporting the Chinese government's on-going research and development program in the area of direct coal liquefaction. This work is being carried out at the Central Coal Mining Research Institute (CCMRI) in Beijing. The author of this report serves as Technical Adviser and a member of a Technical Committee whose duties are:

a) To review the research and development activities of the project and report, monitor, review and evaluate the progress over a four (4) year period (1985-1988 inclusive).

b) To advise on the annual work program with the aim of keeping it in its proper perspective in relation to developments in other countries.

c) To recommend to the Chinese government, UNDP and the executing agency (UNIDO) on the specific utilization of UNDP funds in the best manner to achieve the project objectives.

This report summarizes the second annual meeting of the above mentioned Technical Committee, and is organized in a daily journal format for the period covered by this trip. Particular emphasis is placed on documenting the approved 1986 Progress Report and 1987 Work Plans for this project. A detailed plan is established for the proposed 1987 R&D work. A determination is made regarding the required UNIDO inputs in terms of Consultants, Fellowships, Study Tours, and Equipment. Milestones are established for monitoring and evaluating work progress for the entire duration of the project.

SUMMARY

This trip covered the period of December 1-7, 1986 inclusive. My time in Beijing, China was spent at the Central Coal Mining Research Institute (CCMRI). My duties were covered by DP/CPR/83/002/11-01/32.1.I and involved my serving as the Technical Adviser to the committee reviewing the Chinese government's present research and development program on coal liquefaction being carried out at the CCMRI.

The overall aim of this program is to proceed orderly from laboratory to commercial scale. It is planned that four or five candidate coals will be evaluated, and a suitable direct liquefaction process selected for commercialization. The overall plan proposes:

a) To evaluate various types of Chinese coals and select several for hydrogenation.

b) To investigate the liquefaction characteristics for the candidate coals and obtain quantitative data for the design of larger systems.

c) To investigate the formation of suitably stable slurry that can be pumped to the reactor without separation.

d) To carry out experiments on selection and preparation of the hydrogenation solvent.

e) To develop laboratory methods for the separation of coal liquids and determine their chemical structures.

f) To evaluate different coal liquefaction catalysts.

g) To study techniques for upgrading of coal liquids to obtain lighter, more stable products.

This trip report covers the items discussed at the annual meeting of the Technical Committee at which time the 1986 Progress Report and the 1987 Work Plans were discussed and approved. A detailed plan for the 1987 R&D work was established and a determination of the UNIDO inputs needed in terms of Consultants, Fellowships, Study Tours, and Equipment was finalized. Milestones required for evaluating and monitoring the project were also established for the duration of the effort.

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INTRODUCTION

The period covered in this report is November 30 - December 9, 1986 inclusive. I served as the Technical Adviser and a member of the Technical Committee established to strengthen and support the Chinese government's present research and development program on techniques of direct coal liquefaction carried out at the Central Coal Mining Research Institute (CCMRI), Beijing. The committee consists of three members, and I functioned as the Technical Adviser under job description DP/CPR/83/002/11-01/32.1.I.

In addition to participating in the work of the Technical Committee, I gave lectures and advice on aspects of coal liquefaction technology of interest to the Chinese research scientists and engineers.

The long-term objectives of this project are the utilization of China's vast coal resources and the development of industrial-scale technologies for the conversion of lignites and bituminous coals to liquid fuels and chemical feedstocks.

This project (Techniques of Direct Coal Liquefaction) has been listed as one of the key projects in the National Research and Development Program; viz.,

a) By the end of 1985, to establish laboratories, conduct basic research, evaluate the liquefaction characteristics of Chinese coals and select suitable liquefaction technologies.

b) During the period of 1986 to 1990, conduct basic research and scale up to obtain the necessary data for construction of a commercial coal liquefaction plant.

c) In the third and final stage, the construction of a commercial coal liquefaction plant is planned in the 1990's.

DISCUSSION

This report is organized on a daily journal basis, followed by conclusions and recommendations regarding future work. Wide ranging discussions with many Chinese workers are summarized with particular emphasis on their plans and needs.

Day 1 - Sunday, November 30, 1986

After discussion in UNIDO headquarters in Vienna, Austria, I flew from there to Tokyo, Japan for a scheduled overnight stay in order to make the necessary connection for Beijing the next day.

Day 2 - Monday, December 1, 1986

Flew to Beijing from Tokyo. Was met at the airport by Mrs. Pang of CCMRI and driven to my hotel. Mrs. Pang Weizhen is an engineer with

CCMRI working in their Office of International Cooperation. She was extremely helpful during my entire stay in Beijing and greatly aided me in all my administrative duties.

