

SIGGE BERGH

OIL SHALE AND SHALE OIL IN SWEDEN

Oil shale, usually called alum shale, is a bituminous clayslate, geologically assigned to younger Cambrium period. It thus belongs to the oldest of its kind in the world. Furthermore, it is also one of the poorest ones, its oil contents being only 4 - 6 %. The oil contents of these shales is estimated at some 300 million tons.

The bitumina content of the richest species amounts to some 20 % with a hydrogen/carbon ratio of only 1 : 10. The oil products obtained from it by pyrolytic distillation are rich in unsaturated constituents and contain no paraffin. Characteristic is a very high sulphur content, occurring as pyrite.

Since the middle of the 17th century, i.e. for more than 300 years, alum shale has been used technically. During the first half of the period it was used exclusively for the production of alum. From the beginning of the 19th century it was used as fuel for burning limestone and this continued until about World War II when shale oil production took over for a good two decades. Since 1961, the shale has ceased to be a raw material of any importance.

Alum Manufacture

Amongst the few chemicals available in the old days, alum, i.e. potassium-aluminum-sulfate, played an important role. The main uses were as a tanning agent and as an admixture in dyeing of textiles. From the middle of the 17th century, alum has been manufactured from alum shale which was burned and subsequently leached with water. The very dilute solution obtained was concentrated and alum was extracted by crystallization. Previously leached ashes were added to the burning shale to adjust the temperature in order to obtain optimal salt formation and a high alum yield.

This process was a purely empirical one as an adequate science did not yet exist. Even today it is not easy to find literature data helping to understand the mechanism of this alum production. To my knowledge, the only source is a petrographical investigation made by my father in 1928 (Sven V. Bergh, GFF 50, p. 413, 1928). From microphotographs at a magnification of 250-2000 considerable contents of very finely divided mica can be observed, a mineral which contains the metallic alum constituents in the proper ratio. The volume fraction of bitumina is found to be some 50 % which should give a corresponding fraction of pores in the ashes upon burning. The pyrite is seen to be extremely finely divided giving after burning a corresponding amount of iron oxide known as one of the best catalysts for oxidation of sulphur dioxide to sulphuric acid. Conditions for alum formation should therefore be good, and probably still better at repeated roasting of leached ashes.

This slow and tedious manufacture of alum finally became too expensive and was replaced by cheaper methods.

Burning of Limestone

The second great use of alum shale was as fuel for the production of calcareous earth by burning limestone, an activity still undertaken in "lime-regions" of Sweden up to the last war. The essential markets for this product were mortar production and agriculture as an agent for soil improvement, both uses now belonging to the past.

This manufacture was also based on the special properties and occurrence of the raw materials. Limestone - also of bituminous character - lies as lenses and layers in the shale and is quarried along with it. The mode of production was entirely manual: limestone and shale were broken into pieces and put - layer upon layer - the shale one foot, the stone two feet of thickness, in big rooms, so-called earth furnaces, simply built by piling big blocks of shale (see photo). The shale layer at the bottom was set on fire at one end of the furnace, the burning then advancing along and upwards through the masses thus converting the limestone to calcareous earth. Quarrying, crushing, piling, burning and taking out took two men two months to complete.

On burning the shale partly sintered, forming easily breakable roofs, protecting the lime from being quenched in rainy weather.

This primitive manufacture was carried out on estates as well as by simple peasants, the smell of sulphur smoke from the furnaces could be traced over vast regions of the country. People of today would not dream of doing a job like this.

Shale Oil

From a global point of view it may be said that exploitation of crude oil (petrol) and the production of shale oil were both started rather simultaneously in the middle of the past century. World resources of oil shale had then been well known for a long time but this was not the case so as far as petrol was concerned. At the beginning of World War I known resources of petrol were estimated to last for some 10-20 years only. As time passed this judgement proved totally unrealistic; oil prospectors of today see no end to liquid oil.

Logically, the interest in shale oil at the beginning of the century was great, nowadays it is rather academic everywhere except in Estonia. Sweden with its poor shale has probably left the stage for good.

The first attempt of importance to produce Swedish shale oil was made in 1889 by L. W. Kyhlberg of Gössäter, Kinnekulle in Västergötland. He had visited the leading shale oil country of the world, Scotland, and was persuaded that his own deposits in Sweden were a "goldmine". He bought a retort from Paisley and hired a competent Scottish foreman. Some 100 tons of oil were produced in one and a half years but the problems were overwhelming and the oil of so inferior quality that the undertaking had to be abandoned.

Obviously the Scottish methods did not suit the poor and sulphurous Swedish shale. Nevertheless some 25 years later several new attempts were to be made (in vain) with later Scottish constructions (see below).

Up to World War I further efforts were made in Sweden by G. Helsing, a chemist. He made systematic studies of decisive properties of shales of different provenances with the aim of finding out optimal sites for future manufacture.

Particularly the removal and utilization of sulphur interested him and led to several claims for patents. Trials on a technical scale were, however, not successful.

This was the situation in 1914. The threatening shortage of oil then led to intensified new efforts from private enterprise. Three companies were formed: AB Kemiska Anläggningar, AB Svenska Skifferverken and AB Svesk Oljeindustri.

