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EDITOR'S PAGE

HIGH-EFFICIENCY TECHNOLOGY FOR OIL SHALE PROCESSING

About four months ago the managers of the journal applied to me with a proposal to write an editorial to Oil Shale. I thought for quite a long time what the topic of this article should be. Finally I decided to present an overview of the history of developing the most efficient technology in the world practice of oil shale processing by the pyrolysis method using the solid heat carrier – the technology called "Galoter". "Galoter" comes from the abbreviation of the name Galynker Israel Solomonovich on the one hand and the word "thermo" on the other. Israel Solomonovich Galynker was the author of the ideology and initial developer of the technology, doctor of technical sciences (DPh), research worker of the G. M. Krzhizhanovsky Power Engineering Institute (ENIN), Moscow, Russia, who patented the main principle of the technology in 1946. "Thermo" meaning "heat" refers to the processing of oil shale by means of heat (heating).

At the end of the 1940s oil shale was subject to thermal processing by means of the technologies existing at that time. Large oil shale lumps (with a size of 25–125 mm) were heated in the rotating horizontal retorts, tunnel and chamber furnaces for obtaining the shale gas for the cities of Leningrad, Tallinn and Kohtla-Järve.

The scientists of the G. M. Krzhizhanovsky Power Engineering Institute had set the aim to develop a technology of the thermal processing of oil shale with a particle size of up to 25 mm to obtain high-calorific liquid and gaseous fuels. The share of oil shale of such particle size constitutes about 70% of total oil shale mined. Therefore only about 30% of the oil shale extracted is subject to a further crushing. In addition to the overwhelming amount of fine-grained (up to 25 mm) oil shale obtained during mining, the shale of such particle size has a few advantages over the lump one:

- the fine-grained oil shale (0–25 mm) obtained by mining is less polluted by rock and contains 34–35% of organic substance per moisture-free mass. The rock lumps with a size of 50–70 mm are practically not removed from the rock mass, and the lower organic content is therefore typical of oil shale of the class 25–60 mm;

- the heat access inside the particles is hindered during the thermal processing of large lumps by the solid or gaseous heat carrier and, therefore, 8–9% of organic matter remains in the semicoke of tunnel kilns, 6–8% in the ash of mining generators and 14–15% in the coke of chamber furnaces;
- the fine-grained shale particles have the most extended surface and, due to this, the process rate of the shale thermal processing is increased (it is just for this reason that the combustibles content in the ash remaining after processing of fine-grained shale does not exceed 1.0% of shale organic matter).

The technology suggested by I. S. Galynker was based on the principle of a quick heating of fine-grained shale by the solid heat carrier – hot ash obtained in the technological furnace during the combustion of semicoke remaining after the thermal processing of oil shale in the reactor-pyrolyser. This main special feature demanded solving many scientific and technical problems that served as the basis of investigations carried out by ENIN researchers in 1946–1956. The experiments in the pilot plant with a capacity of 2.5–3.0 t of oil shale a day created at the Ilmarine Works by the ENIN researchers of a special department formed in Estonia were carried out in 1949–1953, in addition to the thermo-physical bench-tests for the development of an optimal diagram variant of the plant with the solid heat carrier (UTT – Russian acronym). Both the bunker and rotating drum-type reactors were used as pyrolysers in this pilot plant. The Estonian specialists also took part in these experiments. In accordance with the experimental results a decision was made to use the rotating drum-type reactor as a pyrolyser.

A pilot unit with a capacity of 150–200 t of shale per day (UTT-200) was erected on the basis of performed investigations. Created at Kiviõli Oil Shale Chemical Plant the unit underwent operational testing from 1954 to 1961 and became a prototype of the larger unit. A unit with a capacity of 500 t of oil shale per day (UTT-500) was also constructed at the same plant at Kiviõli. The scale factor of the smaller to the larger unit was 2.5–3.

In addition to the researchers of ENIN, also specialists of the Institute of Chemistry of the Estonian SSR Academy of Sciences, Kiviõli Oil Shale Chemical Plant and Kohtla-Järve Oil Shale Scientific-Research Institute took part in the development of UTT-200 and UTT-500. The units were in service up to 1981, i.e. more than 17 years. From 1964 to 1980, the average annual running time of UTT-500, 6083 h, met the requirements for industrial installations. The fractions of shale oil obtained in UTT-500 passed through the release testing. The shale oil as a gas turbine fuel was tested in a 15 MW gas turbine GT-15 in Leningrad Central Boiler-Turbine Institute, 6000 t of furnace oil was burned in one of the boilers at Tallinn Power Plant (PP), 1500 t of total shale oil was tested at Kohtla-Järve Combined Heat and Power Plant (CHPP). The shale oil was examined on an industrial scale for making a preparation "Nerozin", and the sleeper and road oils.

