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INVESTIGATION OF THE FUNDAMENTALS OF OIL-SHALE RETORTING

Reference #

Data Inventory Sheet

1. Commodity OS

2. Author

GAVIN, M. J., AND L. H. SHARP. Investigation of the fundamentals of oil-shale retorting. U.S. Bureau of Mines Rept. of Investigations 2141, 1920, 4 pp. See also Oil Age, vol. 16, Aug. 1920, pp. 25-28; Petrol. Age, vol. 7, Aug. 1920, pp. 64-65; Oil, Paint, Drug Reporter, vol. 98, July 26, 1920, Petrol. Sec., p. 11; Railroad Red Book, vol. 37, 1920, pp. 729, 731; Oil Gas Jour., vol. 19, Aug. 13, 1920, pp. 94-95; Oil Weekly, vol. 18, Sept. 11, 1920, pp. 66-67; Chem. Age, vol. 28, 1920, pp. 293-294; Nat. Gas Gasoline Jour., vol. 14, July 1920, pp. 211-212; Colo. Sch. Mines Magazine, vol. 10, Sept. 1920, pp. 178-179; Petrol. World (London), vol. 17, 1920, pp. 373-374; Shale Rev., vol. 2, Aug. 1920, p. 7.

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BUREAU OF MINES - - JULY, 1920 - - DEPARTMENT OF INTERIOR

INVESTIGATION OF THE FUNDAMENTALS OF OIL-SHALE RETORTING.

(In cooperation with the State of Colorado)

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and
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Those of the oil-shale operators in this country who are sincerely attempting to make a real industry out of oil-shale developments, are anxious to obtain fundamental data on the retorting of oil-shale; particularly as regards the effect of certain variable factors in the process of retorting on the quantity and quality of products yielded from oil shales when they are subjected to destructive distillation. From careful examination of a considerable number of suggested processes for treating oil shales and the conflicting ideas on which they are designed, it seems probable that accurate information of a fundamental nature is highly essential to the successful establishment of an oil-shale industry in this country.

Accordingly, the United States Bureau of Mines, in cooperation with the State of Colorado, is undertaking to furnish some definite and impartial information of this type through investigations now under way at the University of Colorado, Boulder, Colo.

A retort for the distillation of oil from oil shale has been designed and installed, together with the necessary auxiliary equipment for controlling and determining variable factors of distillation, and for recovering and determining the quantity and quality of the products yielded from the shales. The retort is of such a nature that conditions of retorting can be accurately and completely controlled, and varied at will. It is not designed as a commercial retort, but only for research purposes. A testing laboratory with equipment necessary for the examination of the shales, physically and chemically, and the products yielded by them, has also been fitted up.

The material used in the investigations is oil shale obtained from the DeBeque, Colorado, shale field. It yields on distillation in the Bureau of Mines testing apparatus, about 42 gallons of oil to the ton, and is therefore a fairly representative sample of the shales that probably will be first worked in Colorado. The shale used will be as uniform as possible in character and oil yield and will all be obtained from the same seam at the same point, in order to avoid the introduction of unnecessary variable factors in the tests and to render results strictly comparable.

Effort will be made, as far as the equipment and capital at hand makes possible, to determine the effect of the following variables factors in retorting on the quality and quantity of the products produced from this shale.

1. Rate of heating to a definite final temperature.
2. Thickness of the shale layer in the retort.
3. Size of individual particles of shale.
4. Vacuum or reduced pressure.
5. Various pressures above atmospheric.
6. Steam atmosphere at various pressures and temperatures.
7. Other atmospheres, such as carbon dioxide, carbon monoxide, hydrogen, illuminating gas, etc.
8. Actual temperature reached.

In each case the rate of formation of products and the total time necessary to bring the retorting process to completion will be determined.

It is doubtful whether all these determinations can be made satisfactorily with the limited personnel and equipment available for the year, but it is hoped that sufficient valuable data may be obtained to be a real contribution to the present knowledge regarding oil shales and to justify a continuation and expansion of the work. As far as possible the effect of each variable will be taken up by itself, and thoroughly studied before passing on to another.

