The Loviisa nuclear power station (NPS) in Finland is equipped with four K-220-44-2 turbines, which were commissioned in 1977–1980. These turbines differed from the first version of this type of turbines by an increased power output with the same parameters and flowrate of live steam, steam reheating temperature, and pressure in the condenser. In its letter to the Nuclear Power Corporation of India written in 2003, the Loviisa NPS management pointed out high quality of the K-220-44-2 turbines and fruitful cooperation with the Turboatom enterprise: by that time, the Loviisa NPP equipped with the K-220-44-2 turbines supplied by Turboatom had been trouble-free operation for more than 25 years. The maintenance program is successfully implemented: each turbine passes inspection every two years; the period between repairs is 8 years for the high-pressure cylinder (HPC) and 12 years for the low-pressure cylinder (LPC). One of the LPCs had been in operation without opening for 16 years. After several years of successful operation and maintenance, the Loviisa NPP management decided to continue cooperation with Turboatom in the field of modernizing the turbines. A contract for modernizing the high-pressure cylinders was signed in summer 1995 and that for modernizing the low-pressure cylinders, in summer 1996.

As a result of stage-by-stage modernization of the K-220-44-2 turbines, the thermal power of the reactor plant’s secondary coolant circuit was increased to 1500 MW and the power unit’s output produced at the generator terminals was increased to approximately 522–524 MW due to increased steam flowrate and turbine unit efficiency. The guaranteed effects obtained at all stages of modernization were confirmed by the guarantee tests that were carried out [1]. The modernized turbines were denoted as K-220-44-2M turbines.

The accomplished stage-by-stage modernization of the K-220-44-2 turbines, the scope of which was determined by the operating conditions and possibilities available at the Loviisa NPS yielded good results; however, the potential possibilities of improving the HPCs were not still been realized to a full extent.

This article describes a comprehensive solution of the problem of improving the technical and economic indicators of the K-220-44-2M turbine unit, which involves increasing the efficiency and power capacity of the HPC flow path as a result of installing an additional stage and carrying out multiparametric optimization of the design and thermal- and gas-dynamic parameters of the flow path and reduction of pressure losses in the steam admission path.

IMPROVEMENT OF THE HPC FLOW PATH

Figure 1 shows the longitudinal section of the existing high-pressure cylinder of the K-220-44-2M turbine after the accomplished stages of its modernization [2]. One characteristic design feature of the flow path is that a vaneless cylindrical guide wheel is used between the first and second stages. All stages are fitted with axial single-comb and radial labyrinth seals: a straight-flow one in the first stage and a TsKTI-type one in the other stages. The outlet compartment comprises a built-in diffuser barrel.

The modernized HPC (Fig. 2) has the casing of the existing HPC (see Fig. 1) and differs from the latter by having an additional stage installed instead of the vaneless guide wheel and by the design of holders.