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EXPERIENCE OF OIL SHALE BURNING IN LOW-TEMPERATURE FLUIDIZED-BED BOILERS

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Since 1989 Scientific Production Association *Polzunov Central Boiler-and-Turbine Institute* (CKTI) in co-operation with *Leningradslanets* JSC has designed and introduced several low- and medium-capacity boilers for oil shale burning in fluidized bed (Table 1).

Table 1. **Boilers Put into Commercial Operation**

Boiler	Plant	Heat rating, MW	Quantity	Introduced in	Note
KE-6,5-14C	Mine *Leningradskaja*, Slantsy, Russia	4	1	1990	Reconstruction, hot-water boiler
DKVR-10-13		6.5	1	1993	
KE-6,5-14C	Municipal plant, Shugozero, Russia	4	2	1994	
KV-R-0,8-95 *Pioneer*	*Remzavod*, Slantsy	0.8	1	1998	New boiler, now not in operation
KV-R-11,63-150	Mine *Leningradskaja*, Slantsy	8.1	1	2001	New boiler
KV-R-11,63-150		8.1	1	2002	New boiler

The basic technical solution of boilers design is the installation of a water-cooled air-distributor grate in the lower part of furnace and the boiler equipped with start-up burner, high-pressure primary air fan, secondary air nozzles, and systems of shale and ash handling.

Serious tests and research with the object of optimization of design solution and burning conditions were carried out on boiler plants. The typical scheme of boiler reconstructed for oil shale burning in fluidized bed is illustrated by Fig. 1 (on the example of boiler KE-6,5-14 C), and the boiler KV-R-11,63-150 is shown in Figs 2 and 3.

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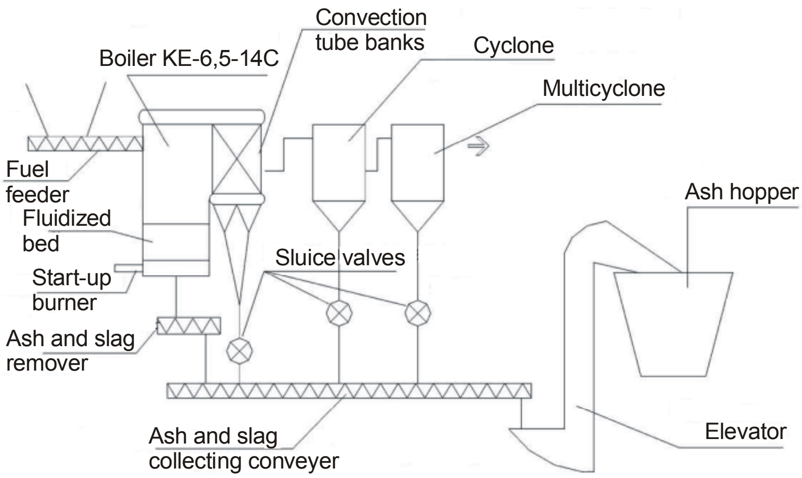

Fig. 1. Scheme for reconstructing the boiler KE-6,5-14C at the boiler house of Shugozero

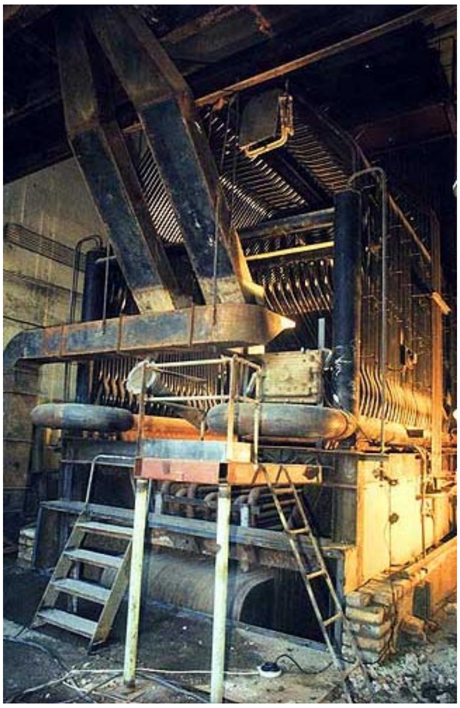

Fig. 2. Mounting of the boiler KV-R-11,63-150 for burning shale in fluidized bed

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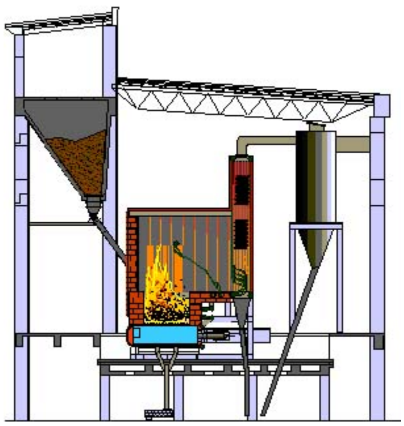

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Fig. 3. General view of the boiler KV-R-11,63-150

Primary air for combustion enters the water-cooled air plenum before it passes through the water-cooled air distributor nozzles (Fig. 4) which uniformly distribute the air across the furnace cross-section and direct oversized material to the 4th spent bed material drain. The start-up burner using light-oil fuel is installed on the back wall of plenum.

a b

Fig. 4. Air-distributor grate of "fluidized bed" (*a*) and layer heat-exchange surfaces in fluidized bed (*b*)

The deflecting water wall divides the furnace and provides gas turn, what contributes to the better mixing of flue gas with air.

