TECHNICAL FEATURES OF FUSHUN-TYPE RETORT TODAY

Wang Xigui (王锡珪) Huang Guizhen (黄桂珍)
Fushun Petrochemical Corporation, SINOPEC
Fushun, China

ABSTRACT

Fushun-type retort today has evolved in about 40 years of development after the founding of PRC. Its technical features are long on-stream period, short start-up time, adaptability to a variety of raw shale, little mechanical impurities in the product-shale oil, self-sufficiency in heat supply in retorting low-grade oil shale (limiting Fischer assay 6%).

INTRODUCTION

Shale oil industry in Fushun has a 60 year history since its beginning in 1928, and has accumulated valuable experience in technology. Fushun-type retort was established in the period from 1928 to 1945. The founding of PRC in 1949 opened a period of developing retorting technology. An improved retort of 200 t/d throughput was developed. Oil yield reached 80% (including gas naphtha), shale utilization reached 85%, on-stream percentage more than 95%.

Fushun-type retort has been proved in production practice to be simple in structure, easy to operate, of long equipment life, readily maintainable, self-sufficient in heat supply when retorting oil shale of Fischer assay over 6%. It is a retort of matured technology and technical reliability.

PRINCIPLE OF FUSHUN-TYPE RETORT

Fushun-type retort is an internal heating retort incorporating an upper pyrolysis section with a lower gasification section. Shale charge of 8-75 mm is fed to the top of retort, moves downward by gravity and undergoes pyrolysis and gasification. Spent shale is discharged continuously from the bottom shale ash trough. Air blast saturated with moisture enters the retort bottom and reacts with shale char to form producer gas. This gas mixes with hot recycle gas from regenerator in retort middle and flows upward into pyrolysis section to supply the heat required for retorting. Pyrolysis products along with heat carrier gas is drawn from the top gas gathering cone into condensation recovery system. The schematic drawing is shown in Fig. 1.

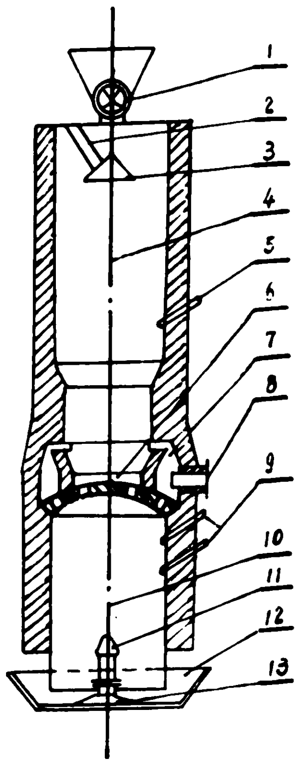

Fig. 1. Fushun-type retort
1-- shale feeder; 2-- gas exit; 3-- gas gathering cone;
4-- pyrolysis section; 5-- thermocouple; 6-- arch;
7-- mixing chamber; 8-- hot recycle gas entry;
9-- thermocouple; 10-- gasification section; 11-- tuyere;
12-- ash trough; 13-- ash discharge.

Heat exchange between heat carrier gas and oil shale lumps ensures effective heat utilization. Heat balance of retorting Fushun oil shale based on production data for the first quarter of 1987 is shown in Table 1.

Table 1. Heat balance of pyrolysis in Fushun-type retort (1st. quarter of 1987)

Basis: 1,000 kg shale

Heat consumption	kcal	%	Heat supply	kcal	%
Shale pyrolysis	227,000	78.5	Gas from gasification section	89,000	30.8
Gas leaving retort	50,000	17.3	Steam from gasification section	100,000	34.6
Heat loss	12,000	4.2	Recycle gas	100,000	34.6
Total	289,000	100.0	Total	289,000	100.0

TECHNICAL FEATURES

1. Long on-stream period, more than 180 days of continuous operation for a single retort

In the early days the on-stream period was very short. Shutdown for clearing clinkering often happened, some retorts operated with caking troubles, the average on-stream period every year was only 38 days for a single retort.

When the temperature of the gasification section got higher than the softening point of shale ash (>1000°C), the extreme case would cause softening and clinkering of a large amount of shale ash, thus resulting in the interruption of operation due to disfunctional ash discharge. Sometimes ash discharge from ash trough was not discontinued, but local overheating due to slanted combustion surface resulted in caking of some shale ash.

