United States Patent Office 3,556,979
Patented Jan. 19, 1971

3,556,979

PROCESS FOR RETORTING OIL SHALE

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No Drawing. Filed Aug. 21, 1967, Ser. No. 661,787
Int. Cl. C10g 1/00
U.S. Cl. 208—11 5 Claims

ABSTRACT OF THE DISCLOSURE

The production of oil from a mass of particulate oil shale, such as that found in a nuclear chimney, is increased by retorting the shale in an enclosed zone at a pressure in the range of about 7 to 65 p.s.i.a. and periodically reducing said pressure at least 3 p.s.i.g. and substantially re-establishing the former pressure.

This invention relates to an improved process for producing shale oil from a mass of particulate oil shale in an enclosed retorting zone.

The mining, crushing, and retorting of oil shale in above-ground retorts has been practiced for some time. It has been proposed to set off a nuclear blast in a subterranean shale formation to create a nuclear chimney of huge size and extract oil from the resulting mass of shale rubble by contacting the same with hot gases. The shale surrounding the nuclear chimney thus serves as an enclosed retorting zone. Thus far, no method or process for retorting shale has been completely successful in recovering all of the oil from the shale. In other words, the various processes thus far proposed have failed to result in the recovery of the Fischer assay value of the oil shale. The proportion of the Fischer assay oil content of the shale recovered depends upon the manner of operating and particularly the rate of heating the shale. Faster heating rates to bring the shale to retorting temperature generally result in higher proportion of production of the Fischer assay.

This invention is concerned with an improved method of retorting particulate oil shale which increases the yield of oil from the shale.

Accordingly, it is an object of the invention to provide a process for retorting particulate oil shale which increases the yield of oil from the shale. A further object is to provide a more economical method of producing oil from oil shale. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises retorting a mass of particulate oil shale in an enclosed zone at a pressure in the range of about 7 to 65 p.s.i.a. and periodically reducing the pressure at least 3 p.s.i.g. and substantially re-establishing the former pressure at relatively short pulsing cycles, using any suitable retorting gas and recovering the produced oil from the effluent gas from the retorting zone. Any conventional retorting gas may be utilized but it is preferred to recycle the pyrolysis gas from the retorting operation after recovering the oil therefrom. Hot combustion gas is generally utilized to initiate the retorting operation. Conventional retorting temperatures may be utilized and these vary from about 750° F. to about 950° F.

The retorting zone may be a conventional above-ground retort or it may be an underground retort such as a nuclear chimney. In retorting a nuclear chimney, it is preferable to introduce the hot retorting gas thru the neck of the chimney and recover effluent gases and oil from the bottom of the chimney. However, the invention is not restricted to this manner of retorting.

It has been found that increasing the gas pressure in the retorting zone has the effect of decreasing the oil recovery from the oil shale. To illustrate this fact, a number of runs were made at 2000 p.s.i.a. and at 15 p.s.i.a. (atmospheric) using nitrogen as the flushing or retorting gas. The oil shale treated had a Fischer assay value of about 30 gallons per ton of shale. Using a retorting temperature of 940° F. at 2000 p.s.i.a., the oil recovery was 13.6 gallons per ton. Using 950° F. retorting temperature and atmospheric pressure, the oil recovery was 19.2 gallons per ton of shale. The difference in the amount of oil recovered is not attributable to the 10° difference in temperature in view of a run at 2000 p.s.i.a. and a retorting temperature of 798° F. in which the oil recovered was 17.0 gallons per ton of shale.

To illustrate the effect of pressure pulsing or pressure reduction and re-establishment during retorting of oil shale, runs were made using a Green River oil shale having a Fischer assay of 30 gallons of oil per ton of shale. The crushed shale sample in each run was placed in a small retort and heated to a temperature of 932° F. at a specific rate. Thruout the heating period, pyrolysis gases were circulated thru the retort and thru a condenser system to move oil and water. As the pressure in the system increased due to creation of gases, a pressure switch actuated an electric valve to control the pressure exit of the retort at a control level within about 2 inches of water pressure. In some runs, the pressure was pulsed or varied by 3 to 5 pounds per square inch periodically. In each of these pressure pulsed runs, the pressure was momentarily decreased about 600 times during the runs. The data obtained from the runs are presented in the table below:

TABLE

Heating rate, ° F./hr.	Oil recovered: gal./ton	Oil recovered: Percent Fischer assay	System pressure, p.s.i.g.	Remarks
100	25.9	86.4	0–.75	No pressure pulsing.
99.7	26.5	88.4	.5–3.25	Do.
106	29.5	94.2	4.85–7.10	Pressure pulsed.
107	26.6	88.8	1.0–1.2	No pressure pulsing.
108	25.9	86.4	1.0–1.5	Do.
14.1	25.8	86.3	0–.25	Pressure pulsed.
14.4	27.4	91.2	.25–.65	Do.
14.5	24.9	82.9	1.0–1.4	No pressure pulsing.

