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EXPERIMENTAL OIL SHALE RETORT WITH SEPARATE TAKE-OFF OF OIL VAPOURS AND GASIFICATION GAS

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An experimental 600-700 kg per day retort for low temperature processing (semicoking) of large particle oil shale has been developed and constructed. The retort is intended essentially for high efficiency processing of organic-rich shales in a thin oil shale bed providing separate take-off of oil vapours and gasification gases. Air and steam for gasification are injected into the upper part of gasifier, the produced gasification gas is drawn off from its lower part. Tests have shown that in this retort it is possible to practically avoid the overflow of gas from the gasifier into the retorting zone (or vice versa*) by maintaining required hydraulic conditions in the retort.*

The main principles of processing relatively organic-rich large particle oil shale in a retort designed for separate take-off of oil vapours and gasification gases are reported in [1].

For testing this novel technical solution developed and designed by the Oil Shale Research Institute, an experimental retort was constructed on the site of RAS "Kiviter" for a throughput of 600-700 kg per day of 10-50 mm sized oil shale particles. The retort is equipped with a separate condensation system. The principal design of this experimental plant is shown in the flow diagram in Fig. 1.

Feed shale is supplied by a charging device to retort *1.* In the upper part of the retort oil shale is contacted with hot heat carrier gas (800-900 °C) and subjected to thermal decomposition yielding oil, gas and water. The solid residue (semicoke) descends into the lower part of the retort to be gasified in the presence of steam-air mixture. The ash residue from gasification is cooled by recycle gas followed by cooling with water in extractor *3.* It is also possible to use only water for cooling the ash residue in the extractor. The latter version was used in our tests.

