ZERO CO_2 EMISSION OIL SHALE PROCESS

Jimmy Jia,
Rick Sherritt,
Jim Schmidt
Steve Yeardley

PROCOM CONSULTANTS

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Abstract

Due to the peak production of conventional crude oil and the higher oil price in the last couple of years, shale oil is a possible alternative source of oil in the future. The global shale oil resources could be trillions of barrels but must first be extracted by retorting the rock-liked oil shale. Current retorting technologies generate and emit CO_2 similar to coal-fired power plants. New shale oil projects may need to consider reducing CO_2 emissions to meet future government environmental regulations.

This paper proposes a novel Zero Emission Oil Shale Process (ZEOSP). The concept is to produce shale oil, energy (electricity, steam) and high purity CO_2 from oil shale with near zero emission of CO_2 and other atmospheric pollutants. A mixture of high purity oxygen and CO_2 from flue gas is used in the spent shale combustion instead of air and thus achieves a concentrated CO_2 flue gas which can be captured and stored.

Current existing solid heat carrier oil shale process and vertical gas heat carrier process can be upgraded with the ZEOSP concept. The conceptual process design and operation performance are evaluated by using Oil shale process simulation package on the energy efficiency improvement and sequestration of CO_2 without affecting shale oil yield. Shale oil production cost is analyzed to provide an insight of the economical performance of the technology.

ZEOSP Process Review

The new ZEOSP concept process integrates an air separation unit (ASU) and carbon capture unit into the existing conventional oil shale process which includes solid heat carrier retort technology such as Galoter or ATP process and vertical gas heat carrier retorting technologies such as Petrosix, Kiviter or Fushun retort. The ASU provides oxygen with purity of 95% to the fluidized combustion furnace instead of air. The flue gas from the spent shale furnace is mainly composed of CO2 and H2O (vapor). About two thirds of the flue gas is recycled back to the furnace after passing through the shale dryer and mixed with oxygen from the ASU.
The economical performance of ZEOSP technology application is analysed by comparing with a conventional oil shale retort process in this paper. The reference oil shale retort process was based on the reported existing commercial solid heat carrier retort process and vertical gas heat carrier retort process. The available published process data makes it easily adopted with other unit operation.

Oil Shale Property

Oil shale Physical Property	Grade	LT0M	98.00
	Bulk Density	kg/m3	771.40
	In-situ Density	kg/m4	1700.00
	Void fraction	v/v	0.55
	Particle top size	mm	25.00
Oil Shale Composition (dried shale) (wt%)	Kerogen	wt% db	28.00
	Carbonate as CO2	wt% db	22.40
	Hydrates as H2O	wt% db	0.00
	Ash	wt% db	49.60
Free Water Content in Raw Oil Shale		wt% db	12.36

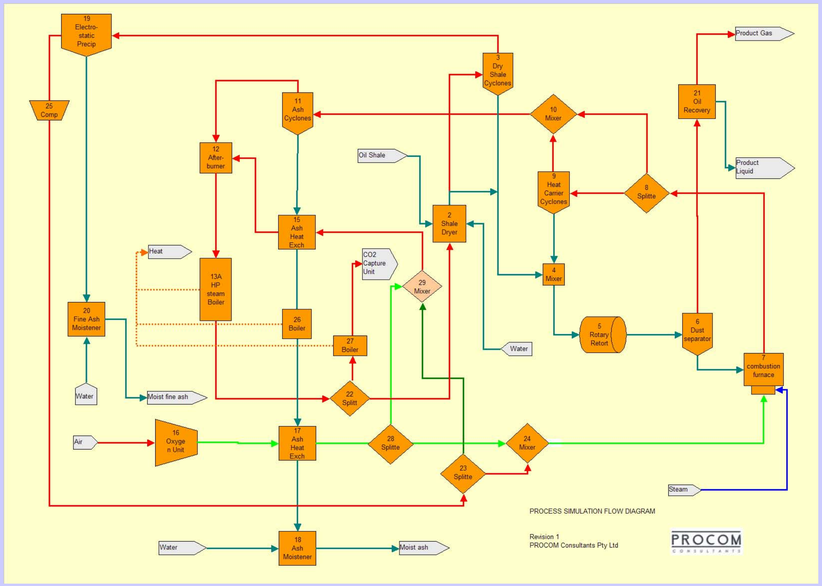


Fig. 1. The ZEOSP technology application in solid heat carrier oil shale process.

