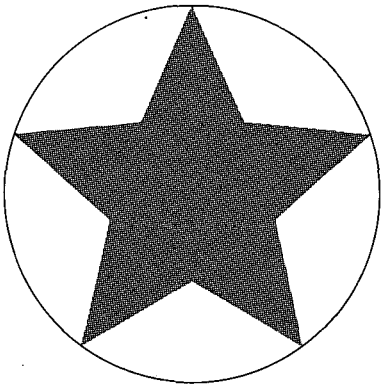


Building and Operation of the First Atomic Power Station: Some Problems and Solutions Recalled

by Professor D.I. Blokhintsev and Professor A.K. Krasin

For a man who has devoted his efforts and knowledge to science and technology, the greatest happiness in life is to see his research and development work transformed into an operating facility. Twenty years ago, on 26 June 1954, this longed-for day arrived for those of us who had taken part in the construction of the world's first atomic power station: on that day, the energy released in the fission of uranium nuclei bombarded by neutrons became, for the first time, a source of electric power on an industrial scale.

The first atomic power station had a capacity of 5000 kW(e). To build such a station we had to solve many scientific and technological problems. During the last twenty years our knowledge of nuclear interactions, and also our experience in the design and construction of nuclear reactors, have grown enormously. Given the present state of knowledge, it is in fact rather difficult to imagine how limited were the scientific and technological resources and methods which we were able to deploy in our work on the first atomic power station.

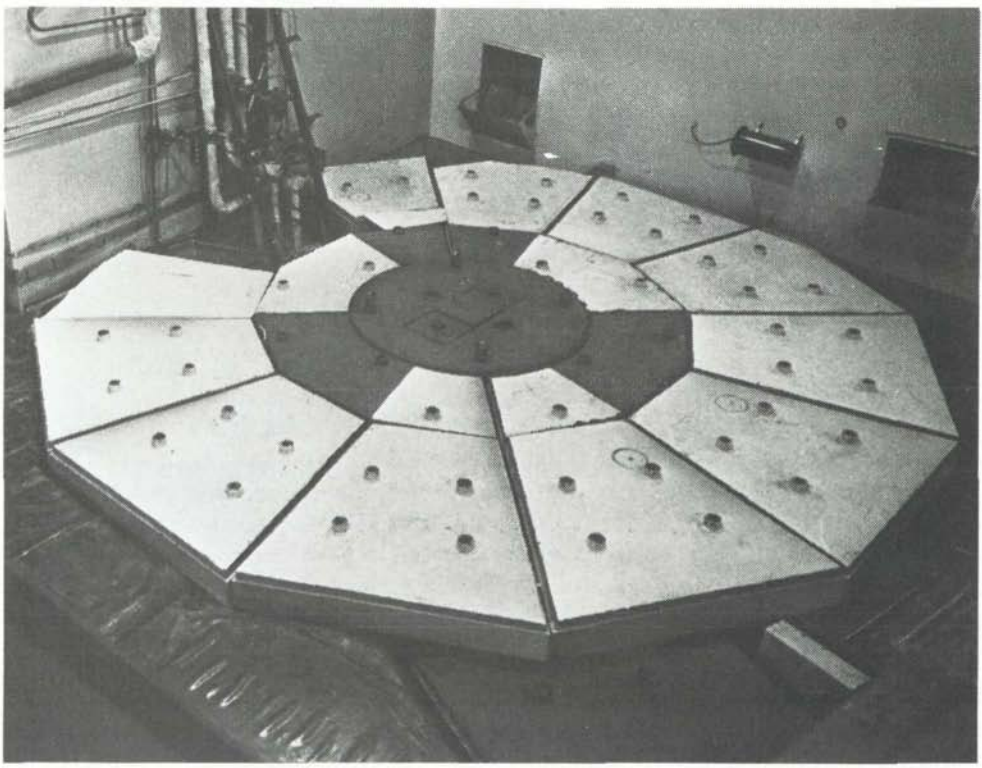
In the first place the answer to the basic question – whether it was worth even trying to derive electric power from nuclear transformations – was still far from certain. Nowadays no one has any doubt about the answer, because in the meatime nuclear power has shown itself to be reliable, safe and economic, but at the beginning of the 1950s it was not only the ubiquitous sceptics who expressed doubts; sensible specialists were also cautious in their opinions.