The first order of business was to meet with Mr. A.W. Sissingh, the Senior Industrial Development Field Adviser for UNDP for help in all my financial matters regarding the per diem arrangements for my stay in Beijing.

After completing the required UNDP administrative details, we went to CCMRI to begin our technical meetings and plan our agenda for the week.

Day 3 - Tuesday, December 2, 1986

Since this is a "coal project" it is under the Ministry of Coal Industry (MCI). The Director of MCI is Mr. Yu Hongen. One of the many organizations in MCI is the Central Coal Mining Research Institute (CCMRI) headquartered in Beijing. CCMRI is the R&D arm of the MCI. CCMRI's Director is Mr. Fan Weitang. CCMRI is responsible for all coal research in China. It is organized into sixteen (16) institutes, viz.,

1. Beijing Research Institute of Mine Construction.
2. Beijing Research Institute of Coal Mining.
3. Beijing Research Institute of Coal Chemistry (Coal analysis, coking, coal gasification, coal liquefaction, and combustion).
4. Research Institute of Economy.
5. Branch of Geology and Exploration.
6. Tangshan Branch (Coal preparation, hydraulic mining, mine surveying, and coal mining techniques).
7. Shanghai Research Institute - (Mining machinery, and electrical equipment).
8. Taiyuan Branch - Mining machinery.
9. Fushun Research Institute - (Mine safety and surface mining).
10. Chongqing Research Institute (Prevention of coal, gas and dust explosion).
11. Nanjing Research Institute (Conventional shaft sinking and drifting techniques).
12. Research Institute of Blasting Technology.

13. Hangzhou Research Institute (Environmental protection, and coal utilization).

14. Changzhou Research Institute of Automation (Mine automation and mine communication).

15. Changzhou Development and Manufacturing Centre.

16. Computer Center.

There are two (2) Deputy Directors for the CCMRI, viz. Mr. Yu Xiang and Mr. Zhang Shingtou. Mr. Yu is in charge of R&D planning while Mr. Zhang is responsible for implementation. This project is under the direction of Mr. Zhang. The Central Coal Mining Research Institute is spread throughout the coal mining areas of the country. These institutes employ 7,800 people of which approximately 1,500 are located in Beijing. Generally the title of the institute indicates its location with the following exceptions:

Organization	Location
Research Institute of Economy	Beijing
Branch of Geology and Exploration	Xian
Computer Center	Beijing

Since the UNIDO project involves coal liquefaction, it is handled by the Beijing Research Institute of Coal Chemistry (BRICC). The Director of the BRICC is Mr. Dai Hewu. All coal liquefaction work in China is done by the BRICC. Its Deputy Director, is Mr. Wu Chunlai, who is now the National Project Director replacing Mr. Ouyang Yuan who has retired. BRICC is composed of seven (7) labs and one (1) section as follows:

1. Coal Analysis Lab
2. Coal Properties Lab
3. Coal Gasification Lab
4. Coal Liquefaction Lab
5. Coal Combustion Lab
6. Coking Lab
7. Special Processes Lab
8. Design Section

The larger "labs" (coal liquefaction, gasification) are staffed with about fifty (50) people, while the smaller "labs" have as little as ten (10) people. Overall BRICC employs 270 people composed of:

Senior Engineers	15
Engineers	80
Associate Engineers	100
Technicians	75
TOTAL	270

We next discussed the plan for the remainder of the week. These discussions were led by Mr. Wu Chunlai, the National Project Director and a member of the Technical Advisory Committee for the UNDP funded coal liquefaction project. Although Mr. Ouyang Yuan has retired, he still attended all meetings to provide continuity. Mr. Wu briefly summarized the objectives, the accomplishments to date, and the plans for the future. During all meetings of the Technical Committee, the following were present:

- Mr. J.J. Lacey - U.S. DOE (UNIDO)
- Mr. Wu Chunlai - Deputy Director, BRICC and National Project Director (NPD)
- Mrs. Pang Weizhen - Office of International Cooperation CCMRI
- Mr. Ouyang Yuan - Former NPD, retired.

The proposed weekly schedule included a tour of the BRICC labs followed by Technical Committee meetings. On Friday it was planned to hold the annual Tripartite Review Meeting with representatives from:

1. Ministry of Foreign Trade
2. Ministry of Coal Industry
3. UNDP
4. UNIDO

As time allowed during the week, I was given the opportunity to lecture on aspects of direct coal liquefaction, particularly the UNIDO funded work in Poland.

