SOME IDEAS ON THE DEVELOPMENT OF MAOMING OIL SHALE AND SHALE OIL INDUSTRY

Liang Guopei (梁国培), Shi Guoquan (施国泉) & Yang Yisheng (杨怡生)
(Research Institute of Petroleum Processing, SINOPEC)
Beijing China

ABSTRACT

The recoverable reserves of Maoming oil shale deposits are estimated to be 4.17 billion metric tons. The total area of Maoming oil shale mine covers 360 sq. km among which only 6% is being exploited. Currently the production of shale oil in Maoming accounts for 100,000 tons per annum and the high production cost has retarded the further development of shale oil industry.

Lowering the production cost of shale oil is a prerequisite for enlivening the shale oil industry. It is suggested to utilize comprehensively the organic mass and minerals in oil shale, the kaolinite in the upper layer as well as the underlying peat besides making high value products from shale oil.

INTRODUCTION

The reserves of oil shale in China are estimated to be 400 billion metric tons, equivalent to 100 billion barrels of shale oil. Thus China is ranked as the fourth largest country in oil shale reserves after the USA, Brazil and the USSR [1].

At the early 1950s when the crude oil resources had not yet been exploited in large quantities in China, shale oil together with the Fischer-Tropsch synthesis of liquid fuels and low temperature carbonization of coal were the main sources of syncrude used to make up the gap between the demand and supply of petroleum products inside China. By the end of 1960 the output of syncrude in China tallied a record of one million tons annually, among which 80% was shale oil.

The Maoming oil shale surface mine is the largest ever known in the history since the founding of the People's Republic of China. It was

commissioned in 1958 with a production capacity of 5.0 million tons of oil shale per annum. The accumulated quantity of oil shale excavated till the end of 1986 totalled 100 million tons. The annual production of shale oil in Maoming had once peaked at a level of 184,000 tons and by the end of 1986 the accumulated production of shale oil had reached 2.4 million tons.

THE PRESENT STATUS OF MAOMING OIL SHALE MINE AND SHALE OIL INDUSTRY

The Maoming oil shale deposits underlie the northwestern part of Guangdong Province. The mine is 50km long along the Northwest-Southeast direction and latitudinally 3-10 km wide. The total area of the oil shale mine is 360 sq. km.

The oil shale deposits in Maoming are bedded very closely to the surface and the recoverable reserves of oil shale are estimated to be 4.17 billion tons. Among the six districts of oil shale deposits, only the Jintang district is being stripped with an area of 21 square km or 6% of the total area of Maoming oil shale deposits. The annual output of oil shale in Jintang district amounted to 3.35 million tons in 1986, accounting for less than one thousandth of the total recoverable resources of Maoming oil shale. Lignite, kaolinite, carbonaceous clay, quartz sand and other co-existing minerals are also obtained along with the oil shale.

The oil shale stripped from the Jintang surface mine is used for retorting in the shale oil plant, which runs on two vertical cylindrical retorts with a total capacity of 100,000 tons of shale oil per year. The spent shale ash after retorting is used as a raw material for Portland cement or the clinker for making silicate cement with a strength grade exceeding 400. The shale oil plant, besides producing annually 70,000 tons of cement, also provides about 200,000-300,000 tons of shale ash as the clinker for other cement works. About one million tons of carbonaceous clay (the so-called 'coal mud') is obtained as a by-product of oil shale stripmining. This carbonaceous clay contains significant amounts of organic matter and fixed carbon. It has a heating value of 300-600 kcal/kg and is used as a fuel in the brick-kiln after it is

formed into raw bricks. The kaolinite as a whole has so far not been efficiently utilized, although it is being processed into activated clay in small amounts.

KEY FACTORS AFFECTING THE DEVELOPMENT OF MAOMING SHALE OIL INDUSTRY AND CONCERNED POLICY

The shale oil produced during the retorting of oil shale is marketed as a fuel oil under a price much lower than its production cost. As far as the comprehensive utilization of by-product minerals has not been realized, the Maoming oil shale mine is hit by a financial deficit amounting to tens of millions of yuan per year. This financial difficulty has led to following consequences:

(1) Lack of production development funds which may limit the expansion of the production scale;

(2) Lack of research funds which may suppress technical innovation;

(3) Hampering the comprehensive utilization of coexistent minerals;

(4) Lack of attractiveness for technical-engineering personnel and research workers to devote themselves to oil shale technology.

It is evident from the above-mentioned that the financial aspect of the oil shale and shale oil industry is the key factor determining its future development. As the crude oils tend to become heavier in the future, keen efforts are being waged worldwide for developing heavy oil processing technology. There is not much difference between processing heavy crudes and shale oil judging from the facilities and capital investment required, the production cost and the value of finished products for both cases. The production cost of shale oil (including that for mining and retorting of oil shale) in other countries is estimated to be 29 to 33 US dollars per barrel which greatly exceeds the present price of crude oil, therefore the economic perspective of shale oil in these countries remains uncertain[2]. The cost of Maoming shale oil, on the contrary, is approaching that of crude oil thanks to the inexpensive stripmining of oil shale deposits and thus the shale oil is advantageous in competing with heavy crudes.

