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STATUS REPORT OF THE SRC-I AND SRC-II PROCESSES

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ABSTRACT

After sixteen years of bench-scale and pilot plant development, large solvent refined coal (SRC) demonstration plants are being planned which could lead to commercialization by the late 1980's.

I. BACKGROUND

Development of the solvent refined coal (SRC) process began in 1962 at Gulf Oil Corporation's Merriam, Kansas Research Laboratories and bench-scale work has continued at that location since that time. This work led to the construction and operation of a one-half ton per day pilot unit in 1964 which provided design data for a 50 tons per day pilot plant. Construction of the 50 tons per day Government-owned facility was completed in 1974 at Ft. Lewis, Washington and has been in operation since then. This extended research and development program has been funded by the U. S. Department of Energy (DoE) and its predecessors.

All work until 1973 was aimed at the development of a process to produce a low-ash, low-sulfur solid product known as SRC-I. In the SRC-I process, coal is slurried in a distilled, coal-derived, recycle solvent, mixed with hydrogen and reacted at high temperature and pressure. The reaction product is filtered to remove ash and unreacted coal which is further processed, such as by gasification, to convert it to an environmentally acceptable form for disposal. The filtrate is vacuum distilled to separate distillate from the "heavy" residual organic material which is removed and solidified as the solid SRC product. The distillate is further distilled to separate it into a recycle process solvent for the reaction area and limited quantities of fuel oil and naphtha. Much of the sulfur in the feed coal is converted to hydrogen sulfide which is recovered and converted to elemental sulfur.

By 1973, Merriam data had indicated a potential problem of insufficient production of the process solvent required for the reaction area. It was theorized that additional solvent production could be attained by recycling a portion of the reactor effluent slurry and utilizing it to replace some of the distilled solvent used to slurry the feed coal. This mode of operation increases the concentration of ash, and its catalytic components, as well as allowing the "heavy" (high molecular weight) organic material contained in the slurry to be subjected to further liquefaction reactions. The initial slurry recycle experiments were successful in achieving the objective of increased solvent production. More importantly, though, indications were that replacing the distilled solvent completely with recycle slurry increased the degree of conversion of the "heavy" organic to distillate liquids to such an extent that a modification of the overall SRC process appeared feasible which would allow the elimination of the troublesome and costly filtration method of solids separation. Instead, solids separation from the reaction product would be accomplished in a much simpler and common commercial processing step -- vacuum flashing -- with the high solids "heavy" organic stream from the bottom of the vacuum flash drum being used as feed to a high pressure gasifier for production of the hydrogen required in the coal reaction area. Subsequent testing has demonstrated the viability of this SRC process modification which is now known as SRC-II. Its use results in the production of a liquid, rather than a solid, as the main product.

Simplified flowsheets of the SRC-I and SRC-II processes are shown in Figure 1. The major differences, as well as the similarities, readily can be seen.

II. FT. LEWIS SRC PILOT PLANT OPERATION

The largest SRC facility is the Government-owned and -funded pilot plant at Ft. Lewis, Washington. Construction was completed in 1974 at a cost of about $21,000,000. It is staffed by 180 Gulf employees.

Since startup in 1974, the plant has enjoyed a high onstream factor. Its major accomplishments to date are:

1. Developed process yield data in both the SRC-I and SRC-II modes of operation sufficient for the design of much larger demonstration plants.

2. Identified process, mechanical, corrosion and erosion problems and determined solutions.

3. Produced solid SRC for small scale combustion tests and 3,000 tons for a large scale test which was completed in early 1977 at Georgia Power Company's Plant Mitchell near Albany, Georgia.

4. Produced about 6,000 barrels of SRC-II fuel oil for a large scale combustion test in a commercial power plant which is scheduled to be conducted this summer. Its main objective is to determine if SRC-II fuel oil will meet the environmental requirements for a fuel for electrical power generation. Encouraging small scale combustion tests already have been performed.

Table 1 shows typical gross yields obtained during SRC-I and SRC-II testing at the Ft. Lewis Pilot Plant. Typical properties of the SRC-I solid and the SRC-II fuel oil produced for the large scale combustion tests are shown in Table 2.

One of the prime objectives in the Ft. Lewis Pilot Plant program for 1978 is to complete the installation and begin testing the Lummus Company's Solvent Deashing process to determine if it is a more viable method of solids separation than filtration.

The work performed at the Ft. Lewis Pilot Plant and the Merriam Laboratory is reported in quarterly, annual and interim Fossil Energy, U. S. Department of Energy, reports (Ref. 1, 2, 3, 4, 5).

III. OTHER SRC DEVELOPMENT

Since 1974, SRC-I process yield studies on several coals also have been conducted on a six-tons per day pilot plant at Wilsonville, Alabama. This plant is operated by Catalytic, Inc.; managed by Southern Company Services, Inc. and funded by Southern, Electric Power Research Institute and the U. S. Department of Energy. The Kerr-McGee Critical Solvent Deashing process will be tested there in 1978 to determine its viability as a method of solids separation.

In addition to the SRC-II development work at the Government-funded Merriam and Ft. Lewis facilities, extensive SRC-II yield studies have been conducted during the past two years with a Gulf-owned and -funded one-ton per day pilot plant at Gulf's Corporate Research Center, Harmarville, Pennsylvania.

IV. HEALTH PROTECTION AND ENVIRONMENTAL MONITORING PROGRAM

A worker health protection and environmental monitoring program has been in effect at the Ft. Lewis Pilot Plant since prior to its startup. It consists of:

1. Periodic physical examination of workers.
2. A worker industrial hygiene program.
3. In-plant monitoring for potentially hazardous materials.
4. Surrounding area monitoring.
5. Toxicological test program with laboratory animals.
6. A trace metals distribution study.