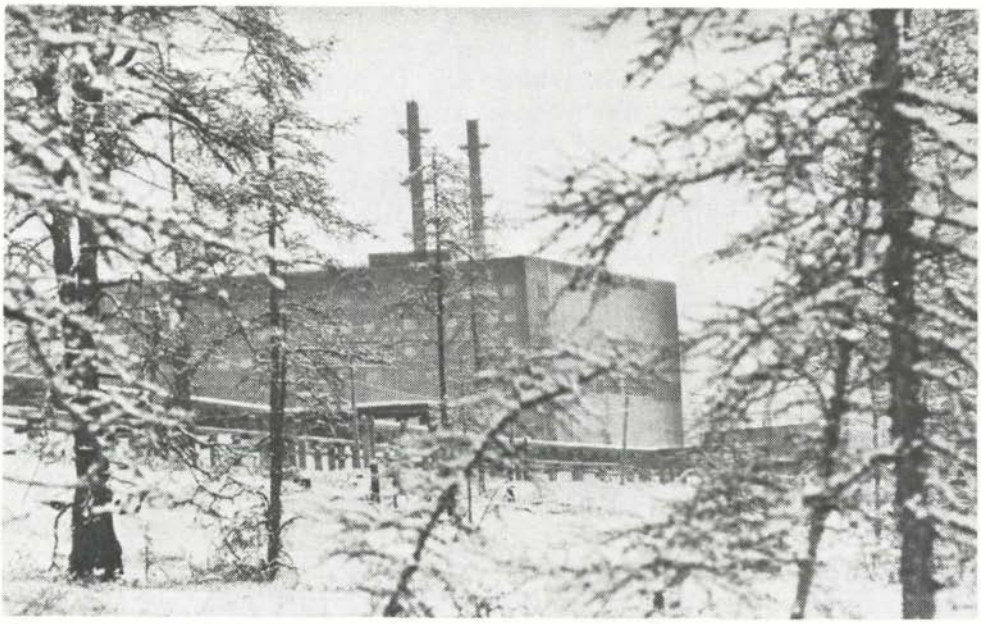
In those years it was only in the Soviet Union that the goal of building an atomic power station had been clearly formulated, and the attainment of that specific goal, rather than the incidental production of electric power, became the task of a large group of specialists. The launching of the first atomic power station in the world was a true and convincing demonstration that the idea of deriving electric power from atomic nuclei was realistic.

Our second fundamental problem, that of selecting a technical design, was also difficult because there were no previous examples of atomic power stations to serve as a guide, and numerous physical and technological designs were, in principle, quite conceivable. The choice ultimately made was a compromise between the urge to do something completely novel and the realisation that acquired experience must have its due: the moderator

The first nuclear power station, built at Obninsk, USSR, in 1954. Photo: Tass.