After these detailed discussions of organization and schedule, we reviewed the coal liquefaction facilities of the BRICC. Their pilot plant facilities include several continuous process units (CPU), viz.,

1. NEDO Unit (CPU #1) 20 kg/hr coal slurry (1/2 T/D slurry)
2. Xytel Unit (CPU #2) 5 kg/hr coal slurry
3. German Unit (CPU #3) 15 kg/hr coal slurry

All slurry rates include 1/3 coal. The Xytel unit was modified for product upgrading service in conjunction with the product from the other units. The NEDO unit was modified to include facilities for:

1. Hydrogen recycle
2. Solvent recycle
3. Computer control
4. Tube type reactor

The German unit (Saarberg-Veba Oil) is finished and began operation in October 1986. It is a complete unit from coal grinding to product distillation. It features hydrogen and solvent recycle, computer control and a tube type reactor.

The New Energy Development Organization (NEDO) unit (CPU #1) was built by Mitsui Engineering and Shipbuilding Co., Ltd. of Japan, and proved very valuable in coal screening studies. It was modified to include H_2 and solvent recycle and is capable of performing process technology assessment studies. The German unit (CPU #3) was built with the required capability for technology assessment studies. The Xytel unit (CPU #2) is utilized in product (from CPU #1 and #3) upgrading studies.

Day 4 - Wednesday, December 3, 1986

The day was spent at CCMRI and we discussed the 1986 Annual Report and the 1987 Work Plan. The discussions were lead by Mr. Wu. The first order of business was a summary of the history of the project which indicated:

1. The effort was established as a key project in the national R&D program for China in 1979, when the Chinese government provided a new laboratory building, some initial equipment and training opportunities in the field of coal liquefaction for several recent university graduates. In 1980, the project "Techniques of Direct Coal Liquefaction" was funded by UNDP at a level of $700K and began as Phase I (1980-1983).

2. At the end of 1981 an agreement was signed with NEDO of Japan whereby the Chinese would supply buildings and lab support, and the Japanese would provide a 20 kg/hr slurry feed (1/3 coal) continuous processing unit (CPU #1). The operating results were to be owned by both governments. This unit has been in operation since March 1983 for over 2000 hours on eight (8) different Chinese coals. It proved very valuable in testing coal types, and was modified for use in the areas of process technology assessment.

3. In July 1984, an agreement was signed with West Germany (the Saarberg-Veba Oil organization) to provide another continuous processing unit (CPU #3). The agreement had similar terms as the NEDO agreement. The equipment was delivered in May 1985 and operations commenced in October 1986. This unit processes 15 kg/hr slurry (1/3 coal) and has the capability of H_2 and solvent recycle, as well as computer control.

4. A unit from the U.S.A. was provided by the Xytel Corp., (CPU #2). It was purchased, installed and operated during this period. This unit processes 5 kg/hr slurry (1/3 coal), but was modified for product upgrading studies.

5. Phase I ended in 1983. During 1984, plans were drafted for Phase II which commenced in January 1985 and will run for four (4) years (1985-1988) at a total cost of $800,000.

6. The project history of "Techniques of Direct Coal Liquefaction" can be summarized as:

Year	Action
1979	Original Chinese Work
1980-1983	UNDP Funded Phase I
1984	Planning Year
1985-1988	UNDP Funded Phase II

Phase II is funded at $800,000 with the UNDP contributing $600,000 and the Chinese Gov't $200,000. Technical Committee will function during Phase II which runs from January 1984 to December 1988.

The first order of business after the historical introduction was a discussion of the 1986 results in the form of an annual report to the Technical Committee by Mr. Wu, the National Project Director. The objective was to review this report, offer suggested revisions, then approve it in final form for presentation at the Tripartite Meeting on Friday, December 5, 1986. The report was divided into the following sections:

A. Modifications and Installations
B. Research and Tests
C. Consultants
D. Fellowships
E. Equipment Procurement

Mr. Wu again stated that Phase I of the project was completed by the end of 1983, and the project document for Phase II was signed formally at the beginning of 1985. Research work has continued during this period and the 1986 results were as follows:

A. Modification and Installation - This work on the continuous liquefaction process development units was extended. These were used in evaluating coals, and assessing coal liquefaction process technology. Modifications were made to include facilities to recycle H_2 and the process solvent. These small continuous process development units continue to be their main approach for coal liquefaction research and development. In order to extend coal liquefaction research from evaluation of coal samples to technology process assessment, the No. 1 unit (Japanese-made) was modified. The No. 3 unit supplied by the Federal Republic of Germany (FRG) was installed with the required modifications.