Carefully conducted work along the lines above indicated should be of value in giving information on the following points:

1. Are oils of different qualities formed from shales consecutively as their boiling points are reached, the so-called "fractional education theory", or does the shale yield a single, more or less uniform crude oil throughout the course of the distillation?

2. If the fractionation above mentioned takes place, to what extent does it progress and hence to what extent may economies be introduced in refining shale oils, if the various fractions are directly recoverable from the retort?

3. The time necessary at a given temperature to effect complete distillation of the shale and the quantity and quality of products so produced.

4. The effect of steam and other atmospheres in retorting --

(a) In forming undesirable emulsions with the oils;

(b) In preventing the formation of undesirable hydro-carbons, such as olefins, diolefins and acetylenes in the oils;

(c) On the recovery of the nitrogen of the shales as ammonia or other nitrogen containing compounds;

(d) On the combustion or utilization of the carbon remaining after the oil has been distilled, to provide combustible gas for retorting;

(e) On quality and quantity of gas formed;

(f) On heating efficiency of the retort;

(g) On capacity of the retort, that is, time of completed distillation under most favorable conditions.

5. What is the most favorable size of shale to retort?

6. What quality and quantity of finished products may be expected from shale oil?

7. How are the nitrogen and sulphur of the shale distributed in the products, and how may they best be removed or prevented from forming?

8. Physical and chemical constants of the shale and products, particularly those of value in the design and operation of commercial plants, will also be determined. Work is under way on the determination of specific gravity, weight per unit volume when crushed to different sizes, heat of combustion, specific heat, heat of conductivity and chemical analysis of the shale, and specific and latent heats of the crude oil and its various distillation products.

Summarized, the purpose of the investigation is to determine with scientific accuracy, the conditions of retorting oil shale to produce the highest yield of the best products.

It is realized that these conditions when so determined may not be applicable in their entirety to large-scale retorting operations, but the work should indicate what the best conditions actually are and these can be applied to large-scale work in so far as practical commercial considerations permit. If fundamental work on oil-shale retorting is to be done at all, it must be conducted on such a scale and in such apparatus and equipment as will enable conditions to be regulated at will and controlled accurately; otherwise the results will be of little value.

The apparatus being used has been designed especially for the work by the writers, with the assistance of L. C. Karrick, junior refinery engineer of the Bureau of Mines, and after consultation with many engineers interested in, and in many cases, working on, oil shale. The retort proper is a cast-iron, externally-heated, horizontal, rotary, cylindrical retort, designed to insure even distribution of the heat through the shale charge during treatment. Its capacity is approximately 75 pounds of shale at a charge. The retort is gas fired. Stuffing boxes, designed to function without leaking at high temperatures, enable stationary inlet pipes and outlet pipes to be connected to the retort. The inlet pipe carries the pyrometer, and permits the

introduction of steam or various gases. The outlet pipe leads to a two-stage condenser, the first stage being cooled by air or hot water, and the second by cold water. From the condenser, the gases are forced through oil and water scrubbers by a small rotary pump. The oil scrubber is for removing any uncondensed light oils, and the water scrubber for removing ammonia from the uncondensed gases. Manometers at various points permit the regulation of pressure in the retort and in the condensing and scrubbing system. The pyrometer system is also so equipped that an automatic temperature control can be used if this seems desirable.

The ends of the retort are well insulated and the whole set in a fire-brick furnace, from which it may be removed easily. The retort is rotated by a 5-horse power electric motor through a belt and worm gear drive.

It is felt that the work is almost to be considered pioneer work in the scientific investigation of oil shales. A material is being dealt with regarding which little is known, both as to methods of treatment and its products. For these reasons, the Bureau of Mines invites suggestions or criticism of a constructive nature as to the conduct of the work. It is hoped that results can be presented to the public as rapidly as obtained through the various trade journals. The completed work is to be the subject of a bulletin of the Bureau of Mines.-- U.S. Bureau of Mines, Reports of Investigations.

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PAPER