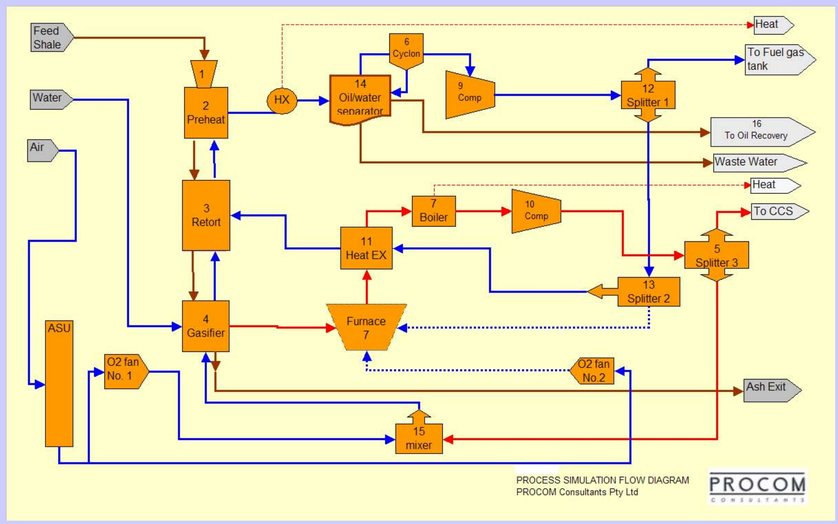
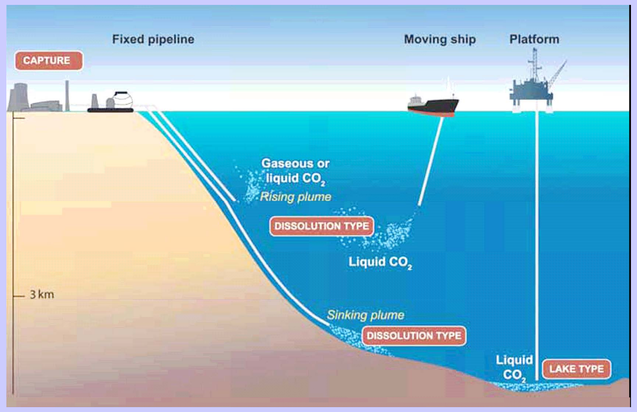


Fig. 2. The ZEOSP technology application in vertical gas heat carrier oil shale process.

CO_2 Ocean Storage Concept



Results and Discussion

Plant performance and costs		Original plant	ZEOSP Plant	
Oil Shale Grade (LT0M)		98	98	
Shale feed rate (t/h)(max)		250	250	
Gross oil product (t/h)(max)		32.5	32.49	
Gross gas product (t/h)(max)		12.9	12.93	
Boiler Power (MW)		22	144.76 (max)	
		Power (MW)	Power (MW)	Cost (US$M)
Flue Gas compresor or Fan	Centrifugal Compressor (MW) (option 1)	0.00	3.05	10.00
	Centrifugal Fan (MW) (option2)	0.00		0.52
Plant Power consumption (MW)				
O2 consumption (t/h)		59.12	59.12	
Operating hours		7500.00	7500.00	
Total Investment cost (US$M)	Shale plant	250.00	250.00	
	ASU	0.00	110.54	
	Flue Gas Scrubber	0.00	-2.00	
Annualized capital cost (US$M)		29.36	42.35	
O&M cost: fixed + variable (US$M/year)	Shale plant	5.25	5.21	
	ASU	0.00	4.42	
	Flue Gas Scrubber			
Annualized O&M cost (US$M/year)		5.25	9.63	
Oil shale cost (US$M/year)		13.13	13.13	
	Mining Cost US$/t	5.00	5.00	
	Crushing Cost US$/t	2.00	2.00	
Total Annualized Cost (US$M/year)		47.74	65.10	
Shale oil cost price (US$/bbl)		30.20	41.19	
Emitted CO2 (t/bbl)		0.21	0.00	
CCS Avoidance Cost (US$/bbl oil)		0.00	5.46	

Table 1. Cost and performance for original and ZEOSP process

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Economical Analysis

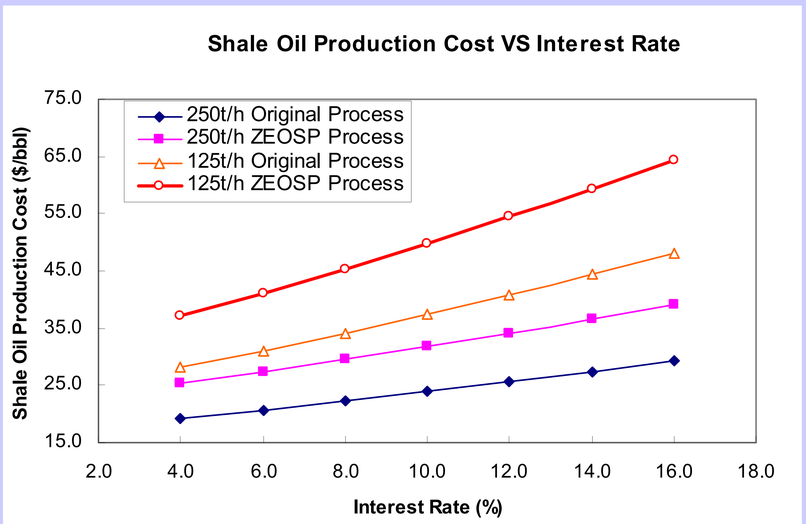

Fig. 3. Shale oil production cost versus interest rate.

