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DEVELOPMENT OF OIL SHALE RETORTING PLANT IN JAPAN
PART 1. CONSTRUCTION OF THE PILOT PLANT

Abstract

On consignment from the Ministry of International Trade and Industry (MITI) and the Japan National Oil Corporation (JNOC), Japan Oil Shale Engineering Co., Ltd. (JOSECO) constructed an oil shale pilot plant.

In this pilot plant, a shaft type retort was selected as the retorting and gasifying unit. Fixed-bed type drying facilities were installed to examine the economics of pre-drying oil shale with a high water content. Fluidized-bed combustion facilities were juxtaposed to study the efficient combustion of oil shale.

Introduction

JOSECO has been engaged in research and development activities related to oil shale since its founding.

JOSECO's R & D program is divided into two phases. During Phase-1 of the R & D program, JOSECO conducted extensive research on various types of oil shale, and performed experiments using three types of bench scale retorting plants (shaft, fixed-bed, and cross-flow types), each having a capacity of three tons per day.

After the successful completion of Phase-1, the work then proceeded to Phase-2 of the program. The main objectives for Phase-2 were to construct a 300 ton per day pilot plant based on the results of Phase-1, and to verify the JOSECO developed process through its operation.

This paper introduces the outline of the pilot plant.

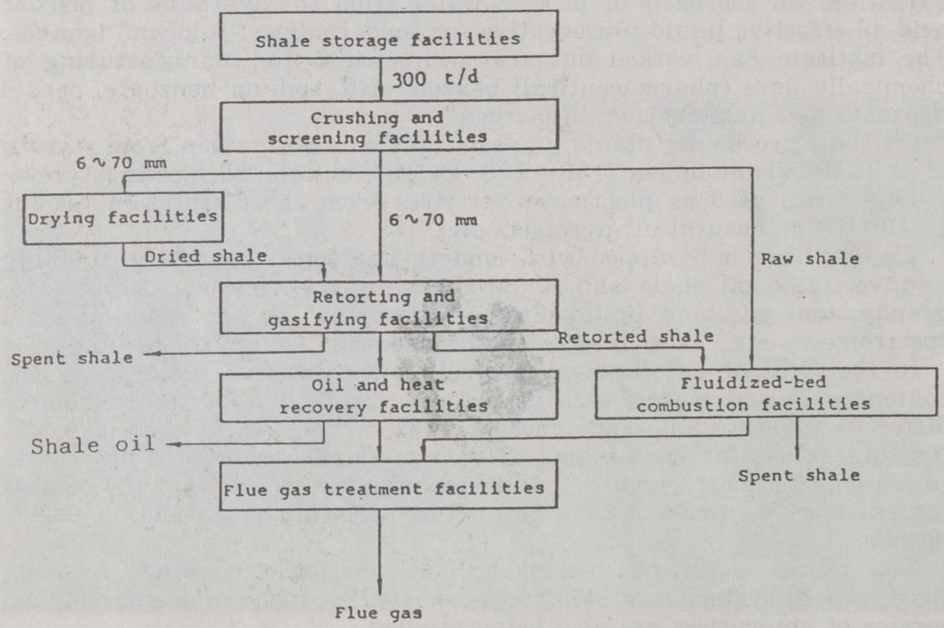

Fig. 1. Block diagram of pilot plant

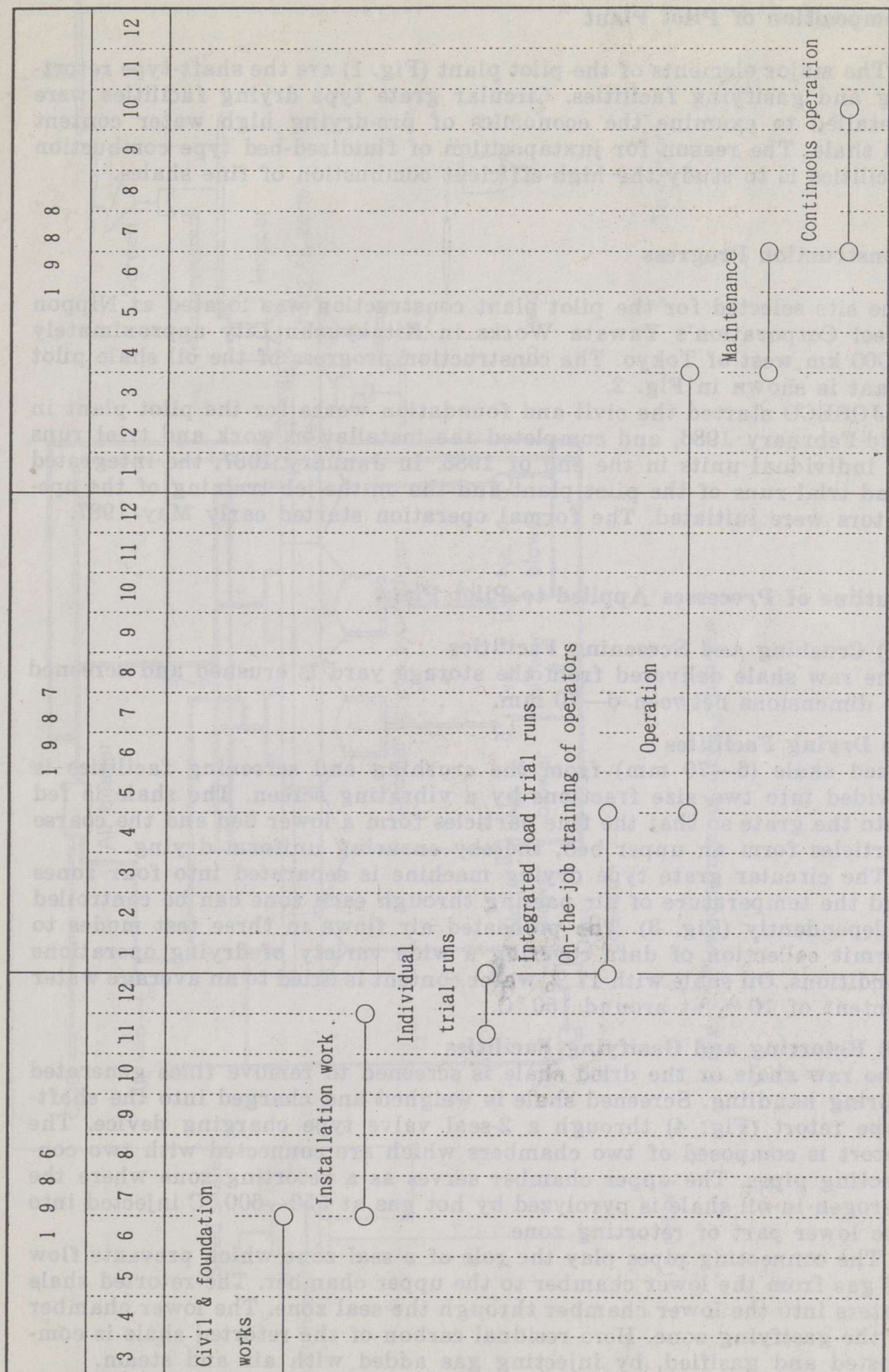

Fig. 2. Construction progress of oil shale pilot plant

Composition of Pilot Plant

The major elements of the pilot plant (Fig. 1) are the shaft-type retorting and gasifying facilities. Circular grate type drying facilities were installed to examine the economics of pre-drying high water content oil shale. The reason for juxtaposition of fluidized-bed type combustion facilities is to study the high-efficient combustion of fine shales.

Construction Progress

The site selected for the pilot plant construction was located at Nippon Steel Corporation's Yawata Works in Kitakyushu City approximately 1,000 km west of Tokyo. The construction progress of the oil shale pilot plant is shown in Fig. 2.

JOSECO started the civil and foundation works for the pilot plant in mid-February 1986, and completed the installation work and trial runs of individual units in the end of 1986. In January 1987, the integrated load trial runs of the pilot plant and the on-the-job training of the operators were initiated. The formal operation started early May 1987.

Outline of Processes Applied to Pilot Plant

(1) Crushing and Screening Facilities

The raw shale delivered from the storage yard is crushed and screened to dimensions between 6—70 mm.