It can be seen from the table that the oil production was increased by 3½ to 8% of Fischer assay for this 30-gallon per ton shale by pulsing. The data presented in the table clearly demonstrate the effectiveness of pressure pulsing at low pressures in retorting oil shale.

When retorting particulate shale in a nuclear chimney there is an additional advantage in retorting at low pressures. When a nuclear chimney is created, some premeability will be generated outside of the chimney proper. The gas leakage thru this incidentally established permeability and thru any natural fractures is higher at higher pressures and results in a loss of oil in the retorting operation. The combination of low pressure and periodic pressure reduction results in maximum oil recovery in any given operation. For a given pressure reduction in the chimney, a greater amount of gas volume flows out of the oil shale particles. Since the gas flow out of the shale particles is the mechanism which removes the oil from these particles, it is desirable to maintain this volume flow of gas at a maximum for any given pressure reduction.

In addition to higher pressures being less effective in producing oil from oil shale by retorting, there is considerably more expense in operation at higher pressures and when operating in a nuclear chimney, the additional factor of gas leakage points to the enhanced value of low-pressure operation.

To illustrate operation in a nuclear chimney when applied thru a chimney formed by a 50K t. nuclear detona-

tion, pyrolysis gas from the operation is recycled at about atmospheric pressure (14.7 p.s.i.a.) and the pressure is built up to about 18 p.s.i.a. This pressure is reached in about 1 day (24 hrs.) using only the gas generated from the shale. When the pressure reaches the 18 p.s.i.a. value, it is decreased as rapidly as practical back to 14.7 p.s.i.a. and the cycle is repeated. By using this method, no outside gas is necessary to increase the pressure in the chimney. However, if more rapid pressure pulsations are desired, inert gases or a small amount of air can be pumped into the chimney.

This process applied to a nuclear chimney results in the retorting of the shale in the chimney in about 1 year. The oil shale undergoing pyrolysis by the circulation of hot gases is heated at a rate in the range of 1 to 10° F. per hour. Under these conditions, pressure pulsing increases the oil yield by about 5 to 10 volume percent of Fischer assay over operation at a steady pressure.

The pulsing cycle depends upon the size of the retorting zone and may be varied widely. To illustrate, the higher pressure phase of the cycle may be short or it may be extended over a period of an hour to several days. Thus, when operating in a nuclear chimney of substantial size, using a 12 to 48 hour period for reducing and building up pressure, it is feasible to hold the maximum pressure only momentarily or for a period of an hour up to several days. However, relatively short pulsing cycles are preferred without any substantial period of holding maximum pressure. The complete pulsing cycle may vary from about 12 hours to several days when operating in a retort of commercial size, particularly in a nuclear chimney.

Any retorting gas may be utilized in the process including nitrogen, flue gas, pyrolysis gas, hydrocarbons and mixtures of these gases, including some oxygen or air up to about 15% by volume.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. In a process for recovering oil from a mass of particulate oil shale which comprises confining said oil shale in an enclosed retorting zone, heating said oil shale within said retorting zone to a retorting temperature in the range of 750° to 950° F., maintaining within said retorting zone a selected retorting pressure within the range of 7 to 65 p.s.i.a. to thus produce an oil-containing vapor, passing said vapor to a condensing zone, condensing said vapor in said condensing zone to thus produce said oil and and pyrolysis gas, and recovering said oil and said pyrolysis gas from said condensing zone; the improvement which comprises heating said oil shale to said retorting temperature at a specific rate in the range of 1° to 106° F. per hour by contacting said mass of oil shale with a continuous stream of moving heated gas, and, in successive periods of pressure reduction and increase, periodically reducing the pressure within said retorting zone from a selected maximum pressure within said retorting pressure range by an amount of at least 3 p.s.i. followed by substantial reestablishment of said selected maximum pressure.

2. The process of claim 1 wherein said retorting zone and said condensing zone are both contained in an underground cavity which also contains and confines said mass of particulate oil shale, said cavity and said mass of shale being produced by the detonation of a nuclear explosive in a subterranean shale formation, and said moving heated gas is introduced at the top of said cavity and moves vertically down.

3. The process of claim 2 wherein said specific heating rate is no greater than 10° F. per hour.

4. The process of claim 3 wherein each pressure pulsing cycle which comprises one of said periods of pressure reduction succeeded by one of said periods of pressure increase requires in the range of 12 hours to several days to complete and said selected maximum pressure is maintained for a period of moments up to several days.

5. The process of claim 4 wherein each of said pressure pulsing cycles requires 12 to 48 hours to complete and wherein said selected maximum pressure is maintained for a moment and then rapidly decreased by an amount of at least 3 p.s.i.a.

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U.S. Cl. X.R.

166—247, 201—35