(1) Modification of hydrogen supply system for CPU #1 was completed. An on-line gas-chromatograph was installed and used during operation. Results showed that con-

version and yield of liquid products were higher. The gas product can also be analyzed more accurately and in a timely manner. During 1986, a recycle solvent/hydrogen system was installed with the assistance of the Japanese. These modifications were required for the assessment of various coal liquefaction process technologies.

(2) The No. 3 continuous process unit supplied by the FRG was delivered in 1985, start up completed in October 1986. Runs with German process technology will be conducted during 1987.

(3) The No. 2 continuous process unit (Xytel) is being used for upgrading of coal liquids produced by the No. 1 and 3 units.

B. Research and Tests

(1) Tests of the liquefaction characteristics for various types of coal from the Shangtong, Shanxi, Inner-Mongolia and Provinces Yunnan were conducted with autoclaves. Catalyst screening studies were also conducted with autoclaves, with 5 types of iron-based catalysts.

(2) Runs with different coal samples were conducted with the No. 1 CPU (NEDO). Several conditions were selected for process technology evaluation. Upgrading of the coal-liquids was also conducted. Catalyst and process technology suitable for upgrading of coal liquids were also investigated. The unit is presently being modified for computer control.

(3) Runs were conducted on CPU #3 (FRG) during 1986 and the unit performed well.

C. Consultants - Consultants were sent by NEDO for modification of CPU No. 1, according to the cooperative agreement. Additionally, thirteen (13) consultants were sent by the FRG for installation and start-up of CPU No. 3 according to the joint research program.

D. Fellowshipholders

(1) A 4 person group (4 people for 3 months) was sent to PETC for training in coal liquefaction research.

(2) A 2 person group (2 people for 1.0 month each) was trained in China on NMR and gas chromatograph/mass spectrometer (GC/MS). This was supported by the Chinese government.

E. Procurement of Equipment

(1) Four (4) items were delivered in 1986:

GC/MS
Surface Determinator
Mass Flowmeter
Two Data Processor

(2) Differential Thermal Analyzer (DTA), ordered by UNDP in Phase 1, was sent back to Japan.

(3) Coal grinding equipment and a product distillation system purchased by the Chinese government was operated on CPU #3. One small hydrogenation unit (product upgrading) designed by the staff was operated.

The DTA provided by Japan has not performed well at the BRICC. It was originally delivered in June 1981, but returned to Japan in September 1981. It was repaired and returned in February 1984, but sent back a second time in October 1984. It was due back in April 1986, but was never received. Since this unit cost $70,000 in 1981 and has never performed satisfactorily, the Chinese should get their money back. I would recommend this, so that new equipment can be procured.

This essentially concluded the discussion of the 1986 work. As a sidelight, Mr. Wu indicated that all work in direct coal liquefaction in China is the responsibility of the CCMRI and is conducted by the BRICC using about 100 of their 270 people. A small amount of direct coal liquefaction work is done at several universities, and this is coordinated by the BRICC. The universities involved are Qinghua University, Taiyuan Polytechnic College (Shanxi), and Shanghai College of Chemical Engineering.

Day 5 - Thursday, December 4, 1986

The afternoon was spent in a discussion of the 1987 Work Plan which calls for the design of a commercial scale plant by 1989. As a result, work is continuing in the areas of processing several coals, screening many catalysts, and upgrading the liquid products from the various runs.

The detailed plans include the following steps, again in the same format as the Work Plan, viz.,

A. Research Work
B. Equipment Procurement
C. Consultants
D. Fellowships
E. Study Tours
F. Technical Committee

Each item was discussed in significant detail in order to finalize every part as follows:

A. Research Work

(1) Autoclave screening of various disposable catalysts for coal liquefaction and coal liquids will be continued in 1987.

(2) After modifications are made to CPU #1 (NEDO), two (2) more Chinese coals will be screened.

(3) CPU #3 (FRG) will be used to evaluate one (1) Chinese coal and assess the German technology.

(4) CPU #2 (Xytel) will be used to upgrade the coal liquids produced by CPU #1 and CPU #3.

(5) The GC/MS delivered and installed in 1986 will be applied to analyzing coal liquids.

B. Equipment Procurement

(1) Accepted delivery of the GC/MS in the fourth quarter of 1986. The GC/MS will be used for the analysis of liquefaction products in 1987.