The findings from this overall program should prove to be beneficial in planning for larger SRC and other coal liquefaction plants. Detailed descriptions of the program and data obtained have been published in several Fossil Energy, U. S. Department of Energy, reports (Ref. 6, 7, 8).

V. SRC COMMERCIALIZATION

Gulf's initial SRC commercialization efforts occurred in 1974 when it provided process design support for the conceptual design of an SRC-I demonstration plant utilizing 2,000 tons per day of coal. The conceptual design was performed by Wheelabrator Clean Coal Corporation, utilizing Wheelabrator-Frye's Rust Engineering Co.

In 1975, Gulf decided to concentrate its commercialization efforts on the SRC-II process. Among its reasons for doing so were:

1. Its concern with the many problems associated with filtration.
2. Alternate methods of solids separation were at a relatively early stage of development.
3. Its belief that SRC-II fuel oil would decrease the demand for imported oil while SRC-I solid product provided only an alternate to coal burning with stack gas scrubbing.
4. Its belief that a liquid produced from coal had a greater variety of potential uses than a solid product and, thus, had more long term marketing potential.

In 1975, Gulf, utilizing the services of Stearns-Roger Inc., completed the conceptual design of an SRC-II demonstration plant with a coal feed rate of 6,000 tons per calendar day. In addition, a less detailed conceptual design of 30,000 tons per calendar day commercial plant was completed. Following extensive engineering studies in 1976, these conceptual designs were updated in 1977. Detailed engineering has begun on the demonstration plant and Gulf has proposed to the U. S. Department of Energy that the two parties jointly fund its design, construction and operation. It is being designed so that, after successful demonstration, it can be expanded to commercial size. Several eastern electric and gas utilities are interested in purchasing the products of this demonstration facility at a premium price in order to ensure the development of an alternate fuel supply. Other companies have proposed the design, construction and operation of solid

SRC-I demonstration plants to the U. S. Department of Energy.

The expected ranges of fuel products from Gulf's planned SRC-II Demonstration Plant are shown in Table 3. This product slate is based on minimizing electrical usage and utilizing naphtha and synthesis gas, in excess of that required for process hydrogen requirements, as plant fuel.

In conclusion, the publicly-owned SRC process has been developed over the last sixteen years to the point that demonstration with commercial-sized equipment can and should be conducted which could allow this process to make a contribution to the Nation's domestic "clean" energy production by the late 1980's.

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Table 1. Ft. Lewis SRC Pilot Plant typical yields,[a] wt. % of moisture free coal

	SRC-I	SRC-II
Carbon oxides	1	2
Hydrogen sulfide	1	2
Ammonia	-	1
Water	5	6
Methane - ethane	3	9
Propane - butane	2	5
Naphtha (Pentane - 350°F)	5	8
Fuel oil (350°F - 900°F)	7	28
Organic vacuum bottoms (SRC)	62	27
Unreacted coal	6	6
Ash	10	10
Hydrogen	(2)	(4)

[a] Gross yields before hydrogen production and fuel requirements

Table 2. Typical properties of SRC-I solid and SRC-II fuel oil

	SRC-I Solid	SRC-II Fuel Oil
Composition, wt. %		
Carbon	87.2	86.5
Hydrogen	5.8	8.4
Nitrogen	2.1	1.1
Sulfur	0.75	0.25
Ash	0.15	0.02
Pour point, ^{o}F		-20
Flash point, ^{o}F		>150
Melt point, ^{o}F	335	
Higher heating value, Btu/lb.	16,000	17,300

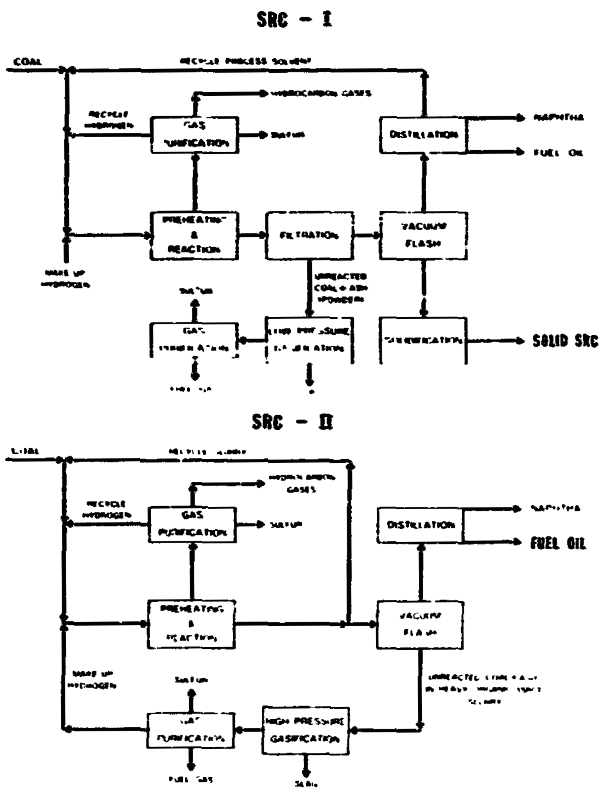

Fig. 1. Simplified SRC Flowsheets

Table 3. Expected range of fuel products from planned SRC-II demonstration plant

	Per Stream Day
Fuel oil, barrels	10,000 - 12,000
LPG, barrels	3,000 - 4,000
SNG, MMSCF	38 - 46