OIL SHALE RETORTING TECHNOLOGY IN MAOMING

Lin Yihe (林怡和)
Maoming Petroleum Industrial Corporation, SINOPEC
Maoming, China

ABSTRACT

Two batteries of 48 gas combustion rectangular retorts and two batteries of 64 cylindrical retorts, were established in sixties for processing Maoming oil shale with high moisture and low Fischer assay. Rich operation experiences have been accumulated. Study on improvement of retorting technologies is under way.

INTRODUCTION

The proven oil shale reserves in Maoming area give a shale oil equivalent of several hundred million tons. Maoming Petroleum Industrial Corporation began research & development of various retorts in mid-fifties. An internal-heating cylindrical retort (Maoming cylindrical retort) of 180t/d throughput and related shale oil processing equipment were built up in March 1958. A gas combustion rectangular retort of throughput 96 t/d (Maoming rectangular retort) was built up in December 1958. Another gas combustion rectangular retort of throughput 180 t/d (Maoming rectangular retort), and jalousie-type retort were built up in November 1959. Testing was made on these retorts in a period of four years. The oil yield (against Fischer assay) of Maoming cylindrical retort, and rectangular retort reached 74%, and 85% respectively. Based on the data from the test retorts, two batteries of 48 gas combustion rectangular retorts of total capacity of 100,000 t/year shale oil and an open pit mine of an equivalent oil shale production were established in early sixties. In late sixties and early seventies two batteries of 64 cylindrical retorts of total capacity of 100,000 t/year shale oil and oil shale mine were added. This paper gives a description of commercial scale retorting plants and the properties of shale oil produced.

COMMERCIAL SCALE RETORTING PLANTS IN MAOMING

The commercial scale retorting plants discussed include rectangular retort and cylindrical retort.

1. Maoming rectangular retort

The retort structure is shown in Fig. 1.

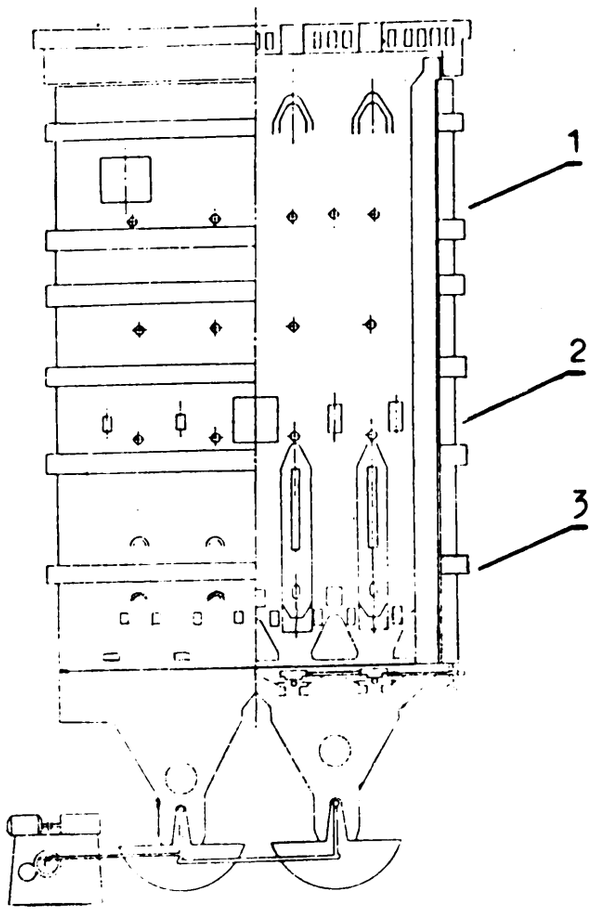

Fig. 1 Maoming rectangular retort structure

1--Pyrolysis section; 2--gas combustion section;

3-- cooling section.

After crushing and screening, oil shale of lump size 15-75 mm is transported by a belt conveyer to the shale bin at the top of the retort, and then fed into the retort by a charger. Oil shale is redistributed on passing an archway. Drying and retorting of oil shale take place in the pyrolysis section heat transfer between oil shale and hot heat carrier gas from the gas combustion section. Retorted shale char descends to the gas combustion section, where gasification of shale char with preheated gas and air takes place.The heat released in gasification raises the temperature to about 1,000 °C. Shale ash is cooled by incoming cold gas in the cool-

ing section to lower than 300°C and then pushed out into the ash trough, where it is further cooled by water to about 70°C and discharged by a scraper.