(2) Drying Facilities

Sized shale (6—70 mm) from the crushing and screening facilities is divided into two size fractions by a vibrating screen. The shale is fed onto the grate so that the fine particles form a lower bed and the coarse particles form an upper bed, thereby ensuring uniform drying.

The circular grate type drying machine is separated into four zones and the temperature of air passing through each zone can be controlled independently (Fig. 3). The preheated air flows in three test modes to permit collection of data covering a wide variety of drying operations conditions. Oil shale with 17 % water content is dried to an average water content of 10 % at around 150 °C.

(3) Retorting and Gasifying Facilities

The raw shale or the dried shale is screened to remove fines generated during handling. Screened shale is weighed and charged into the shaft-type retort (Fig. 4) through a 2-seal valve type charging device. The retort is composed of two chambers which are connected with two connecting pipes. The upper chamber serves as a retorting zone where the kerogen in oil shale is pyrolyzed by hot gas at 550—600 °C injected into the lower part of retorting zone.

The connecting pipes play the role of a seal zone which prevents flow of gas from the lower chamber to the upper chamber. The retorted shale enters into the lower chamber through the seal zone. The lower chamber is the gasifying zone. Here residual carbon of the retorted shale is combusted and gasified, by injecting gas added with air and steam.

The spent shale is discharged from the retort by a screw conveyor type discharging device.

(4) Oil Recovery Facilities

The product gas generated in the retorting zone leaves the retort from the top. After removing the dust from the gas by a wet type cyclone,