(2) Surface Determinator (catalyst pore size) delivered in 1986 will be used in 1987.

(3) Data Processor for liquid chromatograph was delivered, installed and operating in 1986 will be operated as needed in 1987.

(4) High Pressure Gas Mass Flow Meter for small upgrading units was delivered, installed and is in present use.

(5) The automatic distillation system was purchased with Chinese government funds and will be operated in 1987.

(6) Microcomputer for CPU #3 (FRG) was cancelled and the available funds used to modify the CPU #2 (Xytel) computer for use on the CPU #1(NEDO). CPU #2 will be used as needed during 1987.

(7) High pressure pump and reactor for small upgrading units was delivered and installed, and will be operated in 1987.

C. Consultants

(1) Technical Committee (Post 11-01) meeting is scheduled in Beijing in November 1987.

(2) Catalytic Hydroliquefaction (Post 11-51) for two (2) weeks was filled up by Prof. Yuzo Sanada, Faculty of Engineering, Hokkaido University, Japan. (Techniques of Coal Liquefaction)

(3) Techniques of Two-Stage Coal Liquefaction (Post 11-52) for two (2) weeks in late 1987 should be filled by Mr. T.M. Torkos of PETC, USA.

(4) Separation and Structural Analysis of Coal Liquids (Post 11-53) for two (2) weeks was filled by Prof. Zhang Qisun, University of British Columbia, Canada.

(5) Kinetics of Liquefaction Reactions (Post 11-54) for two (2) weeks in 1987 should be filled by Dr. Ingo Romey, Bergbau Forschung, West Germany.

(6) Liquefaction Reaction Engineering (Post 11-55) for two (2) weeks in 1988 should be filled by Dr. John A. Ruether of PETC, USA.

(7) Upgrading Techniques of Coal Liquids (Post 11-56) for two (2) weeks was filled by Dr. Etsuro Nakamura, Deputy Director of the National Research Institute for Pollution and Resources, Agency of Industrial Science and Technology, Japan.

D. Fellowships

(1) Training on Structural Analysis Techniques of Liquefaction Products (Post 31-01) for four (4) people for three (3) months is at PETC, USA, and will conclude in early 1987.

(2) Training on "Study of Catalysis For Liquefaction" (Post 31-02) again for four (4) people for three (3) months in 1987 should be in the Government Industrial Development Laboratory, Hokkaido Agency of Industrial Science, Japan.

(3) Training on Scaling-Up Techniques of Liquefaction Processes (Post 31-03) for four (4) people for six (6) months is postponed until 1988.

(4) Training on Modifications of Continuous Process Units (Post 31-04) has been scheduled for 1987. It is four (4) people for four (4) months to Bergbau Forschung.

E. Study Tours

(1) Two-Stage Liquefaction Techniques (Post 32-02) for four (4) people for three (3) weeks is planned for early 1987 and will include the USA, particularly PETC.

(2) Liquid Solvent Extraction Techniques (Post 32-03) should be scheduled for four (4) people for three (3) weeks in 1987 in the UK, and will include Poland and Russia.

(3) Study status and development trends in coal liquefaction (Post 32-04) for five (5) people for one (1) month for mid-1988 in Europe (West Germany, Poland, and Russia).

(4) Send three (3) people for two (2) weeks to Holland to attend the International Coal Science Meeting in late 1987.

F. Technical Committee

(1) The committee will consist of:

(a) National Project Director (Mr. Wu)
(b) UNIDO Official (Mr. Williams)
(c) Technical Adviser (Mr. Lacey)
(d) Chinese Consultant (Dr. Wang)

(2) The tasks will be:

(a) Review progress on project
(b) Advise on project activities
(c) Make recommendations to China and the UN

(3) The committee will meet again in Beijing in November 1987.

This concluded the formal discussions. We next discussed the proposed involvement of Mr. Torkos (Post 11-52 Two-Stage Liquefaction) and Dr. Ruether (Post 11-55 Reactor Engineering) of PETC for 1987 and 1988. It was recommended that Study Tour (Post 32-02) be scheduled before the visit of Mr. Torkos. After the Chinese Study Tour at PETC, Mr. Torkos (Post 11-52) will be better prepared for his visit to China.

We next discussed the Polish Direct Coal Liquefaction PDU. It was tested in June 1986 and in operation by November 1986. The scheduled Chinese visit (Post 32-04) in mid-1987 would be appropriate, and I

recommended that each side present a detailed review of their work at this time.