An excess of cold gas is introduced into the retort to keep the combustion temperature in the gas combustion section lower than the fusion point of shale ash, thus in turn preventing sintering of shale char.

The condensation and oil recovery system for Maoming rectangualr retort is shown in Fig. 2.

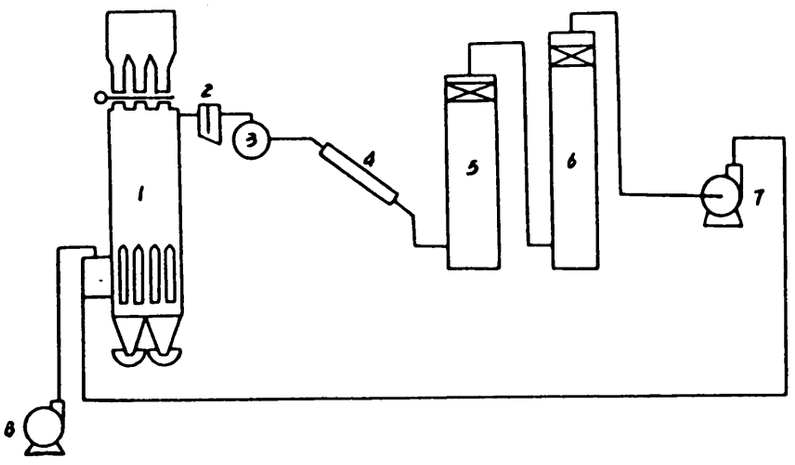

Fig. 2 The condensation system for Maoming rectangular retort

1--retort, 2--water seal, 3--gathering pipe, 4--scubber pipe, 5--ammonia tower, 6--cooling tower, 7--gas exhauster, 8--air blast blower.

The gaseous product from the retort is drawn into the gathering pipe at 90-100°C, and spray-cooled by recycling dilute ammonia water. The entained dust is removed and large part of shale oil is condensed. The gas temperature is lowered to 72-77°C after spray washing. The gas is further cooled by recycling water in scrubber pipes and some more shale oil is recovered. Then ammonia is recovered in ammonia absorber. The gas passes through a cooling tower for condensation of oil vapor and is coóled to about 45°C. Then gas passes to an exhauster. Most of the gas is sent back to teh retort as combustion gas and cooling gas. The balance is vented to atmosphere through a stack. Separaters and recycling pumps are installed in the condensation-recovery units.

The throughput of one rectangular retort is 160-200 t/day (on wet basis of oil shale) with cross sectional intensity of 400-500 kg/m²hr.

The retort effluents are in Table 1.

Table 1. Retort effluents (rectangular retort)

Shale oil kg/ton shale			50
Oil yield against Fischer Assay, %			70
Gas naphtha, g/Nm³			8
Ammonia, g/Nm³			1.5
Hydrogen sulfide, g/Nm³			4.4
Surplus gas, Nm³/ton shale			385
Heating value of gas, kcal/Nm³			605
Gas composition			
CO_2 %	14.2	H_2 %	8.6
C_nH_m %	0.2	CH_4 %	1.9
O_2 %	0.9	N_2 %	67.8
CO %	6.4		

Shale oil produced in Maoming rectangular retort is a brownish black paste at room temperature, with pungent odor. It belongs to the paraffinic oil, with more paraffin and less asphalt. The oil properties are listed in Table 2.

Table 2 Maoming shale oil properties (rectangular retort)

Specific gravity, D_4^{20}		0.9278	
Solidification point, °C		32	
Kinematic viscosity, centistokes 50°C		10.1	
Engler distillation		Elemental analysis	
IBP °C	219	C %	84.18
10 % °C	273	H %	11.54
20 % °C	296	S %	0.50
30 % °C	321	N %	1.08
40 % °C	342	O %	2.70
50 % °C	362	C/H	7.29

2. Maoming cylindrical retort

Maoming cylindrical retort is developed on the basis of Fushun-type retort, with an external mixing chamber in the middle for circumferential gas intake (Fig. 3).