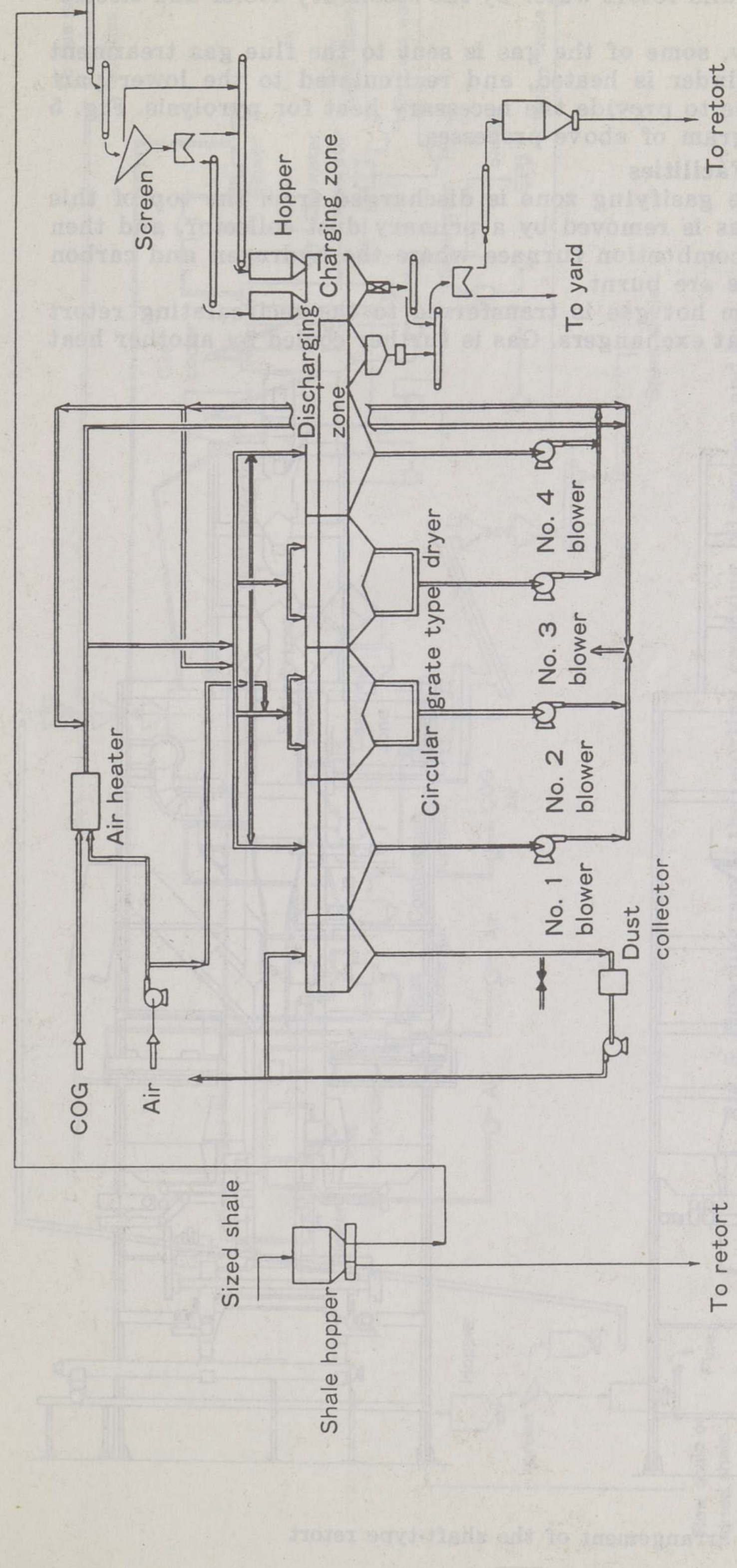

Fig. 3. **Flow diagram of drying process**

the gas is introduced to the gas cooling process. The cooling process is a two-stage system. Heavy oil and sludge are recovered by the primary cooler, and light oil and retort water by the secondary cooler and electrostatic precipitator.

After oil recovery, some of the gas is sent to the flue gas treatment facilities. The remainder is heated, and recirculated to the lower part of the retorting zone to provide the necessary heat for pyrolysis. Fig. 5 shows the flow diagram of above processes.

(5) Heat Recovery Facilities

Gas produced in the gasifying zone is discharged from the top of this zone. Dust in the gas is removed by a primary dust collector, and then the gas enters the combustion furnace where the hydrogen and carbon monoxide in the gas are burnt.

The heat from the hot gas is transferred to the recirculating retort gas through two heat exchangers. Gas is further cooled by another heat