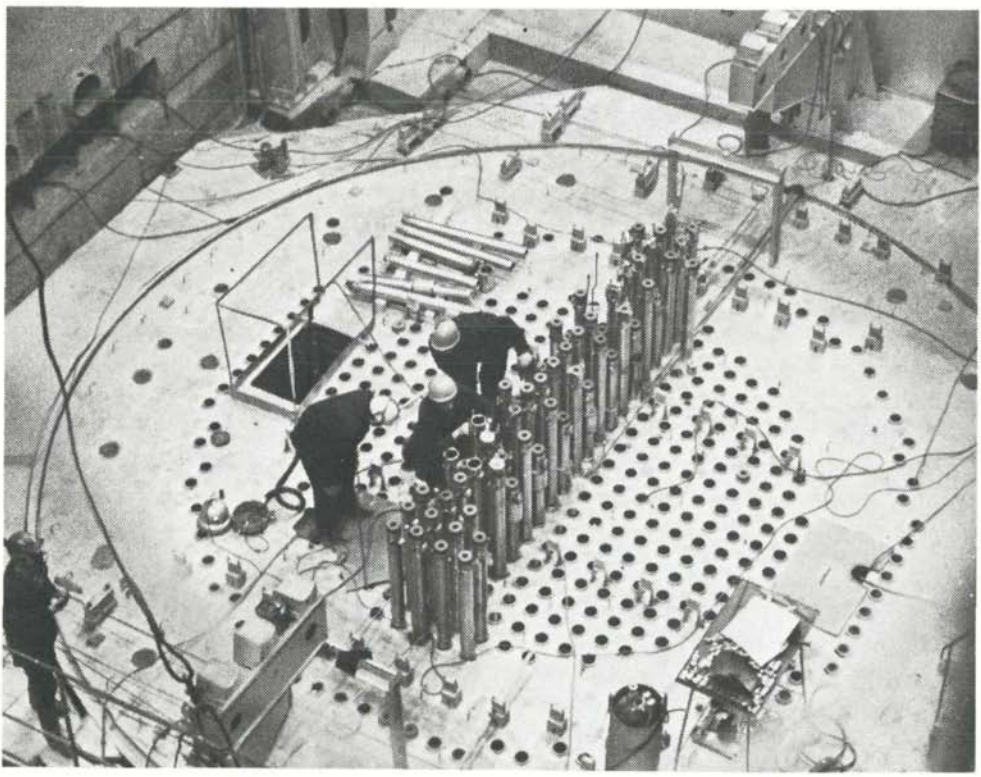
The reactor top cover plate of the Obninsk nuclear power station. Photo: USSR State Committee on the Utilization of Atomic Energy.





A general view of the Soviet graphite moderated, water cooled Bilibinsk nuclear power plant. Photo: Tass.

Assembly of the reactor core at the Bilibinsk nuclear power plant. Photo: Tass.



selected was graphite, the coolant ordinary water, the fuel enriched uranium and the structural material stainless steel. This choice, together with the first evaluations of the design as a whole, was made by I.V. Kurchatov, N.A. Dollezhal and S.M. Feinberg. The technical solutions adopted for the first atomic power station have often been described, and they turned out to be well justified not only as a first step on the path towards nuclear power, but also as a technical basis for the development and construction of many later nuclear power stations in the Soviet Union.

A third and particularly difficult problem connected with the project was that of finding highly qualified staff. At the beginning of the 1950s there were very few specialists in nuclear technology, and not only beginners in the field but also project leaders had much to learn. The staffing problem was solved largely by training and recruiting young scientists and technologists.

Of the numerous technical problems that had to be solved during the construction of the reactor we would like to single out one that proved to be particularly difficult, namely, the development of a suitable fuel element technology. This task was handled successfully by V.A. Malykh. Early on in the design work it was decided to build a channel type reactor using tubular fuel elements, with the coolant at a pressure of 100 atm within the tube, and with the fuel material located outside the coolant tubing. A number of possibilities were considered: rigid attachment of the hollow fuel cylinders to the tube, the provision of an elastic layer between the hollow cylinders and the tube, and a number of others. The design ultimately selected was that proposed by Malykh, using an enriched uranium-molybdenum alloy in powder form (particles 0.1 - 0.5 mm in diameter) dispersed through the intertube space in a magnesium matrix. This dispersion proved to be capable of functioning under high heat fluxes, above 7×10^6 kcal/m^2/hr, and to burn-ups of 35 000 MWd/t. The fuel element design guaranteed the first atomic power station a long and accident-free operating life. An important factor for the high reliability of the fuel elements was the system of non-destructive testing of components during mass production devised by V.A. Malykh. Tests on fuel specimens carried out in the RFT reactor of the Atomic Energy Institute, which now bears the name of Academician Igor Vasilievich Kurchatov, also had an important bearing on the fuel element technology selected for the first atomic power station.

At the beginning of the 1950s the resources available for calculating the physical characteristics of a reactor were in many respects – particularly as regards counting technology, methods of calculation and the availability of nuclear data – inadequate. A helpful basis for evaluating the correctness of the physics calculations carried out for the reactor was provided by experiments on critical assemblies made of materials and in sizes similar to those chosen for the reactor design. As a result, the calculated characteristics of the reactor and the true characteristics as they ultimately emerged were reasonably similar. M.G. Minashin was responsible for a great deal of this work.

