Vertical-section tube furnaces (VS) are characterized by high levels of technoeconomic indexes: low cost of materials of construction relative to capacity, small consumption of alloy steels, low heat losses, and compactness. The sectionalized furnace design provides a means for obtaining furnace sections with heat capacities from 33 to 420 GJ/h or more by means of a set of modules, monotypical sections mounted in the same housing. However, operating experience with these furnaces has revealed a number of shortcomings, particularly the unsatisfactory operation of the GEVK-500 burners and unsuitable design of the convection chamber.

The burner housing, under windy conditions, overheats because of combustion of gas within the housing. Attempts to eliminate the shortcomings of the GEVK-500 burners by changing their design and regulating the operating conditions were not completely successful. In this connection, VNIInefte mash [All-Union Scientific-Research and Design Institute of Petroleum Machinery Construction] developed the GGM-5 burner, which is distinguished by high reliability in operation. A prototype passed commercial tests. Regular production of the GGM-5 burners has been targeted for 1984.

The convection chamber of the furnace section (Fig. 1a) had a coil which, together with the return bends, was mounted in the convection shaft and was supported on two 20Kh23NI8 stainless steel tube sheets, which were also located in the shaft. A considerable quantity of the combustion products passed through the clearance between the walls of the convection chamber and the tube sheets, giving up little heat to the small surface of the return bends. The heat exchange conditions were still poorer when, during operation, the finned part of the coil located between the tube sheets became plugged with deposits. This increased the load on the radiant coil and raised the temperature of the flue gas.

Moreover, in the initial period of furnace service, as a result of jamming of the dampers located in the gas ducts, it became impossible to regulate the draft in the firebox, which reached a level of 0.49 kPa, with the result that considerable quantities of excess air were drawn into the working space of the furnace, and this led to additional heat losses.

Because of these problems, the furnace efficiency was no higher than 58%, the temperature of the combustion products after the convection coil was \(\approx 575^\circ C\), and the consumption coefficient was 1.6 or higher (the corresponding design values are 67%, 500°C, and 1.3).

The convection tube sheets were exposed to particularly severe conditions, as they were washed on both sides with hot flue gas; the temperature of the bottom part of the tube sheets reached levels of 800-850°C; when the furnace load was increased, this temperature rose above 900°C. As a result of severe high-temperature vanadium–sulfur corrosion, these tube sheets failed after 1.5 years of operation.

Lengiproneftekhim [Leningrad State Institute for the Design of Facilities in the Petroleum Refining Industry], with the cooperation of VNIInefte mash, has developed a new design of the convection coil for VS furnaces of LK-6u units. The return bends are brought outside, into isolated chambers; the convection tube sheets are made of thick sheets; the tubes are arranged in a checkerboard pattern and are equipped with two rows of blowoff devices. Groziproneftekhim [Groznyi State Institute for the Design of Facilities in the Petroleum Refining Industry], on the recommendation of VNIInefte mash, in VS type furnaces of KM units and process units for the adsorption recovery of paraffins on zeolites, has applied a different design solution: The convection tube sheets (sheet steel) are insulated on the fire side from the action of combustion products by means of refractory concrete (Fig. 1b).
After eliminating the deficiencies that have been noted and retrofitting the furnaces with the required instrumentation, including several surface thermocouples on the radiant tubes of the coil, a test was run on the furnaces to determine the effectiveness of the measures that had been taken for improving their operation, and to adjust the furnaces to their optimal operating conditions. The operating indexes of the furnaces in the LK-6u units and the results obtained by working up these data are presented in Table 1.

The load on the furnace sections during the time of the tests was held constant at 180 m³/h (90 m³/h per stream). The temperatures of the topped crude at the furnace inlet and outlet were also held constant. The burners were fed with a mixture of residual fuel oil and refinery gas (respective heats of combustion 40,780 kJ/kg and 46,680 kJ/m³) in a 2:1 ratio. The fuel oil and gas were preheated to 120°C; the atomizing steam temperature was 360°C.

During the time of the tests, all of the burners in the section were loaded uniformly. The tests showed that, as a result of reworking the design of the convection chamber, the coil received up to 24% of the total quantity of heat, the average heat load on the radiant tubes was reduced, the temperature of the combustion products after the convection chamber was lowered, and the operating conditions of the convection tube sheets were improved.

In order to determine the optimal operating conditions for the furnace, the draft at the inlet to the convection chamber was varied from 0 to 0.1 kPa in steps of 0.02 kPa. In Fig. 2 we show the efficiency of the section and the consumption of fuel oil as functions of the draft at the inlet to the convection chamber. The optimal efficiency of the furnace section corresponds to a draft of 0.02-0.03 kPa. The minimum fuel oil consumption is also registered at this draft. The fuel gas consumption was held constant during the time of the tests, so that changes in the furnace efficiency resulted only in changes in the fuel oil consumption. The optimal coefficient of air consumption at the inlet to the convection chamber was 1.21-1.23, and after the convection chamber 1.29-1.31.