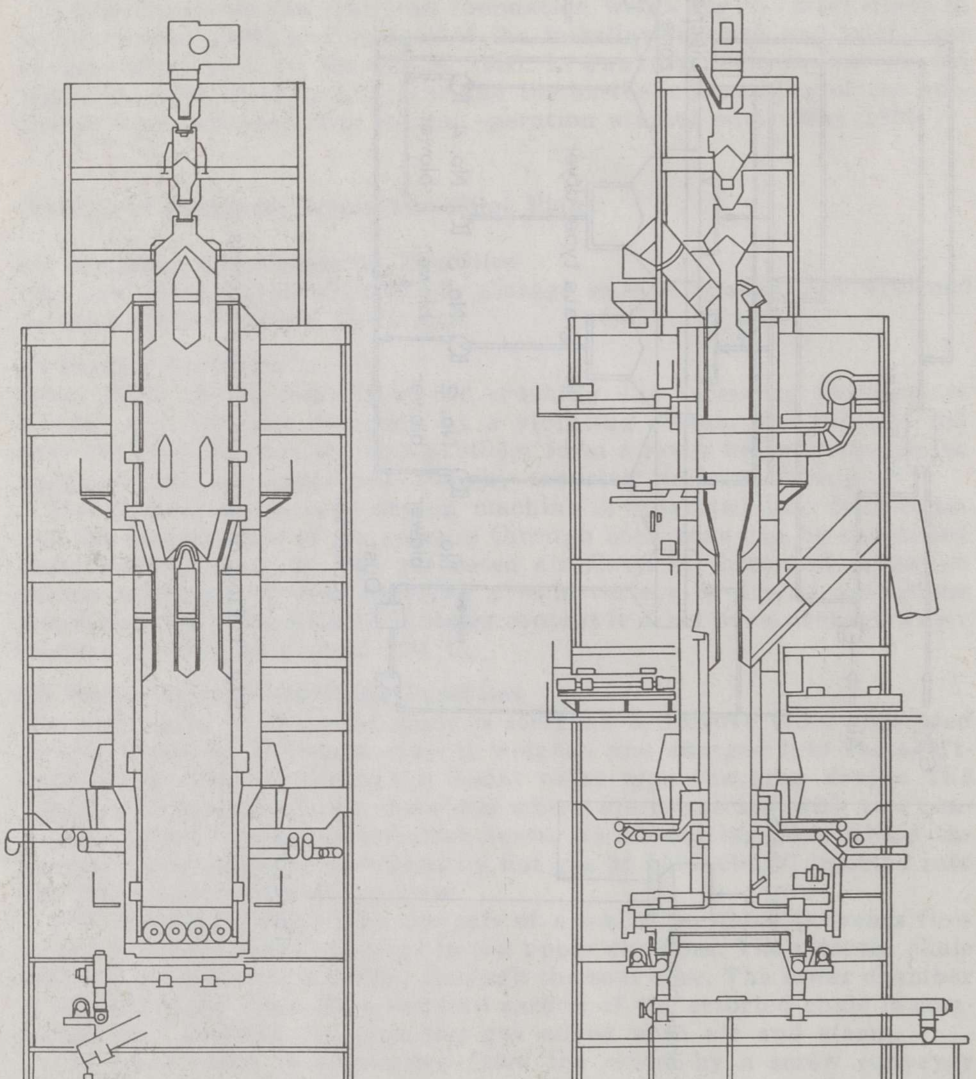

Fig. 4. General arrangement of the shaft-type retort

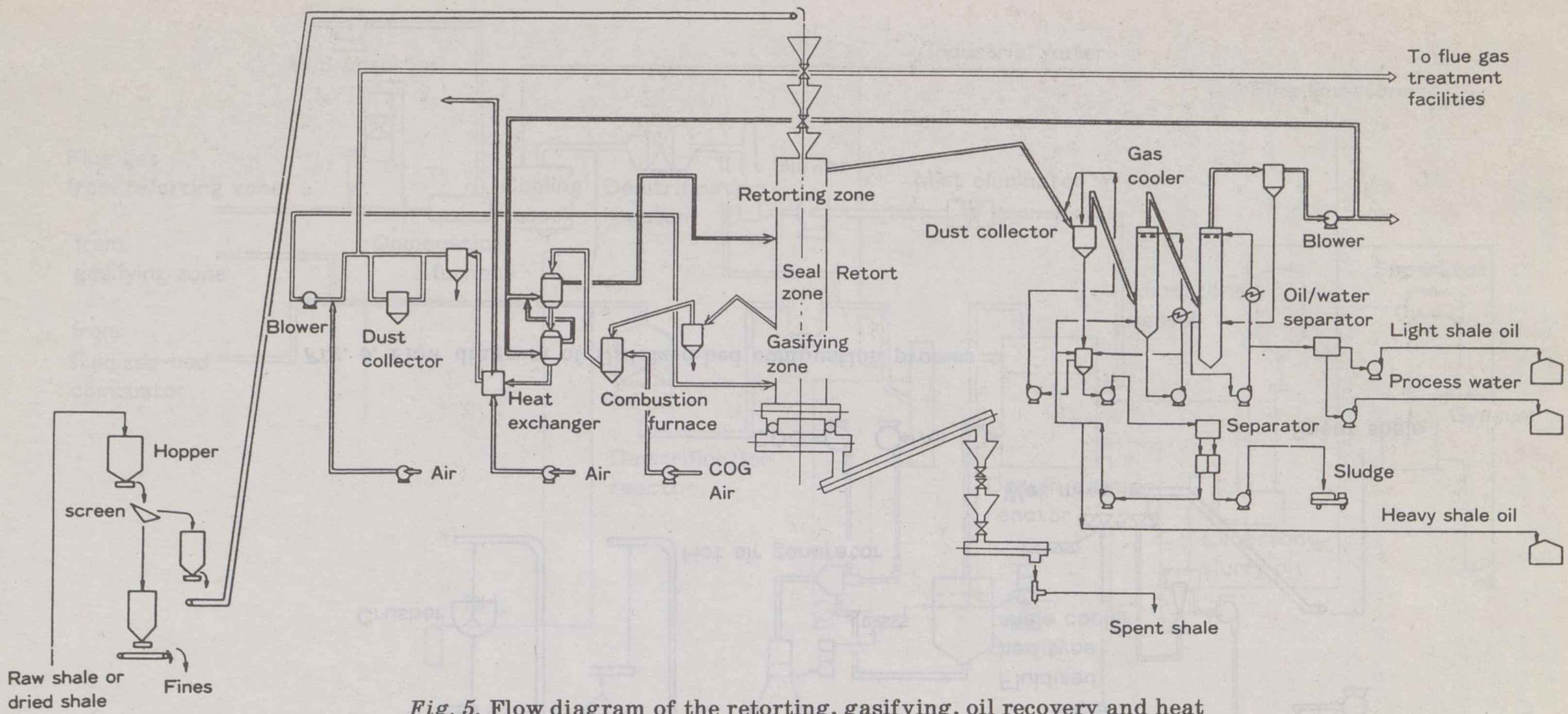

Fig. 5. **Flow diagram of the retorting, gasifying, oil recovery and heat recovery processes**

