The safety and economy requirements for the large-scale nuclear power technology are examined. The design particularities are presented. It is shown that serious accidents can be prevented and that the BREST-OD-300 reactor can operate in a closed NFC. Completed and planned works on safety and serviceability validation of the unit are noted.

Work on the concept of nuclear power with natural safety began in the mid-1980s. Large accidents at NPPs, higher building and operating costs of nuclear power facilities and the implementation of an open nuclear fuel cycle, which reduces the scales and levels of nuclear power development, served as the prerequisites for this work.

The main principles with which the new face of nuclear power must comply are as follows:
1) elimination of serious accidents at NPPs (reactivity, loss-of-coolant, fires and explosions) requiring evacuation of the population;
2) closure of the nuclear fuel cycle for full utilization of the energy potential of uranium raw material;
3) systematic approach to radiation-equivalent (with respect to the naturally occurring raw material) disposal of radioactive wastes;
4) technological enhancement of nuclear weapons nonproliferation (no separation of uranium and plutonium during reprocessing of spent nuclear fuel from fast reactors and elimination of the uranium blanket and uranium enrichment); and
5) competitiveness with respect to other forms of electricity production.

The first result of this work was a conceptual design of a reactor unit with natural safety operating in a closed nuclear fuel cycle.

Lead coolant was chosen to attain the required neutron spectrum at low pressure in the first loop as well as to realize other required functions (high thermophysical properties, no crisis of heat transfer in the working range, inflammability at realizable temperatures, high inertness to water and air, low activation, and high radiation resistance).

Full breeding of fissile nuclides in the fast spectrum of the core (CBR ≥ 1) secures efficient use of the energy potential of natural uranium. A high nuclear concentration of fissile and breeding materials due to the use of a dense uranium-plutonium fuel composition secures breeding in the core. This makes it possible for fast reactors to operate in an equilibrium fuel regime without a uranium blanket and with makeup from waste (depleted) uranium only, which eliminates the production of weapon-quality plutonium and creates the prerequisites for rejecting uranium enrichment and mining in the long-term future. Elimination of uranium blankets makes a large contribution to nonproliferation of weapon-grade nuclear materials.

Radiation-equivalent handling of wastes (with respect to extraction and disposal of radionuclides) is achieved by organizing a closed fuel cycle with recycling of long-lived actinides into fuel and only fission products being separated during reprocessing.
Accidents requiring evacuation and resettlement of the population is achieved as a result of the physical properties of the materials and structural features. The small power effect due to a small change in the temperature of heat-conducting nitride fuel combined with CBR \( \approx 1 \) enables operation with low reactivity excess comparable to \( \beta_{\text{eff}} \), which eliminates reactor runaway on prompt neutrons. The use of dense heat-conducting fuel made it possible to decrease the stored energy appearing in the fuel during disruptions of normal operation and thereby facilitate transitional processes.

An integrated arrangement of the first loop of the reactor unit in the reinforced concrete vessel was proposed to prevent loss of cooling of the core during disruptions of normal operation which are associated with loss of coolant. This solution also increased the heat capacity of the loop considerably and facilitated transitional processes. The use of lead coolant gives the required level of natural circulation during disruptions of normal operation together with lower expenditures on pumping during normal operation. A loop with a high heat capacity and high inertia made it possible to use a passive emergency cool-down system with atmospheric air as the terminal absorber.

The use of a coolant that is chemically inert with respect to the working body made it possible to do away with an intermediate loop. Because of the large margin to boiling of the coolant at moderate energy density in the core high live-steam temperature was proposed, which gives efficiency 44–47%.

All these fundamental advantages of the concept made it possible to switch in 1999 to implementation of the technical design and perform R&D work on a 300 MW(e) experimental-demonstration fast reactor with natural safety (BREST-OD-300) – a prototype of a reactor unit with high commercial power. The power level of the reactor unit under development was determined not only by the desire to ensure portability of lay-out decisions and implementation of the main equipment for future commercial reactors but also by the possibility that the reactor unit will reach an equilibrium fuel regime with operation in a closed NFC using internal regenerated fuel with makeup by depleted uranium only.

The materials pertaining to the technical design of the reactor unit and the design of a NPP with a BREST-OD-300 reactor have been released, and work on experimental validation has begun. In 2002, an experts’ analysis revealed that R&D work performed in separate directions is incomplete, the validation of some technical solutions is inadequate, and the work was largely stopped.

The understanding of the key problems limiting the possibility of developing large-scale nuclear power based on existing technologies has activated the development of fast reactors with natural safety operating in a closed NFC. In 2010, the Federal Targeted Program on New-Generation Nuclear Power Technologies for the Period 2010–2015 and to 2020 was approved. This program implements the development (including experimental validation) and construction by 2020 of an experimental-demonstration power unit with a BREST-OD-300 reactor.

**Design Features of the BREST-OD-300 Reactor.** The main technical solutions incorporated today conform to the concept developed two decades ago and take account of previous work.

The BREST-OD-300 reactor is designed in a two-loop implementation (the third loop is the terminal absorber) with supercritical water vapor as the working body. The general characteristics of the BREST-OD-300 reactor are as follows:

**Power, MW:**
- thermal .......................................................... 700
- electric ............................................................ 300

**First-loop coolant** .......................................................... High-purity lead

**Reactor block arrangement** ........................................... Integrated

**Thermal scheme of the reactor unit** ................................. Two-loop

**Second-loop coolant** ........................................................ Subcritical water–steam

**Second-loop coolant temperature, °C:**
- at entrance into steam generator ................................. 340
- at exit from steam generator ................................. 505

**Second-loop coolant temperature, MPa:**
- at entrance into steam generator ................................. 18
- at exit from steam generator ................................. 17