The rest of the day was spent at the CCMRI in a review of the detailed plan for the R&D work for 1987. The Work Plan was revised to agree with the Project Plan. It was agreed that the Work Plan be presented at the Tripartite Review Meeting on Friday, December 5, 1986. Special emphasis was placed in assuring that the Work Plan specifies the UNIDO inputs needed in terms of Consultants, Fellowships, Study Tours, and Equipment.

As regards monitoring and evaluating work progress for the entire duration of the project, it was decided that the Technical Committee will meet yearly in November to review the past year's work and plan the upcoming year's schedule. At this time the past year's progress report will be prepared and approved. The upcoming year's work plan will also be approved at these November meetings. These approved reports can then be presented at the Tripartite meeting.

I again stressed establishing close communications with the direct coal liquefaction work being conducted in Poland. This work is very similar to the Chinese effort and each side can profit from an active information exchange. It was recommended that the Chinese study group (Post 32-04) should include Poland on its agenda. The best time to go would be in early 1987, after the Polish PDU has been in operation. It is necessary to maintain a communication link between these two UNDP funded projects in the area of direct coal liquefaction.

Consultants, Fellowships, and Study Tours, were finalized for inclusion in the 1987 Work Plans. They were specified by name, organization and date (month and year). These have proved very valuable to the Chinese and the project has benefitted accordingly. It is obvious to see in the Chinese effort the positive contribution of the various consultants and the net benefit obtained from the fellowship program. The study tours have proven worthwhile in keeping the Chinese abreast of current technology.

Considerable time was devoted to a discussion of the Equipment Procurement. All of the equipment has been delivered and it was possible to assess the current status of the UNDP budget in light of the fact that several pieces of equipment came in over the budgeted amount (e.g., GC/MS).

Day 6 - Friday, December 5, 1986

The Tripartite Meeting was held today attended by:

- Mr. Wu Chunlai, CCMRI (National Project Director)
- Mrs. Pang Weizhen, CCMRI
- Mr. A.W. Sissingh, UNDP
- Dr. Wang Yinin, Consultant
- Mr. J.J. Lacey, UNIDO (DOE) (Technical Adviser)

The purpose of this meeting was the annual review of this project "Techniques of Direct Coal Liquefaction." Phase II of the project was signed in February, 1985 and this was the second annual review. Subsequent reviews will be held in November 1987 and 1988. Although Phase I is history, there were a few loose ends to be considered. Dr. Pugmire had been an invited consultant to the CCMRI and lectured on "Application of NMR", but was late submitting a trip report to UNIDO, Vienna. It was stated that this report has been submitted and thereby closes out this aspect of Phase I.

Another item left over from Phase I was the Differential Thermal Analyzer (DTA) which has never performed satisfactory, and has been returned to the Japanese manufacturer on two occasions. It was recommended that the Chinese contact the manufacturer to recover the purchase price and possibly additional funds due to the loss of research effort attributed to the non-performance of this equipment.

On the subject of Phase II, the 1986 progress report was read, discussed, and approved by the Technical Committee. Considerable progress was made during 1986 particularly in the areas of equipment procurement.

As regards the 1987 Work Plans, considerable discussion was devoted to ensuring that these plans were reasonable as regards schedule and that they were broad enough to be in agreement with the Chinese Seventh 5-Year Plan certified in January 1986, since the coal research plans were not yet firmly defined in this seventh 5-year plan. Particular emphasis was placed on specifying, in considerable detail, the required UNIDO inputs regarding:

1. Equipment
2. Consultants
3. Fellowships
4. Study Tours

For equipment, it was recommended that a general accounting is needed to take into account the actual delivered purchase price of all the equipment. It would appear that the present equipment budget has been fully utilized.

On the subject of Consultants, Fellowships and Study Tours, the plans are rather ambitious and call for implementation of some aspects in early 1987. The Chinese were requested to get the appropriate job descriptions into UNIDO as soon as possible. The Technical Committee approved the 1987 Work Plans.

After the meeting a detailed tour was arranged to review the mechanical progress of the following continuous process units:

1. CPU #1 Japan (NEDO)
2. CPU #2 USA (Xytel)
3. CPU #3 Germany (Saarberg)

The NEDO unit was being actively worked on to modify it for computer control. The Japanese had three (3) people (1 engineer and 2 technicians) on-site at CCMRI participating in these modifications. The USA unit was modified for product oil upgrading work processing the production from CPU #1 and #2. The work on CPU #3 was complete.

After the tour, the Technical Committee scheduled the next meeting in Beijing in November 1987.