AB Kemiska Anläggningar. A distillation plant was erected at Rockesholm in Närke, essentially a modern Scottish development known as the Pumpherston retort, adapted to Swedish shale by G. H. Hultman & E. Gustafsson. In principle it consisted of a vertical upwards tapered cylindrical tube of iron and refractory bricks, some 20 feet high and 2 feet wide, at the bottom provided with a hatch for manual discharge. The retort was externally heated by burning distillation gases + additional fuel.

The Scottish prototype acts in its lower parts as a watergas generator fully utilizing the carbon content of the coke that remains after distillation. This chemical reaction requires high temperature. It is, however, not adaptable to Swedish shale. The hot coke was quenched by water spraying, the vapour formed improving the distillation yield. A proceeding like this had drawbacks. First of all the economy was impaired by not making use of the carbon in the coke. The burning of the coke on the wastepiles implied severe environmental damage (see below, part II).

The oil output of the plant was good (some 85 % of the theoretical value) and the quality of the oil satisfactory. The economy, however, was poor and only acceptable in an emergency situation.

AB Svenska Skifferverken. The initiator of the plant built by this company was Axel Svedlund, known later on (in the 40ies) for his ingenious constructions of gas generators for charcoal used for motorcars, which kept Sweden going during the last war.

In 1916 his aim was gas production from oil shale with a simultaneous extraction of oil, a method somewhat resembling the one now being used in Estonia. Once again, however, the very much poorer Swedish shale did not function as expected. The high sulphur content proved harmful, giving oils with as high as a 6 % sulphur content.

The rather big plant built at Lanna in Närke had to be discontinued after futile efforts at reconstruction.

AB Svensk Oljeindustri. The method to be used by this company also emanated from the Pumpherston prototype. Sulphur extraction according to Hellsing was to be tried. However, peace arrived before the completion of the plant which was never actually used. The reason for mentioning it at all is that a key-person, Sven V. Bergh (see below) was, for a short time, employed there as an operational engineer. Realizing, however, the weak prospects of the undertaking he soon left to start a career of his own in shale oil.

Sven V. Bergh

Sven V. Bergh, a young mining engineer, was the one who, in the period between the wars, elaborated a new method designed for Swedish shale that later on, during World War II, made oil production possible on a very big scale.

Unlike his predecessors he realized that a raw material as poor as the Swedish shale necessitated a production method using as nearly as possible the total calorific content of the shale. Half of this resides in the coke, hitherto considered as waste. The fundamental patents of Bergh deal with the conditions for coke combustion enabling complete oxidation of the carbon without melting the ashes. To a great extent this process depends on diffusion via a pore system created by the pyrolysis of distillation. Melting of the ashes would obstruct this pore system. Bergh made calculations on heat formation and radiation losses and was thus able to specify the degree to which the shale should be crushed.

Roughly speaking his method implies retorts essentially shorter and smaller than the Scottish ones used hitherto, retorts open at both ends, enabling a continuous flow of material. The hot coke from pyrolysis leaves the lower end and ignites immediately. The combustion gases formed flush along the outside of the retort and heat it sufficiently for complete pyrolysis to occur inside. The combustion heat is also sufficient to generate the steam that is added to the zone of pyrolysis. The diffusionaly determined combustion speed of the coke defines the capacity of the process.

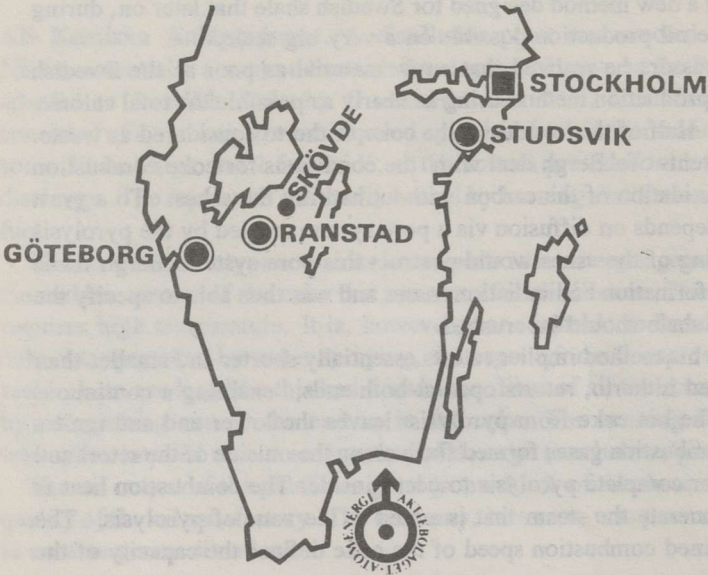
The final products of a Bergh-plant are oils (some 85 % of the theoretical yield), gases of high heat value containing some 25 % hydrogen sulphide and cold carbonless ashes not harmful to the environment. Sulphur is separated from the gas and converted to elemental sulphur, a valuable byproduct. After extraction of lighter hydrocarbons (gasol) from the gas the remaining gases are burnt and converted into electrical energy.

More details of the elaboration of the Bergh method will be given in a later article. Suffice it to be said that on the outbreak on World War II detailed plans were ready for a rapid erection of oil producing units on a big scale, the oil intended to produce in the first place for military uses, above all as fuel for the Navy.

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Ranstad



AB ATOMENERGI