After the founding of PRC, hydraulics modeling was made to achieve even distribution of temperature in retort. An improved retort with central arch structure and widened waist was developed. Adjustment of the ratio of heat supply in gasification and pyrolysis section, higher moisture saturation in air blast, control of outlet temperature of gaseous products and instrumentation of pyrolysis process eliminated stoppage due to clinkering. Caking troubles were also greatly lessened. The average on-stream period every year for one retort reached 180 days, and oil yield increased by 5%.

2. Simple start-up technique

In the past, start-up of a retort consumed a large amount of firewood. It took about 7 days from ignition of firewood to normal operation.

In late fifties flue gas from gas burning heater was passed into the bottom of pyrolysis section loaded with oil shale. Flue gas temperature was controlled at about 650°C. As oil shale was heated up, air blast was introduced into retort bottom to initiate retorting operation. This start-up method with flue gas saved firewood, simplified process, improved working condition, and more importantly, start-up took a much shorter time, only 16 hours from switching on flue gas to normal operation, one tenth of the time before.

3. Flexibility in processing various oil shale

(1) Low-grade oil shale

The oil shale processed in Fushun-type retort has a lower limit of Fischer assay 4.75% but no restraint on its upper limit. From the view point of heat supply and economics, for oil shale with average Fischer assay above 6%, the operation can be self-sufficient in heat supply and is economically justifiable. The retort can be operated at higher shale input, with increased air blast and the fixed carbon in shale char can be well utilized. For oil shale with Fischer assay below 5.5%, retorting can be self-sustainable by increasing the ratio of heat supplied to pyrolysis section, but it is not economically justifiable. For oil shale with Fischer assay below 5%, the heating value of gas produced is too low to sustain retorting, operation is possible only with burning gas or fuel oil from outside.

(2) Thermally disintegrable oil shale and oil shale with high (16-22%) moisture content

Retorting is possible by increasing the heat supply and the ratio of heat supplied to pyrolysis section and maintaining a constant combustion layer temperature.

(3) High carbonate oil shale

For oil shale with high carbonate content (20% in terms of CO_2), satisfactory retorting can be achieved by adjusting operation parameters and wet discharge of shale ash can be normally used.

(4) Lump shale of 8-75 mm can be processed with shale utilization 85%.

4. Fast and effective inspection

Assessment of retorting performance is a complicated and difficult matter. It has been found from production practice that the deposits on sheathed temperature sensor at the retort outlet are closely related to shale oil production. Inspection of the outlet deposits provides an effective, comprehensive and fast determination of retorting performance.

5. Little mechanical impurities in shale oil

The outlet temperature of Fushun-type retort is controlled no higher than 100°C, during heat exchange between upflowing gas and new shale charge, an oil water film is formed on the surface of oil shale under gas gathering cone, preventing the entrainment of shale dust. The retorting gas leaving the retort into condensation recovery system is washed directly by hot recycle water to separate mechanical impurities. Quality shale oil is obtained after warming-up, sedimentation and separation. The mechanical impurities content is below 0.006%.

6. Self-sufficency in energy requirement

The fixed carbon in shale char can be well utilized in Fushun-type retort. For each ton shale oil produced, the total heat of the gas produced is sufficient to support heating recycle gas, the surplus heat is still more than enough to compensate energy consumption in water, electricity and steam used in retorting plant.

7. Simple structure, easy construction

The retort and equipments are simple and do not need special materials. Retort construction is also not complicated. It is noted for long service life and technical reliability.

OUTLOOK

Fushun-type retort today has evolved in sixty years of operation with new technical features. The disadvantages are low single retort throughput, exclusion of shale particles below 8 mm, unsatisfactory oil yield. An improved version of Fushun-type retort with higher throughput and higher oil yield can be developed by further research in the following aspects: better distribution of shale charge and gas flow, uniform descent of shale charge, improvement of condensation recovery system, use of electrostatic deoiling precipitator, recovery of gas naphtha, adjustment of heat supply, lowering pressure drop in retort, burning shale particle below 8 mm in ebullated bed boiler, etc.