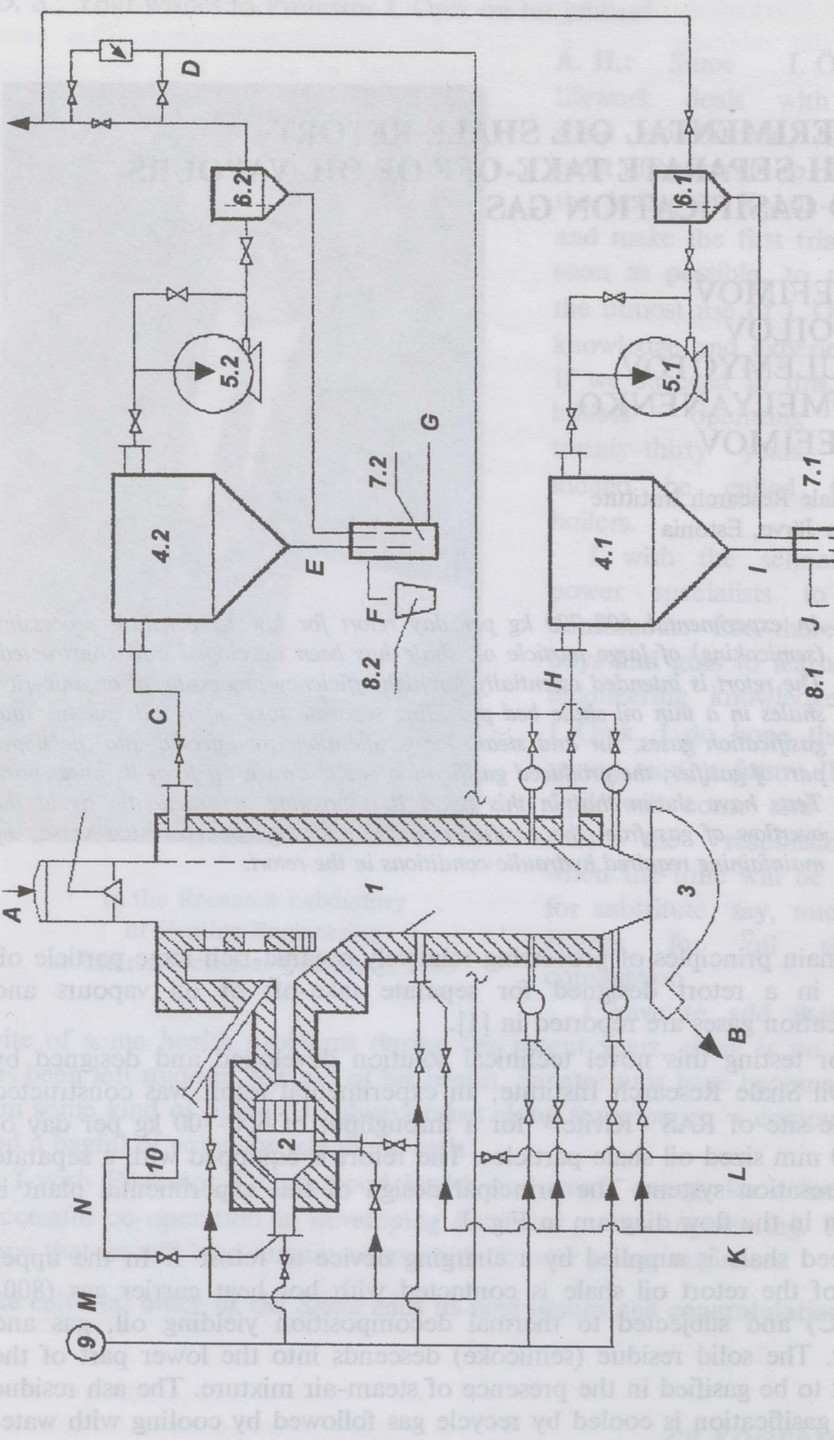


Fig. 1. Flow diagram of experimental retort

The hot heat carrier gas is prepared in burner *2* by combustion of the gas from operating commercial retorts (*L*) or of the recycle gas from the experimental retort (*D*). The same gases are added to control the temperature level of the produced heat carrier. For start-up of the retort propane-butane (*N*) from cylinder *10* is used. Air (*M*) is supplied from the plant air main *9*. Oil vapours (*C*) formed as a result of thermal decomposition of oil shale, are drawn off by exhauster *5.2* from the upper part of the retort at a temperature of 200-220 °C *via* cooler *4.2* to effect condensation of oil and water. Gas from the exhauster moves to condensation trap *6.2*. Condensed oil and water from cooler *4.2* and condensation trap *6.2* is collected in hydroseal *7* for the separation of oil (*F*) and water (*G*). The oil is collected in receiver tank *8*. Gases from gasification and cooling of ash residue are drawn off by exhauster *5.1 via* cooler *4.1* and condensation trap *6.1* and released to gas flare. Water condensate (*I*) is collected *via* hydroseal *7.1* in the receiver tank. Steam for the process (*K*) is supplied from the plant steam system.

In order to make the design simpler and less expensive, no heat exchanger for preheating the heat carrier gas is included in the experimental retort plant (Fig. 1). Heat exchangers for heating or cooling of gases are widely used in the world practice, and there was no urgent need of testing the performance of heat exhangers in this particular experimental plant. During the tests carried out in the retort, instead of the recycle heat carrier, flue gases were used from combustion of the low calorific commercial retort gas (gross heat value of 3000-4000 kJ/m^3, excl. C_5^+) in the burner shown in Fig. 2.

Operating Conditions of Processing Oil Shale in the Experimental Retort

Indices	Average of test runs
Feed shale throughput rate, t/day	648
Underpressure at gas outlets, Pa (mm water column):	
Retorting zone	598 (61)
Gasification zone	490 (50)
Temperatures, °C:	
Heat carrier into retorting zone	890
Oil vapours from the retorting zone	220
Gasifier outlet	700
Steam-air mixture	58
Gas after cooler *4.2* (retorting)	50
Gas after cooler *4.1* (gasification)	60

