

SIXTY YEARS OF OIL SHALE RETORTING
INDUSTRY IN FUSHUN

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ABSTRACT

Oil shale retorting industry in Fushun dated back to 1928 and has been operating for 60 years, 1928-1949, build-up of retorting industry, 1949-1960: development of retorting technology, 1960 to present, comprehensive utilization of oil shale. The annual shale oil production reached a maximum of 257,000 tons in 1942, a hallmark of industrial operation. Since the founding of PRC in 1949, retorting technology had been developed considerably and the annual production topped 780,000 tons in 1959. In the fifties shale oil accounted 30-50% of the total oil production and played an important role in economy and defense in China. Since the drastic increase of crude oil production in the sixties, comprehensive utilization of oil shale has got due attention and upgrading of technology has been pursued to develop this alternate energy. Six decades of operation in Fushun can be ascribed to rich resources, matured technology, economical justifiability and great demand. In these sixty years, large amounts of shale oil, gasoline, kerosene, diesel oil, lubricants, paraffin, oil coke, ammonium sulfate, etc have been produced. A much brighter prospect is ahead for the oil shale retorting industry in Fushun.

BUILD-UP OF OIL SHALE RETORTING INDUSTRY

Rich resources of oil shale have been found in Fushun area. Oil shale deposits of 5.4 billion tons with average Fischer assay 5.5% exist in formations of 135 m thickness and 2 km width, 17 km length. The total heating value is equivalent to that of one billion tons of coal. Moreover, oil shale formation lies over coal layer and is first stripped before open pit mining of coal. The exploitation cost of oil shale is

fairly low. Oil shale retorting in China was reported long ago. A document of the Ministry of Agriculture and Commerce in 1912 recorded oil shale retorting research in Northeast China by two Chinese for ten more years. The immediate cause of establishing retorting industry was to meet the political and military purpose of Japanese occupationists. Northeast China fell under Japanese influence after Japan-Russian War in 1905. The shale in Fushun was to satisfy further warfare needs.

From October 1925 to April 1927, pilot tests of 7 t/d, 10 t/d, 40 t/d were made in Fushun, giving oil yield of 90% (against Fischer assay) and 10.9 kg ammonium sulfate per ton shale. Based on the above data, internal heating retort of daily throughput 50 tons was designed in 1928, and 80 Fushun-type retorts were built and commissioned in 1930. In the initial stage low throughput and abnormal operation resulted in losing business. Starting from 1933 retort throughput was doubled to 100 t/d. In 1939 sixty retorts of daily throughput 180 tons were built. In 1945 sixty retorts of daily throughput 200 tons were built in another factory in Fushun. At this point oil shale retorting came to industrial operation. The peak annual output before 1942: shale oil 257,000 tons, ammonium sulfate 32,000 tons, wax 40,000 tons, oil coke 16,000 tons, gasoline 11,000 tons, diesel fuel 120,000 tons.

DEVELOPMENT OF RETORTING TECHNOLOGY

The retorting plants were devastated by war in 1943-1948. At the founding of PRC in 1949, the total oil output (crude oil plus shale oil) in China was 120,000 tons, and shale oil production in Fushun amounted 50,000 tons, 41.7% of total oil output. Shale oil played an important role in crude oil deficient China. Restoration and development of retorting industry was sped up. In the fifties shale oil accounted for 30-50% of total oil output.

1. Technical restructuring and expansion was carried out after restoration of production.

An eighth battery of 26 retorts of daily throughput 200 tons each were built in Refinery No. 1, additional 80,000 to 90,000 tons shale oil were produced. Six gas naphtha recovery units were built in Refinery No. 1 and three units in Refinery No. 2 in 1957, recovery of

gas naphtha amounting to 100,000 tons. In 1959 forty retorts with pre-heat, daily throughput 275 tons were built in Refinery No. 2. At that time the shale oil production reached 780,000 tons, more than triple 1942 output.

2. Better utilization of raw shale for retorting

The shale size for retorting was 20-75 mm, only 60-65% of raw shale could be utilized before 1949. After 1949 the shale size was changed to 8-75 mm. In order to solve solids segregation and improve uneven gas distribution, shale fractions of 8-35 mm and 36-75 mm were retorted separately. The wall effect was lessened, heat supply to the center was increased, good gas flowability and even heat distribution were achieved. Shale utilization was increased from 65% to 85%, shale consumption was cut from 34 tons to less than 30 tons for each ton shale oil produced.

