THE PETROSIX PROJECT IN BRAZIL - AN UPDATE

by

Edwin M. Piper
Stone & Webster Engineering Corporation
P.O. Box 5406
Denver, Colorado 80217

and

Osmar Chaves Ivo
Petroleo Brasileiro S.A.
Av. Chile 65
20035 - Rio de Janeiro - Brazil

Abstract. This paper will provide an update about the Petrosix oil shale project in Brazil. The project consists of a pilot plant, a demonstration facility, an 18 ft diameter retort operating commercially and a new 36 ft diameter industrial retort facility under construction.

Besides the update, information and data will be given on fines retorting, fluid bed combustion, operations and economics for Irati, U.S.A. and other oil shales.

Summary

This document provides an update of the PETROSIX project in Sao Mateus do Sul, Brazil. The commercial plant (18 foot diameter retort), called the UPI, has been in operation since 1972 and is no longer considered as developmental. It has operated over 82,000 hours, processing over 4,600,000 metric tons of Irati shale and produced in excess of 1,820,000 barrels of crude shale oil. The longest operating period started November 2, 1984 and was shutdown November 20, 1985 for inspection and routine maintenance. It started up again December 3, 1985.

The PETROSIX facilities, in addition to the UPI, have an 8 inch diameter retort pilot plant, a 6 foot diameter demonstration retort, FBC test facilities and a PLASOL fines retort plant.

Although operating variables influence shale oil production, the quality of an oil shale has a major effect on the economics. The costs of production of the PETROSIX process for a single 36 foot diameter retort industrial plant may vary from as high as $32 per barrel for processing 12-14 GPT oil shale to as low as $13 per barrel for processing 35 GPT oil shale. Economies of scale may improve these costs as well.

Pilot Plant

The PETROSIX pilot plant was designed to simulate the operation of the UPI. It is comprised of all the equipment of the UPI as follows:

- 8 inch diameter retort
- Cyclone
- Electrostatic precipitator
- Recycle gas compressor
- Fired gas heater
- Light oil and water condenser

The plant can process up to 220 lbs per hour of Irati oil shale.

The retort is insulated and electrically traced to operate with minimal heat losses. Throughput rate can be varied and the unit will operate 16-24 hours continuously. The plant is instrumented well to allow control and/or measurement of the main variables which are:

- Oil shale rate
- Hot recycle gas flow
- Cold recycle gas flow
- Amount of heavy and light oil (naphtha) recovered
- Amount of water recovered
- Internal retort temperatures
- Pyrolysis bed pressure drop

The pilot plant has produced a volumes of data on retorting Irati oil shale and this information is used as a comparison and evaluation basis for retorting other oil shales. This unit has successfully retorted eastern Devonion as well as Colorado and Utah oil shales up to 35 gpt. Western oil shale quality up to 63 gpt has been mixed with the 35 gpt shale in porportions of two times its expected percentage and the mixture retorted successfully.

Demonstration facility

The demonstration facility consists of a 6 foot diameter retort which operates in parallel to the 18 foot unit of the UPI. Its purpose has been principally to study the scale up relationships between the 8 inch, the 18 foot and the 36 foot diameter retorts as far as hot solids flow, pressure drop and operability. It has a discharge mechanism with the same components as the larger units but has the minimum of each component.

UPI

The UPI was designed to process up to 2,200 TPD of Irati oil shale and is presently operating commercially at 1600 TPD. The diameter of the retort is 18 feet. The plant facilities, in addition to the retort processing section (same type equipment as pilot plant) is comprised of the following:

- Mining
- Solids handling
- Gas treating and sulfur recovery
- Products storage
- Shale oil dedusting
- Shale oil distillation
- Power house
- Sulfur handling
- Administration, laboratory and support facilities

The UPI was programmed for six-month operating periods and a two week scheduled shutdown. However, because of the experience of minimal maintenance required during shutdown, it is now operating on a yearly basis with a two week scheduled shutdown. The extended continous periods of operation achieved in the UPI are as shown in Table 1:

TABLE 1 UPI OPERATING HISTORY

PERIOD	1972 to 3/1986	11/2/84 to 11/20/85
Hours of Operation	81,500	8,900
Shale Oil Produced (BBL)	1,824,000	285,000
Raw Shale Processed (MT)	4,560,000	597,000
Sulphur Produced (MT)	24,700	8,500

The total operation time up to March, 1986 for principal equipment is shown in Table 2.

TABLE 2 EQUIPMENT OPERATING RECORD

Equipment	Time, Hrs.
Rotary Feeder	52,000
Feed Mechanism	61,000
Hot Gas Injectors	81,500
Discharge Mechanism	81,500
Retorted Shale Removal	49,000
Electrostatic Precipitator	81,500
Gas Heater	81,500
Compressor	81,500

Industrial Plant

Based on the successful commercial operation of the UPI, PETROBRAS decided to complete a basic design and cost estimate of an industrial complex to produce 50,000 BPD of crude shale oil utilizing 20 retorts (36 foot or 11 meter diameter units. Design was based on two stages of 10 retorts each with 9 retorts operating and 1 on standby. Total investment cost of this plant was U.S. $2.2 billion (1981 costs) including a 90 kilometer pipeline to the refinery in Curitiba. Because of the world economic situation at that time, which impacted Brazil, these plans were postponed.