Day 7 - Saturday, December 6, 1986

The day was spent reviewing the items discussed at the Tripartite Meeting and making final corrections to the 1986 Progress Report and the 1987 Work Plans.

Day 8 - Sunday, December 7, 1986

A morning meeting was arranged with Mrs. Pang of the CCMRI to discuss the mechanics of obtaining a visa for China in the most efficient manner. She recommended that once UNIDO and DOE approval is obtained, my next contact should be with the CCMRI to insure that an invitation is forthcoming and a visa is issued in plenty of time. She recommended that this invitation be obtained about two (2) months before commencing travel. After this meeting, Mrs. Pang was kind enough to accompany me to the Beijing airport and facilitate my customs clearances. I then flew to Tokyo for a scheduled overnight stop.

Day 9 - Monday, December 8, 1986

The day was spent in transit flying from Tokyo to San Francisco. The long flight afforded the opportunity to make the final revisions to this report.

Day 10 - Tuesday, December 9, 1986

This was the final day of my trip, and I flew from San Francisco to Pittsburgh, PA.

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December 16, 1986
English

CONCLUSIONS

During my stay in Beijing (December 1-7, 1986) I participated as the Technical Adviser to the Technical Committee whose goal is to strengthen and support the Chinese Government's on-going R&D program in "The Techniques of Direct Coal Liquefaction". This work is being carried out at the Central Coal Mining Research Institute (CCMRI), Beijing. The Technical Committee has been established for the duration of the project (4.0 years) to facilitate its successful implementation. The project is scheduled to run through December 1988.

As the Technical Adviser (Job Description DP/CPR/83/002/11-01/32.1.I), my duties during the committee meetings were:

1) To review the R&D activities and to report, monitor, review and evaluate the project.

2) To advise the Chinese Government through the National Project Director on the Annual Work Plan. Keep the program in its proper perspective in relation to developments in other countries.

3) To recommend to the Chinese Government, UNDP and UNIDO on the specific utilization of UNDP inputs in the most efficient way to achieve the project objectives.

This particular project, "Techniques of Direct Coal Liquefaction", has been listed as one of the key project in the National Research and Development Program for China. The major milestones are:

1) By the end of 1985, establish laboratories, conduct basic research, evaluate the liquefaction characteristics of Chinese coals and select suitable liquefaction technologies for these types of coal.

2) During the period from 1986 to 1990, continue conducting basic research, scaling up the results and obtain the necessary data for the design and construction of a commercial coal liquefaction plant.

3) The long term goal is the construction of a commercial coal liquefaction plant in the 1990's.

This project is part of an overall Chinese plan for the utilization of the country's coal resources and the development of industrial-scale technologies for the conversion of lignites and bituminous coals of high volatile and sulphur contents to liquid fuels and chemical feedstocks. These resources, which are normally not suitable for other purposes such as power production or steel making, can then be utilized in a manner more compatible with the present and future modes of transportation, as well as industrial and domestic fuel needs.

Based on the results of the Technical Committee meetings, the project's immediate objectives are being satisfied. These are as follows:

1) To evaluate various types of Chinese coals and select those best for hydrogenation;

2) To investigate the liquefaction behavior of the selected coals in autoclave experiments. Use continuous process units (CPU) to obtain quantitative data necessary for the design of larger systems;

3) To investigate the formation of a stable slurry that can be transported without phase separation;

4) To carry out experiments on selection and preparation of the hydrogenation solvent;

5) To develop laboratory methods for the separation of coal liquids and determine their chemical structures and properties;

6) To evaluate different coal liquefaction catalysts;

7) To study techniques for upgrading of coal liquids to obtain lighter, more stable products.

The Government's R&D programme is well-planned and should carry the work from the laboratory to commercial application. By the end of this project, 4-5 candidate coals will have been thoroughly evaluated and a suitable direct liquefaction process selected for commercialization.

A detailed plan for the 1987 R&D work was determined and the required UNIDO inputs were specified as regards:

1. Consultants
2. Fellowships
3. Study Tours
4. Equipment Purchases

As regards project monitoring, it was concluded that the Technical Committee should meet annually in November to review and approve the past year's Progress Report and determine the Work Plan for the coming year. The Technical Committee meetings should be scheduled to be held in conjunction with the yearly Tripartite Meeting.