In order to utilize the abundant Maoming oil shale reserves and render the shale oil industry more competitive, the Maoming Petroleum Indus-

try Corporation (MPIC) has decided to buy from the Maoming Mining Company 100,000 tons of shale oil annually under a price comparable to that of crude oil in the international market, i.e. 460 yuan per ton of oil. This measure will help the shale oil industry to cut the financial defcit and gain a marginal profit.

Improvement of the production facilities for oil shale mining will make possible the expansion of the oil shale production capacity to a level of five million tons per annum and consequently a further reduction of production cost.

The excessively high content of water (about 17% by weight) in oil shale hinders the amelioration of retorting efficiency making the specific consumption of oil shale as high as thirty tons per ton of oil produced. Pre-drying of oil shale before retorting can reduce the water content to 12%. It is then possible to increase the output of shale oil by some 20,000 tons per year without increasing the number of retorts.

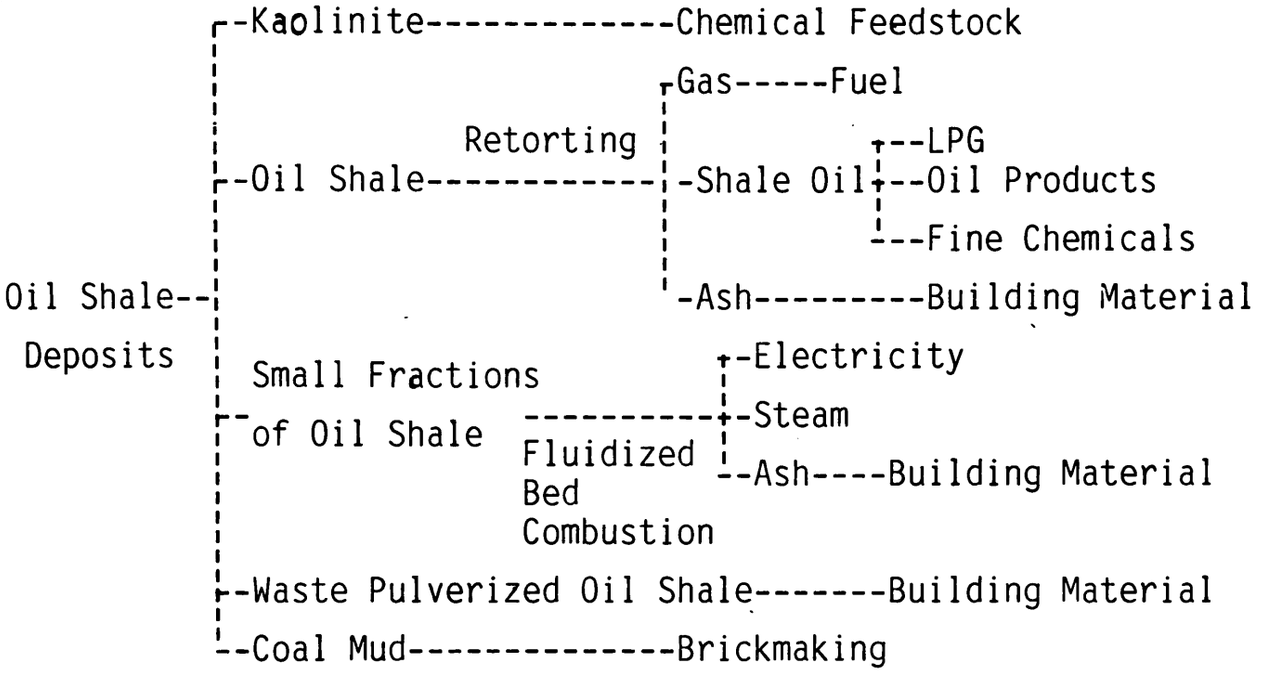
Comprehensive utilization of oil shale is an effective way to improve the economy of shale oil industry. It is suggested to expand the scale of utilizing spent shale ash for cement production. A new cement plant with a capacity of 40,000 tons of cement per year and a brick-kiln with a capacity of 20 million bricks per year are scheduled to be on stream in the near future. Using the oil shale as the fuel for power-plants is a ripened technique. The smaller fractions of oil shale not suitable for retorting can be handled in the fluidized bed combustion furnace to generate steam for electricity. Thus two fluidized bed boilers which consume hourly 35 tons of oil shale fines per unit, coupled with two electric generators with an output of 12 MW each are to be commissioned soon in MPIC. Therefore as much as 350 to 400 thousand tons of oil shale fines will be used annually to generate about 55 million kWh of electricity.

The policy mentioned above will give economic benefits leading to a 40% reduction in the production cost of shale oil and will offer possibility for further development of Maoming shale oil industry.