Pyrolysis and gasification take place in the same retort. Shale char after pyrolysis goes for gasification, the sensible heat of gasification gas provides for the part of heat required in pyrolysis. The remaining heat comes from the hot recycle gas, which is the gas produced in the re-

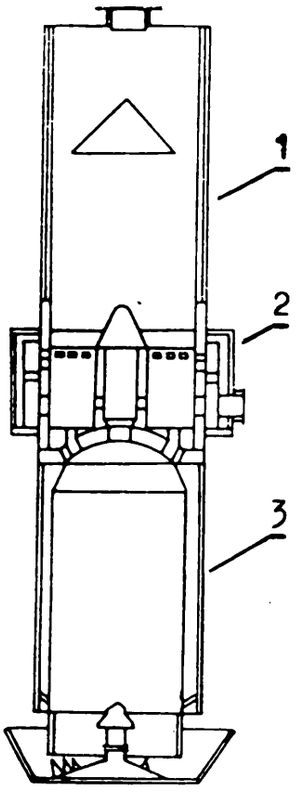

Fig. 3. Maoming cylindrical retort structure
1--pyrolysis section; 2--mixing section;
3--gasification section.

tort inself, heated to 600-650°C in a regenerative heater. Hot recycle gas enters the retort from the middle, mixed with the gas from the gasification section to exchange heat with down-moving oil shale. Drying, preheating and pyrolysis of oil shale take place in the pyrolysis section. Pyrolysis comes to completion as shale descends to the central arch at 600 °C. Oil vapor from the decomposition of organic matter in oil shale is drawn out from the top of the retort along with the heat carrier gas. As shale char moves downward into the gasification section, the reaction temperature can be as high as 1,000°C. The air blast is humidified to control this temperature below the fusion point of shale ash. Humidification is achieved through passing air blast in a saturator in contact with hot water and additional steam supply.

The moisture content of Maoming oil shale amounts to 12-24%, averaging 17% (wet basis). The moisture evaporated increases the amount of gaseous product, the heat carrier gas is also increased accordingly. An external mixing chamber is designed to lower pressure drop due to excessively high

flow resistance.

Disintegration of Maoming oil shale during retorting causes smaller voids among the shale lumps and in turn higher resistance to gas flow. Channelling through the space between retort wall and shale charge may result in uneven distribution of gas flow. Therefor many gas intake holes are provided on the three legs of arch in the middle section of the retort it enables more or less even flow of the heat carrier gas.

The condensation and oil recovery system for Maoming cylindrical retort is shown in Fig. 4.

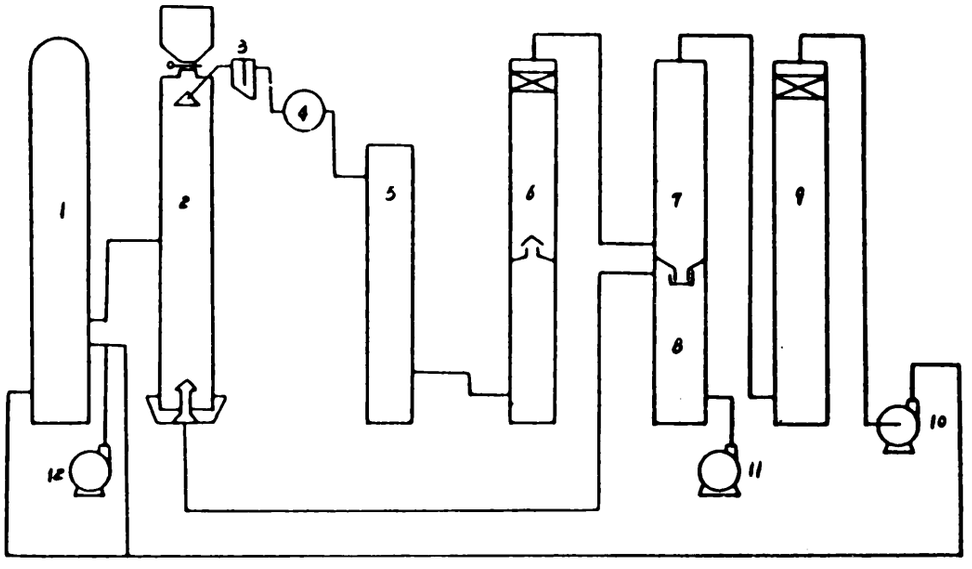

Fig. 4. The condensation system for Maoming cylindrical retort

1--recuperative heater, 2--retort, 3--water seal, 4--gathering pipe, 5--srubber, 6--ammonium sulfate tower, 7--precooler, 8--saturator, 9--final cooler, 10--gas exhauster, 11,12--air blast blower.