It was further concluded that there is significant progress being made in the area of direct coal liquefaction throughout the world. The Chinese must keep abreast of the long range, high risk type of research being conducted in the USA, particularly in the area of two stage liquefaction. The liquid solvent extraction work in the UK must also be followed closely. Several large scale process development units (PDU) are being operated in Japan, Germany, Russia, Australia, and Poland. As regards Poland, it was

stressed that this is another UNDP sponsored project that shares many characteristics with the Chinese effort. Both projects have similar goals and are at the same stage of development. I will ensure that there is an exchange of technical information between these projects and urged the Chinese to include the Polish PDU in one of their planned study tours.

RECOMMENDATIONS

Based on the discussions with the staff of the CCMRI and the BRICC the following recommendations seem to be in order:

1. The autoclave work should be directed at catalyst screening to determine an active catalyst that is abundant and inexpensive for use in a disposable mode in their continuous units.

2. Modifications to the NEDO unit (CPU #1) should be completed as soon as possible to make it possible to perform process technology assessments.

3. The Xytel unit (CPU #2) should be used for product oil upgrading.

4. The FRG unit (CPU #3) should prove to be a valuable processing tool for technology evaluations. It was designed and built for recycle (H_2 and solvent) operation and is complete in all respects from coal grinding to product distillation. Operation of this unit should be given top priority in 1987.

5. The GC/MS was delivered in 1986. This is a valuable piece of equipment that will prove very useful in analyzing coal liquids. The operation of CPU #1 and #3 combined with the upgrading potention of CPU #2 will rely on this GC/MS.

6. Equipment purchases in general have been on-time; however, there have been several instances where the delivered cost was significantly higher than the budgeted estimate. I would recommend that a general accounting be made at this time.

7. The DTA unit ordered from Japan was delivered in June 1981 and has not performed satisfactorily. It has been returned to the manufacturer twice with no results. At present it is back in Japan and no progress is being reported. I would recommend that this unit remain in Japan and that the purchase price be refunded to the Chinese.

8. The plans for Consultants, Fellowships, and Study Tours were well developed into 1988. I would recommend that every effort be made to arrange the scheduling in order to obtain the maximum benefit. For example the Study Tour on Two-Stage Liquefaction (Post 32-02) should take place as early as possible in 1987 and schedule an extended visit at PETC to consult with Mr. Torkos and Dr. Ruether. Then these two consultants can then visit China to discuss two-stage liquefaction (Post 11-52) and reactor engineering (Post 11-55) later in 1987 and 1988.

9. As regards Fellowships, I would recommend that this type of training be at an institution where a free exchange of information is possible, e.g., the Pittsburgh Energy Technology Center in the

USA. Industrial installations due to their restrictions on patent information may not be able to discuss many aspects of direct coal liquefaction, e.g., Chevron in the USA.

10. On the subject of Study Tours, I would recommend that these be concentrated at the installations where large scale operations involving direct coal liquefaction are taking place. Again one must be assured of a free exchange of information. Some plants that I would recommend would be as follows:

    a) Polish Pilot Plant, Katowice
    b) German Pilot Plant, Bottrop
    c) NEDO Pilot Plant, Japan
    d) Australian Pilot Plant, Victoria

11. The Study Tour to the UK (Post 32-03) should concentrate on Liquid Solvent Extraction Techniques.

12. One area that should start receiving emphasis is the conduct of economic surveys and the study of direct coal liquefaction technology to evaluate the feasibility of constructing commercial coal liquefaction plants in China after 1990. The Coal Liquefaction Technology Data Base (CLTDB) at PETC should be considered.

13. When a visit is made to Poland, the Chinese should report on their work as well as hearing a report on the Polish work. This interchange between UNDP sponsored projects should be encouraged.

14. Due to currency fluctuations, the delivered price of several pieces of equipment has been larger than budgeted. Since the present UNDP equipment budget is practically spent for this project, it is recommended that an accurate accounting performed on the remaining funds.

15. Since the 1987 Work Plans call for Consultants, Fellowships, and Study Tours in early 1987, it is recommended that the Chinese submit the documentation (Job descriptions, etc.) to UNIDO for these efforts as soon as possible. It was stressed that they adhere to the Work Plan in order to proceed in an orderly manner, particularly as regards the expenditure of funds for these areas.

16. The Technical Committee should meet on an annual basis near the end of the calendar year to review the progress during the year and approve the work plans for the coming year. The Technical Committee should meet at a time convenient to the annual Tripartite Meeting. I would recommend that the next meeting of the Technical Committee be scheduled for November 1987.

Finally, it was recommended that my next trip should be in November 1987 and the visit should be arranged to include the yearly Tripartite

Meeting. At this time a more accurate status of project cost and schedule should be possible.

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