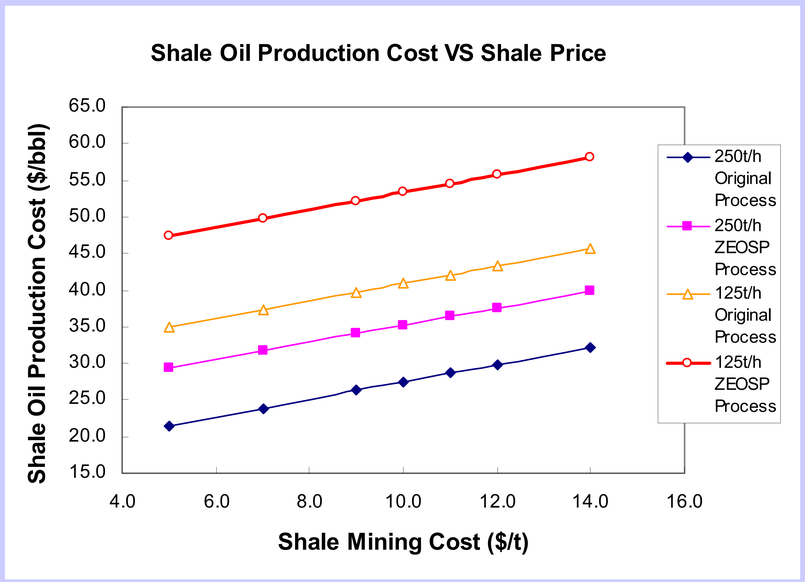

Fig. 4. Shale oil production cost versus oil shale price

Conclusion

- The oil shale process simulation package developed by PROCOM demonstrates the capability in simulation of conventional and new concept of oil shale process. Mass and heat balance through out process streams have calculated. The steady state operation performance in various condition can be well simulated and provides essential information for process optimization or scale up.
- The oxygen combustion technology can be applied to conventional oil shale process to establish a new Zero CO2 emission oil shale process (ZEOSP).
- The shale oil production cost in the ZEOSP is expected to be higher than that in conventional oil shale process with the same feed rate.
- The simulation results showed that the heat efficiency is increased significantly in ZEOSP than that in conventional oil shale process.
- The shale oil production cost decreased significantly with the increase of oil shale feed rate.
- The shale oil production cost versus varied interest rate were analyzed and showed that the shale oil production cost in ZEOSP commercial operation is within the range of $36/bbl ~ $65/bbl for 125t/h feed rate and $25/bbl ~ $39/bbl for 250t/h feed rate.
- The shale oil production cost versus varied oil shale mining cost were analyzed and showed that that the shale oil production cost in ZEOSP commercial operation is within the range of $47/bbl ~ $59/bbl for 125t/h feed rate and $29/bbl ~ $40/bbl for 250t/h feed rate.
- The ZEOSP commercial operation is quite profitable with the current crude oil price in world oil market for the current interest rate and oil shale cost.

PROCOM Contact Details

Office

- **Corporate House**
  Building 6, Garden City Office Park
  2404 Logan Rd
  Eight Mile Plains Qld 4113
  p 07 33405135, f 07 33740695
- 12 Huntingdale Street
  Pullenvale Qld 4069
  p 07 3374 32956, f 07 3374 0695

Office Administrator

- Kylie Rose m 0410 618 499 e kylie.rose@procom-consultants.com

Marketing Support

- Peter Schofield m 0418 154 732 e peter.schofield@procom-consultants.com

Contacts

Jim Schmidt	0418 152 732	e jim.schmidt@procom-consultants.com
Steve Yeardley	0418 987 160	e steve.yeardley@procom-consultants.com
Rick Sherritt	0418 152 732	e rick.sherritt@procom-consultants.com
Jimmy Jia	0418 152 732	e jimmy.jia@procom-consultants.com

PROCOM Consultants P/L

PROCOM Consultants P/L, together with associates, (PROCOM), is a small but dedicated company set up in 2005 following the closure of Demonstration Plant (4,500 barrels per day) on an innovative Oil Shale Process in Gladstone, Queensland, Australia. The collected expertise of that group of specialists who had been involved in the conceptual design, pilot plant development, commissioning, operations and maintenance of this first of a kind plant for over 6 years is now retained in PROCOM.

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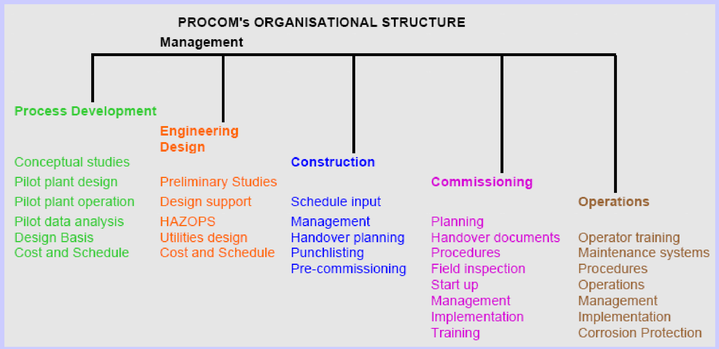

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