SOME ASPECTS CONCERNING THE FUTURE DEVELOPMENT OF MAOMING OIL SHALE AND SHALE OIL INDUSTRY

After the Maoming oil shale and shale oil production has been boosted to gain marginal profits it is necessary to set forth future targets toward comprehensive utilization of the minerals coexisting with oil shale and secondary processing of shale oil for high value products.

The development alternatives according to authors' suggestion are presented as follows.



The above-mentioned scheme can be realized in three stages. The first stage is characterized by exploitation of the coexistent kaolinite to cut sharply the cost of shale stripmining so that the oil shale mine can live on its own revenue.

The kaolinite layer in Jintang district, being over ten meters thick, is found to be easy to strip and of good floatability and high quality according to the assessment made by the local geological research institute[3]. The Institute of Papermaking under the Ministry of Light Industry has verified the good physico-chemical performance of refined kaolin as a paper coating agent which has to be importedxfor years under a price of 300 US dollars per ton[4]. This kaolinite is also an excellent raw material for manufacturing petroleum processing catalysts according to the analytical data obtained by the Research Institute of Petroleum Processing (RIPP). It is expected that the exploitation and utilization of kaolinite can give an economic benefit significantly surpassing that provided by the oil shale stripping. A kaolinite mine with a capacity of 100,000 tons per annum will provide after payoff of the capital in-

vestment a revenue somewhat equivalent to the expenditure needed for stripping 3.5 million tons of oil shale. Therefore the cost of oil shale will be remarkably reduced making the oil shale surface mine develop on its own revenues.

At the second stage it is supposed to set up an integrated technology of 'oil shale retorting - power generation - building material production' to cut down further the production cost of shale oil so that the revenues obtained by this integrated technology may pay for the expenditure on shale oil production.

In the overall production cost of shale oil the share of oil shale itself comprises 65%, while the power consumption comprises 17% and other expenses comprise 18%. The implementation of targets in the first stage will result in a meaningful reduction of the production cost on oil shale and consequently as much as 40% cut in the production cost of shale oil is possible. The further improvement of retorting technology to utilize gas recycling in the retorts will lower the specific oil shale consumption from 30 tons to 20-25 tons of oil shale per ton of shale oil produced. Recovery of the gas from the retorts may contribute to a further 10% cut in shale oil cost. Meanwhile, it is possible to utilize the granular oil shale, rejected by the vibrating screens before entering the retorts, in fluidized bed combustors for steam or power generation. It is able to run three boiler-generator units with a capacity of 35 tons of steam for each to make the retorting process self-sufficient in steam and electricity. It is also projected to install three additional boilers with a capacity of 130 tons of steam per hour for each, coupled with dynamo units to generate electricity for sale to other users and the electrical power generated may amount to 600 million kWh annually. Additional revenues may stem from the Portland cement and building blocks made from spent shale ash. Therefore it is evident that the economic benefits of sideline production after paying back the capital loans may compensate for the expenditure on the production of 120,000 tons of shale oil.

At the third stage the shale oil plant will be confronted with a need to explore techniques of upgrading of shale oil to enhance the economy of shale oil production. Although the physico-chemical proper-

ties of shale oil are close to those of crude oil, its nitrogen content is much higher rendering the processing of shale oil more complicated. At present time the raw shale oil is being marketed merely as a fuel oil. Only deep processing of shale oil to produce oil products meeting the market needs can raise the economical value of shale oil. Advanced techniques such as hydrocracking and catalytic cracking are considered to be suitable for upgrading of shale oil. The hydrocracking process can produce premium quality products but its economics remain prohibitive due to its high investment and high production cost. The catalytic cracking technique, however, is popular and economically justified in China. Recently a new catalytic cracking process aimed at boosting the output of gas as well as gasoline has been developed by RIPP. This process can yield as high as 50% gas and 20% naphtha. Since Guangdong Province is experiencing a sharp shortage of energy including city gas and gasoline, the upgrading of shale oil may contribute at some extent to the alleviation of these difficulties. Catalytic cracking of shale oil tends to be promising in producing high quality products and creating economic benefits comparable to those obtained from the processing of crude oil with regard to revenues on the same weight base of feedstock.

CONCLUSION

It is expected that the above-mentioned ideas on the future development of the shale oil industry are technically feasible, economically beneficial and realistic from the standpoint of resources. The realization of the new scheme will offer vast possibility of developing the Maoming shale oil industry and in the meantime serve as an example for the innovation of shale oil processing technology worldwide.

REFERENCES

1. Hou Xianglin (editor-in-chief), 'The Chinese Shale Oil Industry', the Petroleum Industry Press, August 1987.
2. Hou Xianglin, Petroleum Refining (in Chinese), 1987, No. 9, pp 1-7.
3. The Guangdong Geological Testing Centre, 'Report on Study of the Physical Properties and Assessment of Jintang Kaolinite in Maoming (in Chinese)', July 1987.
4. The Research Institute of Papermaking, 'Report on the Assessment of Jintang Kaolinite Sample used for Paper Coating (in Chinese)',July 1987.