In mid-1982, PETROBRAS decided to build a single industrial plant of 2,600 BPD capacity, having one retort (36 feet diameter), gas treatment and an LPG unit. The unit will be located on the same site as the UPI plant, thereby optimizing use of the infrastructure, offices, shops, laboratory and utilities. Product storage will be increased. Operation is scheduled for mid-1988. Industrial plant data is presented in Table 3 and Investment costs in Table 4.

TABLE 3 INDUSTRIAL PLANT DATA

Mining Capacity	7,800 TPD
Retort Capacity	260 TPH
Low Sulfur Fuel Oil	2,390 BPDO
Naphtha	260 BPDO
Sulfur	52 TPD

TABLE 4 INDUSTRIAL PLANT INVESTMENT COSTS (in U.S. $ x 10^6)

Mining	0.1
Solids Handling	19.4
Retorting	19.7
Gas Treatment	8.4
Oil Treatment	3.2
UPI Adaptations	4.1
Complimentary Items	1.4
Total	56.3

Research Projects

The technical team which has been working many years together is active in areas of acquiring more knowledge on process optimization, products treatment, fines utilization and environmental issues. Two of the projects have important contributions to project economics, FBC and PLASOL (fines utilization).

FBC - Petrobras is interested in fluidized bed combustion for two general reasons. One is to consider FBC to make use of the fines in power generation and two is to have a capability to recover the carbon values of retorted shale for shales that may warrant this treatment such as Moroccan shale with high carbon content and some torbanite residue. Irati and Western oil shales leave the Petrosix process at lower values than justify recovery of the energy, example: Colorado and Utah oil shales have energy values lower than 400 BTU/lb. for the retorted shale and do not justify energy recovery. Petrobras is designing and will build larger FBC facilities to be completed by 1987.

PLASOL - This is an entrained bed indirect heated system to process oil shale fines. At present there is a PLASOL pilot plant which has been in operation since January, 1982. Some main features of the process are:

Shale mass velocity	Up to 6,000lbs/hr/sq.ft
Retorting temperature	Up to 600°C
Solids residence time	10 to 80 seconds
Oil plus gas yield	+ 90% FA
Gas used	Steam, inert gas, recycle gas
Particle size	minus 1.5 mm

The plant is capable of running various shales up to 10 tons per day. PETROBRAS also has a cold flow test apparatus to conduct physical modeling studies and visual observation of flow phenomena.

A larger plant is projected for operation in 1988 which will have a capacity range of 10-25 TPH of oil shale fines.

Petrosix Economics

Brazil expects to produce shale oil from Irati shale for approximately $24-28 per barrel (operating costs). An eastern oil shale project was evaluated for the same size plant as the industrial unit that is being constructed presently in Sao Mateus do Sul, Brazil. Crude shale oil from this plant will be produced for approximately $28-32/barrel (operating costs).

For the same size unit, shale oil produced from the Moroccan Timahdit deposit would cost approximately $28-32 per barrel (operating costs).

An evaluation of duplicate unit for western U.S.A. oil shale resulted in a production cost for crude shale oil of $13-17 per barrel (operating costs) from 35 gallon per ton shale. Table 5 presents costs, investment and production for several projects, all based on the 36 foot diameter retort industrial unit under construction in Brazil.

TABLE 5 PLANT COSTS

	ONE RETORT			
	EAST USA	WEST USA	BRAZIL	MOROCCO
CAPITAL INVESTMENT x10^6$(85)	120	150	70	100
BPD	2,300	5,700	2,600	2,600
PRODUCTION COST,$/BBL	28-32	13-17	24-28	28-32

There are economies of scale in expanding from a single retort to a plant of ten retorts in the areas of mining, retorted shale management and solids preparation, light oil recovery, gas treating, oil cleanup and storage, ancillary facilities (i.e. laboratory, warehouse, etc.), and administration buildings. Table 6 presents the expanded plant costs.

TABLE 6 EXPANDED PLANT COSTS

	TEN RETORTS			
	EAST USA	WEST USA	BRAZIL	MOROCCO
CAPITAL INVESTMENT x10^6$(85)	760	850	1,000	620
BPD	23,000	57,000	26,000	26,000
PRODUCTION COST, $/BBL	22-26	12-16	18-22	20-24

There are also process considerations to improve the economics:

- Firing the recycle gas heater with lower value coal instead of product gas which results in high Btu gas revenue opportunites

- Firing the recycle gas heater with oil shale fines which allows the high Btu gas to be sold as a product and utilizes the total oil shale reserves

These considerations if instituted would lower the required selling price of a barrel of crude shale oil by serveral dollars per barrel.