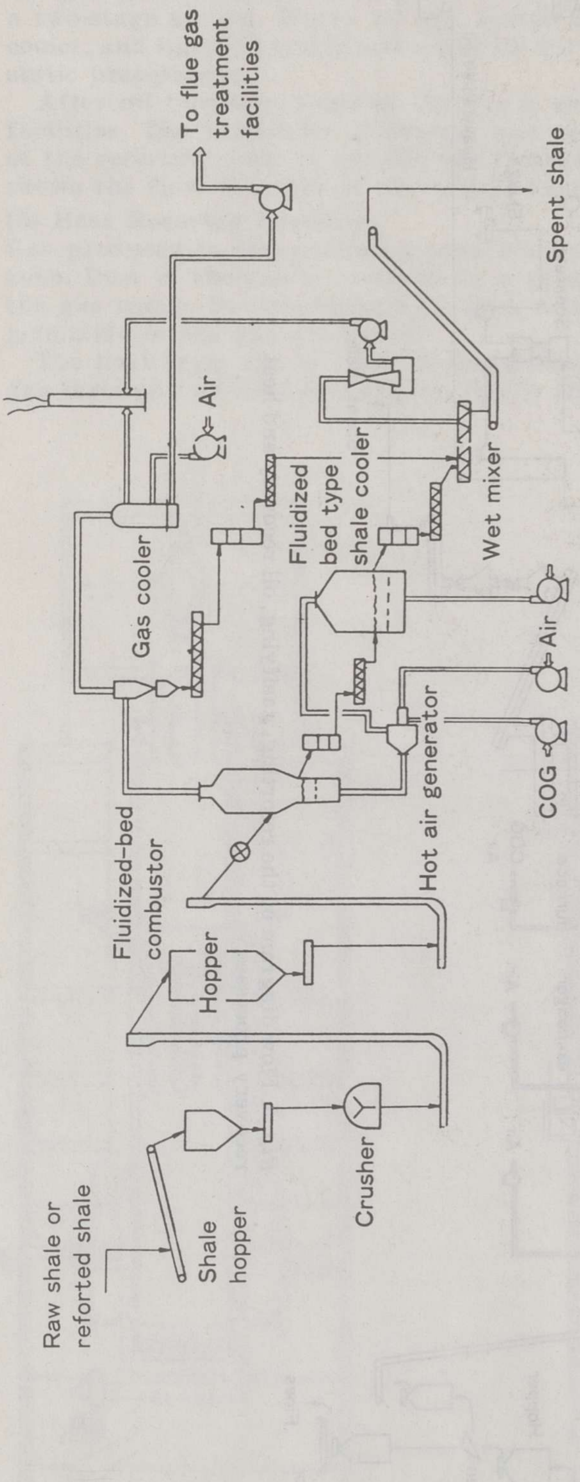

Fig. 6. **Flow diagram of fluidized-bed combustion process**

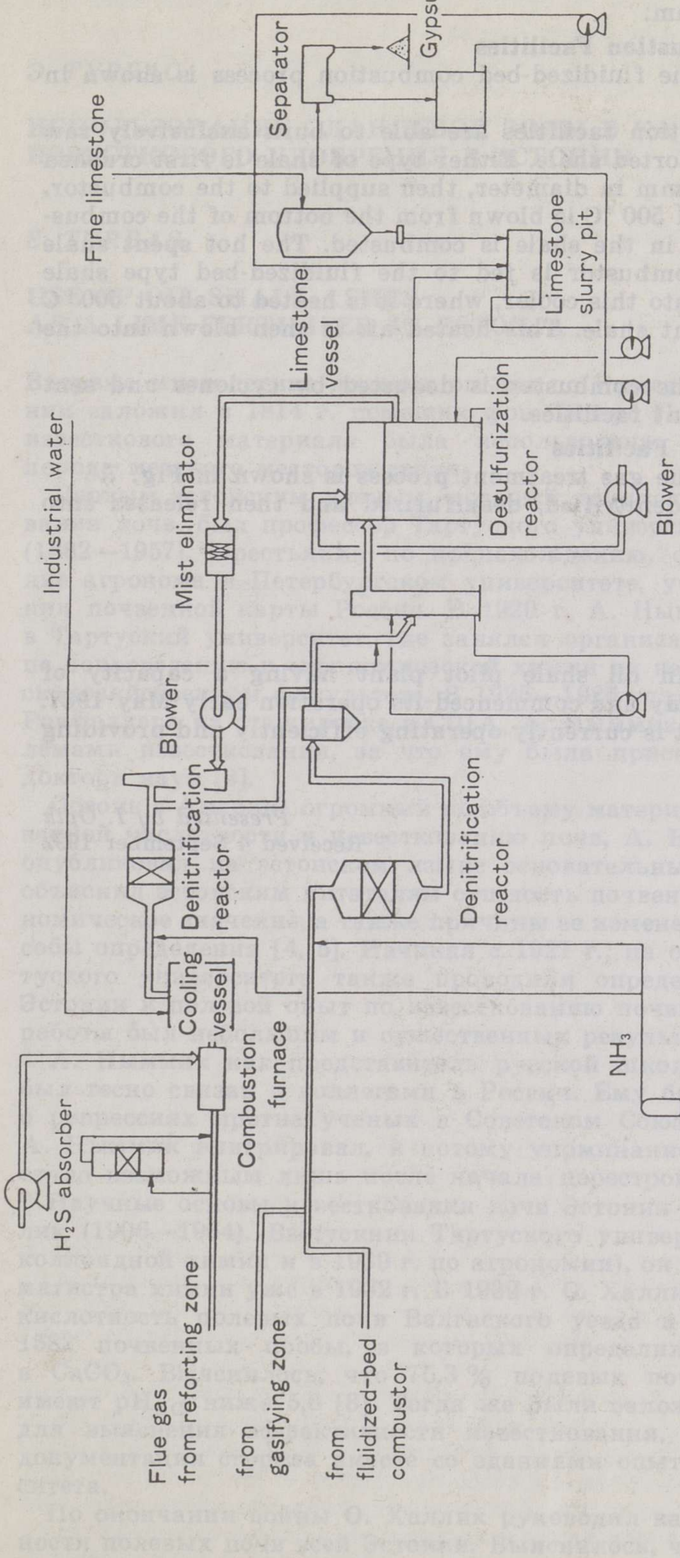

Fig. 7. **Flow diagram of flue gas treatment process**

exchanger. Some of cooled gas is sent to the flue gas treatment facilities. The rest is recirculated to the lower part of the gasifying zone after the addition of air and steam.

(6) Fluidized-Bed Combustion Facilities

The flow diagram of the fluidized-bed combustion process is shown in Fig. 6.

Fluidized-bed combustion facilities are able to burn exclusively raw shale, or exclusively retorted shale. Either type of shale is first crushed to particles less than 6 mm in diameter, then supplied to the combustor. Air preheated to around 500 °C is blown from the bottom of the combustor so that the carbon in the shale is combusted. The hot spent shale discharged from the combustor is fed to the fluidized-bed type shale cooler. Air is injected into this cooler, where it is heated to about 500 °C by cooling the hot spent shale. This heated air is then blown into the combustor.

The flue gas from the combustor is dedusted by cyclones and sent to the flue gas treatment facilities.

(7) Flue Gas Treatment Facilities

The flow diagram of flue gas treatment process is shown in Fig. 7.

Gases are dedusted, denitrified, desulfurized and then released into the atmosphere.

Conclusion

JOSECO constructed an oil shale pilot plant having a capacity of 300 tons — crude ore/day and commenced its operation early May 1987. The oil shale pilot plant is currently operating efficiently and providing promising results.

Presented by I. Öpik
Received 4 September 1992

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