The results of operation of UTT-500 and the positive results of release testing of the different fractions of shale oil obtained in this unit laid down the foundations for ENIN specialists to begin work on developing the plant of type UTT-3000 with a capacity of 3300 t of oil shale a day.

Under the scientific leadership of ENIN, the design organizations of Leningrad developed the projects of UTT-3000 and a power engineering complex at the site of the Estonian Thermal Power Plant (TPP). The complex was to be equipped with four UTT-3000 and four GT-100-750-2 units. In the process of approval, the project underwent significant corrections concerning hardware configuration, including the number of UTT-3000, which was reduced to two.

The first UTT-3000 unit was erected in 1980, the second one, in 1984. Regrettably, due to numerous defects in equipment manufacturing and mounting, errors in design, etc., the units were operating up to 1986, in the conditions of an acute shortage of repair materials and slow clearing, with only 25-30% of the designed yearly capacity.

At that time, proposals were heard, also from academicians of the USSR Academy of Sciences and an academician of the Estonian SSR Academy of Sciences, to cease work on mastering UTT-3000, because the unit did not succeed in achieving the scheduled running time and sufficient productivity. On an initiative of the ENIN administration a program of updating UTT-3000 units was prepared. Great assistance in the organization of financing and fulfillment of the program of works was rendered by the then USSR Minister of Energy, A. I. Mayoretz. Demanding considerable scientific efforts, major reconstruction works were done in 1987–1988. The lining of the aerofountain furnace and the high-temperature screws of semicoke were substituted; the section of pyrolysis gas treatment from solid particles and other elements were reconstructed.

The updated UTT-3000 were put into operation in 1989. In the same year the units were again under threat of stop and demounting. But it was now for ecological reasons: one of the leading academicians of the Estonian Academy of Sciences declared that the UTT-3000 units irreversibly damaged the environment and should be dismantled. Again, on an initiative of the ENIN administration a special committee was created for assessment of the environmental impact of functioning UTT-3000. The Committee consisted of Russian and Estonian specialists, including representatives of the Estonian Academy of Sciences. It was fixed in the conclusion of the Committee: "The power engineering unit UTT-3000 for processing fine-grained oil shale is original in terms of operating principle and technological process, is of high scientific and practical interest and irreproachable from the ecological point of view".

In the complicated 1990s just the operation of two UTT-3000 units was for a long time the main source of financing for the staff of the Estonian TPP. Up to now the UTT-3000 units are among the world's largest units for processing oil shale, having the most efficient process.

These units allow obtaining from oil shale with a calorific value of 7.8–8.4 MJ/kg a high-calorific fuel with a calorific value of 38–40 MJ/kg and gaseous fuel with a calorific value of 41–42 MJ/kg. The output of total shale oil from one ton of oil shale of the Baltic deposit constitutes 129–131 kg, the output of pyrolysis gas or semicoke gas constitutes 35–36 nm^3 (40.2–41.3 kg). The units of UTT-type can be practically used for oil shale with any calorific value, including low-calorific oil shale with the respective value of up to 2.9 MJ/kg (700 kcal/kg).

In addition to the possibility of processing oil shale with any fractional composition and quality, as well as high unit capacity, the units also have other advantages:

- due to the separation of processes of oil shale pyrolysis (in the drum-type reactor) and preparation of the solid heat carrier – ash (in the aerofountain-type process furnace), only the solid phases (the dried shale and ash) come in the reactor. Therefore the pyrolysis gas contains neither oxygen nor nitrogen of the atmospheric air and, due to this, its calorific value is 2.5–3.0 times higher than that of gas in foreign units.
- utilizing for pyrolysis of oil shale ash but not the gas increases the thermal efficiency of UTT-type units up to 84–89%, while the efficiency of the majority of foreign units using the gaseous heat carrier is no more than 65%;
- due to the application in the UTT-type units of principally new solutions for the withdrawal of dust from cyclones, their total efficiency reaches 99.5%;
- because of this fact the content of dust does not exceed 1.0–1.5% even in the heavy fractions of shale oil;
- for some years worn-out car tyres, mixed with oil shale (up to 10% of oil shale mass), have been burnt in UTT-3000 units at the Estonian TPP. The processing in UTT-type units of soils saturated by oil products and formed as a result of emergencies at petroleum refineries and during transportation of mineral oil in tankers, rail tank cars and truck tanks is technically possible, and this has also been confirmed in practice. This allows increasing the output of liquid fuel as a marketable product.