The flue gas turns once again at the furnace outlet and passes through the labyrinth separator. The ash particles, collected by the separator, settle out to the hoppers from where they are removed to the ash-handling system. Then flue gas transfers the heat to the convection tube banks and leaves the boiler. To avoid dust settling on the convection tubes a cleaning system (by gas impulse) is used. Then flue gas passes through the multi-cyclone.

Fuel is supplied to the boiler through front furnace wall. The secondary air is also introduced through front furnace wall. The secondary air contributes to nitrogen oxide and carbon monoxide reduction. By means of redistribution between primary and secondary airflows the control over heat release in fluidized bed is performed.

Tests carried out at each boiler have proved high technical characteristics and ecological ones acceptable for this range of capacity. Some characteristics of boiler KV-R-11,63-150 are listed below:

- Boiler efficiency (rated capacity) > 87 %
- Summary losses from both unburned carbon and incomplete combustion < 1 %
- Nitrogen oxide concentration in flue gas < 200 mg/m^3
- Carbon monoxide concentration in flue gas < 400 mg/m^3
- Sulphur oxide concentration in flue gas < 500 mg/m^3

Characteristics of shale burnt during the tests are as follows:

- Heating value 2,035 kkal/kg
- Ash content 46.4 %
- Carbonate content 15.4 %
- Moisture content 10.3 %

The temperature in the fluidized-bed boiler furnace is in the range 800–900 °C and is optimum for SO_2 removal process (due to the calcium carbonate content). The direct measurement of sulphur oxide content in flue gases proves that the efficiency of desulphurization reaches 80–90 %.

The oil shale burning in fluidized-bed boilers is distinguished by very small value of unburned carbon in fly ash. This is conditioned by high content of volatile in shale and also by high value of heat exchange in fluidized bed. Thus, there is no noticeable necessity of fly ash re-injection into furnace chamber. The fly ash (70–90 % of total ash content depending on boiler load) is collected by the labyrinth separator and multicyclone. In this case the content of solid particles in stock gases is 4 mg/m^3. Further reduction of this value is possible when more efficient and, accordingly, more expensive gas cleaning equipment is used.

Apparently the fly ash content depends on fuel granulometric composition, first of all on the dust content. The fractional analysis of shale burnt during the tests is illustrated by Fig. 5 and characteristics of ash removed from the boiler plant by Table 2. The diagram shows that the shale had an excess dust content what caused the rather high value of solid particles in stock gases.

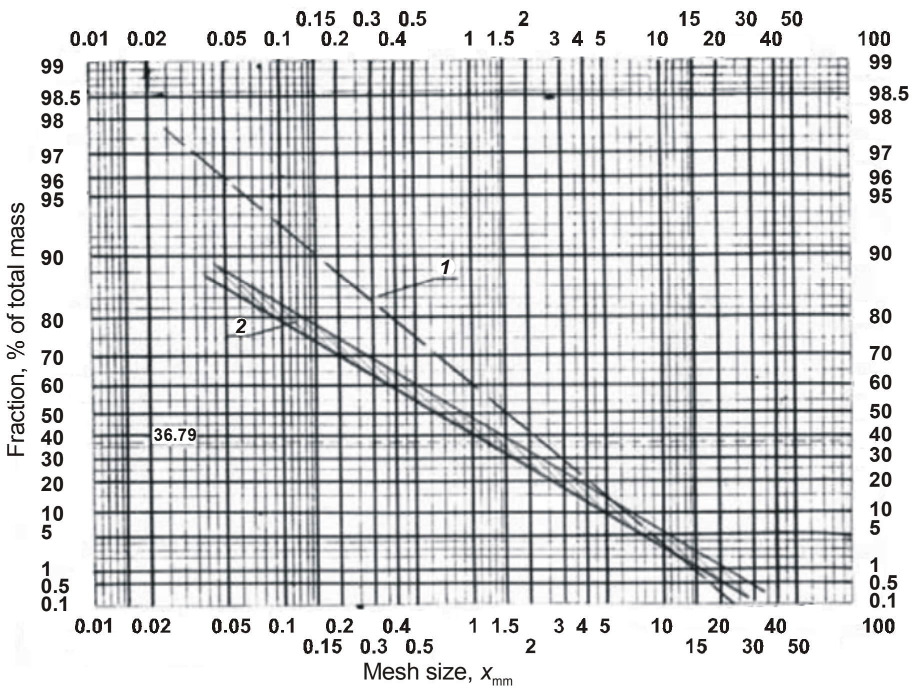

Fig. 5. Granulometric distribution of shale burnt at testing boiler KV-R-11,63-150: *1* – calculated; *2* – actual

Table 2. **Characteristics of Ash Removed from the Boiler Plant**

Indices	Removal point		
	Slag from the furnace	Fly ash collected in	
		labyrinth separator	multicyclone
Granulometric composition, mm	<20	<1.0	<0.5
Moisture, %	<0.5	<0.2	<0.5
Unburned carbon, %	<1.5	<0.5	<0.2
Fraction of total mass, %	10–30	40–50	40–60

More than ten years of commercial operation of oil shale fluidized-bed boilers of small and medium capacity have proved efficiency and economical expedience of oil shale using as a fuel. The wider oil shale power-producing usage is possible with the solution of the ash utilization problem.

This problem is not a new one: ash characteristics are explored, absence of harmful and hazardous components is proved, there is a practical experience of shale ash usage in agriculture (as an ameliorant) and in building industry (as a cement additive). It appears that oil shale combustion ash processing should be integrated in the common plant.