3. Improvement of retort structure to achieve better distribution of shale charge and gas flow.

Four-way and two-way feed distributors were installed in 100 tons retorts. Rotary automatic distributor was installed in 180 tons retort. Central arch was added to each retort. Even distribution of shale charge leveled the combustion surface and the radial temperature difference in pyrolysis section decreased from 300°C to 50-100°C, the temperature difference between outer and inner sides in the gasification section decreased from 400°C to 100°C.

4. Improvement of operation.

Ignition with gas in retort saved 20 tons firewood and 150 workdays for each battery of retorts, and shortened ignition start-up by 152 hours. The heat supply for retorting and heat intensity were raised, and the heat supply ratio in gasification and pyrolysis sections was adjusted. The heat supply for each ton oil shale was increased from $22-23 \times 10^4$ kcal to $24-25 \times 10^4$ kcal, the highest 27×10^4 kcal, heating temperature was raised from 550°C to 700°C. The heat supply in the pyrolysis section was increased from 30% to 35%. The residual oxygen content was lowered. Less clinkering resulted in longer on-stream period. The conversion of nitrogen in oil shale into ammonia was raised from 50%

to 55%.

5. Better instrumentation and control were achieved.

Modern instrumentation and analysis control eliminated manual detection with poking. Labor intensity was lessened and working condition was improved. One worker operates 20 retorts instead of 5 in the past.

COMPREHENSIVE UTILIZATION OF OIL SHALE

In the sixties oil exploration in China provided considerable amount of proven crude oil reserve. Oil production increased drastically with the development of Daqing Oil Field. Crude oil output increased from 120,000 tons of 1949 to 21,750,000 tons in 1969, shale oil amounted to 780,000 tons, only 3.6% of total output. Under this situation, retorting industry in Fushun turned to comprehensive utilization of oil shale for reasonable utilization of resources and improvement of environment.

1. Utilization of particulate shale.

In the 60's particulate oil shale was retorted. Some success has been achieved. In 1986, an ebullated bed boiler burning shale particles below 10 mm was built in Refinery No. 2, rated steam pressure 35 kg/cm², steam temperature 450°C, capacity 35 tons steam per hour. Normal combustion can be obtained using Fushun oil shale only (Fischer assay 6%, heating value 1200 kcal/kg), bed temperature 850-950°C, steam generation 1-1.2 tons per ton shale, SO_x, NO_x contents meet environmental standards. Trial operation is under way.

2. Utilization of shale ash.

Retorting shale ash is used as backfill material in coal mines to 75% of total ash. As compared with river sand, its cost is one fourth, shale ash has a small specific gravity, better perviousness, is favorable to roof maintenance and safety. Besides, shale ash can be used to make pozzolanic cement and as filler of railway bed.

3. Closed loop recycling of retorting waste water.

Retorting waste water contains a large amount of oil, S-compds., phenols and COD. Sedimentation, oil interception, filtration, dephenolization are used for waste water treatment. Treated waste water can be used for cooling spent shale in gasification section. Basically no retorting

waste water is discharged.

4. Sludge disposal.

Oil sludge of high dust content is mixed with about 10% water and separated by centrifuge to recover oil and water, the dry mass is sent to retort. Emulsified oil formed in oil water separation is treated with acid deemulsification, thermal deemulsification, or burned in the gasification section of retort to reduce pollution.

5. Dust control in crushing.

Multi-tube dedusting, electrostatic separator, dust settling pocket are used in Refinery No. 1 and No. 2. The dust content in dust source decreases from 3,000 mg/m³ to 2 mg/m³. The worst case is still no greater than 10 mg/m³.

Brick making with shale fines, ceramsite production with particulate shale, generation of steam by gas burning have also been successful.

Sixty years of retorting industry in Fushun can be ascribed to rich resources, easy exploitation, matured technology and preferential policy, so the shale oil industry is economically profitable, its production cost is much lower than the world market price of crude oil.

Oil shale retorting industry in Fushun is not given the same priority in investment as crude oil processing, but it has its economic and technical importance as an alternate energy source. Comprehensive utilization of oil shale, including oil, gas electricity, chemicals, building materials has a bright prospect ahead.