It is also important that the investigations allowed determining the efficiency of utilizing the waste formed. During the operation of plants the ash constituted about 50% of the dry oil shale mass processed. Therefore ENIN, with the attraction of specialized organizations, studied possibilities of utilizing the shale ash. As was shown by the tests carried out by some agricultural organizations (All-Russian Scientific-Research Institute for Agricultural Use of Reclaimed Areas, All-Russian production-scientific association on agrochemical service of agriculture "Soyuzselkhozkhimiya", etc.), the ash from UTT units can be used as a reclamation agent – deoxidizer of acidic soils instead of lime powder, as well as the agent,

instead of expensive germicides, for fighting plants bacteriosis. Field experiments with barley, clover, rye, flax and potato demonstrated that the increase of crop yield due to the introduction into the soil of lime powder or ash from UTT units was practically the same, equalling 4%.

In addition to agriculture, the ash from UTT-3000 received verification as a raw material for obtaining building materials, with the involvement of specialized organizations. The tests carried out by the mentioned organizations showed that it is possible to use about 80% of the UTT-3000 ash as a component of raw meal in the cement industry for the production of clinker. The input of about 15% of the UTT-3000 ash in the composition of Portland cement allows obtaining the Portland cement of mark M400, while with the input of ca 25% of this ash the trass cement of the same mark can be obtained. The advantage of the ash from UTT-3000 over the shale ash of thermal power plants is the absence of overburned and slowly hydratable quicklime, and therefore its preliminary slaking is not necessary.

The very fine ash from UTT-3000 found the application for the production of marblites – colored facing slabs. The advantage of UTT-3000 ash for producing marbled glass over other materials consists in that no addition of fluorine to the mixture is necessary. As is known, fluorine is a major pollutant of the environment.

Thus, the technological process was suggested and a unique power engineering unit UTT-3000, with a capacity of 1 mil t of oil shale per year, for processing oil shale by the pyrolysis method using the solid heat carrier was developed, constructed and mastered. This came true as a result of long, hard and huge work of large research teams of different scientific, design and industrial organizations in Russia and Estonia under the leadership of the specialists of the G. M. Krzhizhanovsky Power Engineering Institute.

This unit has no equivalent in the world practice in terms of thermotechnical, economic and ecological characteristics. The main developers of the technology were the scientific researchers of the G. M. Krzhizhanovsky ENIN I. S. Galynker, B. I. Tyagunov, D. A. Vorona and A. S. Smirnov. The chief engineer of the project was A. E. Lerner from the Leningradsky Department of "Teploelectroproject". A. I. Chikul, M. S. Petrov, A. I. Kaidalov and S. A. Vereshchaga were those who put the units into operation. The participation of the Director of the Estonian TPP, K. I. Senchugov, in all stages of project realization was of great importance.

The researchers of the G. M. Krzhizhanovsky ENIN received, during the development of the technology of oil shale processing by means of the solid heat carrier, more than 60 patents and certificates of recognition, eight of them were patented in 12 foreign countries. In 2008, the International Award Committee conferred on those involved the highest international prize in the energy area – the Global Energy Prize for the creation of this technology. Thus, the titanic, perennial work of the specialists of the G. M. Krzhizhanovsky Power Engineering Institute was noted.

At the present time it is very important to improve the existing technology through implementing new technological solutions for obtaining high-added-value products: petrol with a high octane level, hydrogen, medical and cosmetic preparations – everything that can promote increasing the efficiency of units under construction and provide the wide usage of oil shale in the world. For these purposes, ENIN is currently preparing a special project of UTT-500 for the realization of these technological solutions.

Efforts are made in Russia and Estonia to organize the implementation of the ENIN technology in different countries, first of all, in Israel, Jordan and Morocco, where oil shale is perhaps the countries' only energy resource. Yet in 1989, the G. M. Krzhizhanovsky ENIN won an international tender for the construction of oil shale units in Israel. The tender was attended by 51 companies from different countries of the world. However, the subsequent events in Russia allowed no construction of four UTT-3000 units envisaged by the tender. Nevertheless, it gave cause to begin negotiations with Jordan, Morocco and USA.

I wish all those who are fighting for the right to construct UTT-3000 units in different countries, success in this very important matter – in the strengthening of the resource base of the world power engineering and honouring the memory of the prominent scientists-enthusiasts of the G. M. Krzhizhanovsky Power Engineering Institute.

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