The gaseous product is drawn from the retort at about 100°C into the gathering pipe, where it is spray-washed and cooled to 73-76°C by recycling dilute ammonia water to remove dust and condense part of the shale oil Some ammonia water, shale oil and shale dust turn into oil sludge and is separated in the sedimentation tank.

The gas is further cooled by recycling water in scrubber and some more shale oil is recovered. It then passes through a precooler, which is installed coaxially above the air saturator. Recycling cooling water of 66 °C is used to cool the gas to 71-72°C. Cooling water at 72-73°C overflows

through the water seal between the two towers into the air saturator, where air blast is heated and humidified to a dew point of 66-68°C. The recycling water temperature from the saturator drops to 66°C. Shale oil condensed is separated in the saturator tank.

The gas after precooler is sent into the ammonia absorber, where sulfuric acid solution is used to absorb ammonia.

The gas after ammonia recovery passes through a final cooler, where it is spray washed by 35-40°C cooling water and cooled to 45-50°C. Part of shale oil is recovered in the final cooler. An exhauster is installed after the final cooler. About 77% of the gas is heated in a regenerative heater and serves as heat carrier for retorting, the remaining gas is used as heater and boiler fuel. A natural draft cooling tower is used in circulating cooling water.

The operation parameters in recent year are listed in Table 3, the retort effluents in Table 4.

Table 3. Operation parameters of Maoming cylindrical retort

Throughput, t/day, retort (wet basis)	135-155
Cross section intensity. kg/m² hr	638
Shale size, mm	12-125
Shale moisture, % (wet basis)	16-17
Fischer assay, % (wet basis)	6.5-7
Oil yield vs. Fischer assay (not including gas naphtha), %	60-65
Air flow rate, Nm^3/ton shale	132
Recycle gas, Nm^3/ton shale	953
Recycle gas temperature, °C	586
Air blast saturation temperature (dew point), °C	65
Retort exit gas temperature, °C	95-100

Table 4. Retort effluents from Maoming cylindrical retort

Shale oil, kg/ton shale				40-45
Gas naphtha, g/Nm^3				9
Ammonia, g/Nm^3				1.8
Hydrogen sulfide, g/Nm^3				4.5
Surplus gas, Nm^3/ton shale				15-30
Heating value of gas, kcal/Nm^3				1400-1500
Gas composition			CO %	3.7
CO_2 %	18.3		H_2 %	18.2
C_nH_m %	1.5		CH_4 %	7.3
O_2 %	0.4		N_2 %	50.4

As compared with the shale oil produced in Maoming rectangular retort, the shale oil from cylindrical retort has a smaller specific gravity and lower solidification point, its properties are listed in Table 5.

Table 5. Maoming shale oil properties (cylindrical retort)

Specific gravity D_4^{20}					0.9122
Solidification point, °C					30
Kinematic viscosity, centistokes 50°C					9.6
Paraffin content, %					13.2
Asphalt content, %					1.54
Gum (sulfuric acid), %					43
Carbon residue %					2.2
Tar acid, % (vol)					2.8
Engler distillation			Elemental analysis		
IBP	°C	214	C	%	84.82
10 %	°C	259	H	%	11.40
20 %	°C	283	S	%	0.48
30 %	°C	306	N	%	1.10
40 %	°C	330	O	%	2.20
50 %	°C	350	C/H		7.40

Rich operation experiences have been accumulated in the research and development of oil shale retorting technology in Maoming for the 30 years since 1958. However, there are some weak points in cross section intensity and oil yield as compared with the world state-of-the-art technology. A study for upgrading retorting technology is now under way in a newly-built testing cylindrical retort.

1. Addition of pre-drying facility. Oil shale charge is to be dried before entering the retort.

2. New retorting technology

The gas after final cooler will all be used for recycling to supply the retorting demand to the greatest possible extent. The burning loss of shale oil produced will be minimized.

3. Improvement of condensation-recovery system

From the analysis of shale ash from the cylindrical retort, almost no oil can be found in shale ash. The shale oil loss can be ascribed to gas inclusion, emulsified oil and oil sludge, in addition to burning in the retort. Improvement of concensation-recovery system will contribute to raising oil yield.

CONCLUSION

The Maoming rectangular and cylindrical retorts are characterized by simple structure, capability of processing oil shale with high moisture (20%), low Fischer assay (4-6%), and low organic carbon (4-8%) in shale char while maintaining heat self-sufficiency. These two types of retorts have been operated for more than 20 years. They are easy to operate in a long period. The burning of shale oil in the gasification section remains to be solved.