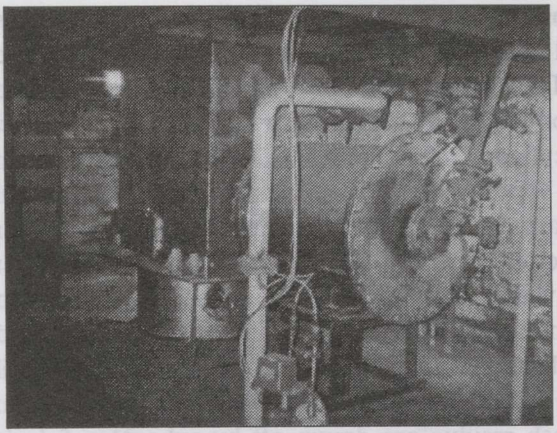


Fig. 2. Retort with side combustion chamber

Fig. 3. Spent shale discharge device

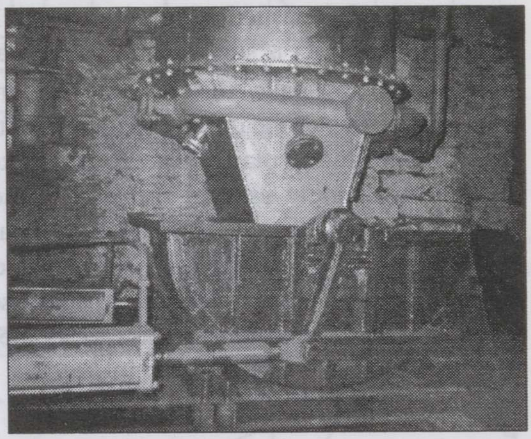
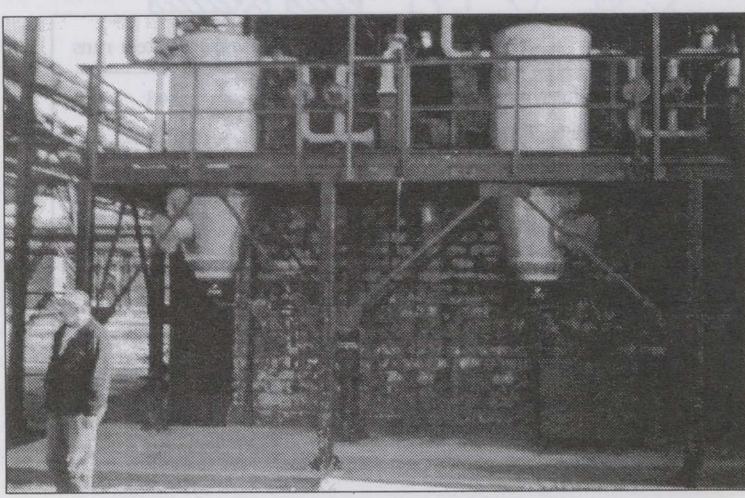


Fig. 4. Condensation and recovery system



The solid processing residue is discharged *via* extractor provided with a hydroseal (Fig. 3). In Fig. 4 the condensation system is shown including two exhausters (for separate draw-off of oil vapours and gases of gasification).

Tests with a duration of three days each demonstrated good performance and stable operation of all technological units of the experimental plant. As feed for the tests oil shale (kukersite) characterized by a Fischer assay oil of 23-24 % was used. As may be seen in Table, an underpressure of about 598 Pa was kept at the outlet of oil vapours from the retorting chamber in comparison to an underpressure of 490 Pa at the gasifier outlet to have the unavoidable small gas leakage directed essentially from the gasifier into the hot chamber of the retorting zone for afterburning. Thus, there were practically no losses of oil caused by gas overflows.

During the retorting tests the shale oil yield was fairly high (about 90 % of the Fischer assay oil). As already noted above, during the tests flue gases were used as heat carrier for the retorting process instead of recycle gas heated in heat exchangers. The flue gases used were produced in the retort burner by burning low calorific retort gas from the company's gas system. As a result, oxygen concentration of the heat carrier inevitably was as high as 2-3 % which is known to have a negative effect on oil yield. Thus, the relatively high oil yield obtained in the tests evidences that minimum gas leaks occurred between different retort zones.

The results obtained from the retorting tests in the experimental retort lead to a conclusion that processing high organic oil shale in vertical internally heated retorts designed for separate take-off of oil vapours and gasification gases can be performed with minimum gas leaks between different retort zones provided suitable hydraulic conditions are selected for the process. In this case no narrow ducts between the zones are required. At the same time it is important that the steam-air mixture be injected into the upper part of the gasifier, and the retorting process be effected by cross-flow of the heat carrier through the shale bed.

Acknowledgements

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