In connection with the design and operation of the reactor, a great deal of attention was given to transitional operating regimes and potential accident situations. Particularly careful study was devoted to the possibility of inner fuel element tube bursts or ruptures of the channel tubing within the reactor. A number of mock-ups were used to develop "cut-off" devices and equipment for removing water from the reactor housing. Subsequently all these devices and operating regimes were successfully tested in

real operating conditions and the requirements of safety were shown to be completely satisfied.

The first atomic power station project was accompanied by a vast amount of research work in different disciplines. The availability in the Soviet Union of the RFT high-flux reactor, described in detail at the First Conference on the Peaceful Uses of Atomic Energy in Geneva in 1955, made it possible to refine much of the data on neutron interactions with fissionable nuclei and nuclei of structural materials; investigations on the radiation stability of structural materials were carried out; experimental loops were built for testing fuel elements specimens; and so on. Methods of calculating physical reactor characteristics and biological shielding also made a great deal of progress during this work.

A great deal of theoretical study was devoted to engineering methods for calculating reactor regulation and control devices. Analog machines were used in addition to computers for calculating changes in the isotopic composition of the reactor core and for analysing non-steady thermal processes.

All this work required the assistance of a large number of theoretical and experimental physicists and of engineers, technologists and designers; and at all stages there was a thorough interchange of ideas, experience and information between the groups belonging to the different institutions taking part in the project.

Once all the technological problems had been solved, the first atomic power station provided a unit where many physical and technological experiments could be carried out. The first in a long series of experiments was a study of reactor operation with boiling water in many parallel operating channels. Channel operating regimes designed for nuclear steam superheat were also devised, under the guidance of A.M. Grigoryants, and the results of this work served as a basis for the design of the Beloyarsk nuclear power station.

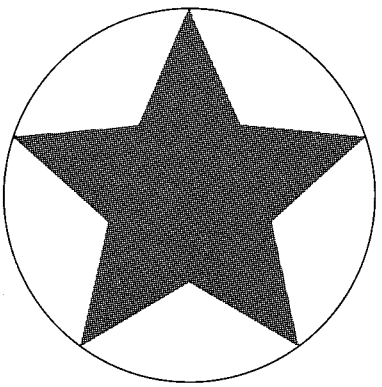
In the years that followed, numerous loop experiments were carried out on individual fuel element models and systems designed for new power stations. These experiments have made a large contribution to the development of nuclear power.

The first Atomic Power Station has operated for 20 years without any significant failures or incidents. This long period of operation confirms that the lifetimes of 20 years now being forecast for future nuclear power stations are perfectly realistic. The specific reason for this success can be summarized as follows:

1. Comprehensive development work and experimental testing of all project components with a view to ensuring the reliability of the whole design;
2. A thorough development of the technology of tubular fuel elements with dispersed fuel particles, and a comprehensive system of non-destructive component testing during fuel element fabrication;
3. A consistently high level of technology in the manufacture of all equipment and instrumentation;
4. Careful preparation of operating standards and strict adherence to them; and
5. Good training of engineers and technical staff, and a keen sense of responsibility for their work among all who took part in the construction, start-up and operation of the power station.

As the first atomic power station progressed from the design stage through construction to start-up and regular operation, the staff of the Institute of Physics and Power Engineering and the town of Obninsk, near which the station is located, grew apace. The Institute was founded in 1946. The task of building an atomic power station naturally stimulated its development. Today the Institute of Physics and Power Engineering in Obninsk is known for its achievements in fundamental research as well as its work on the engineering aspects of power reactor design and the specific development work carried out for many nuclear power stations.

After 20 years it is gratifying to recall how the start-up of the world's first nuclear power station in the Soviet Union demonstrated to all the world the reality of the utilization of atomic energy, not for the destruction of cities and people, but in the service of human happiness and prosperity.



Atomic Power Generation and Future Technical Progress

by Academician A.P. Aleksandrov and
Professor N.N. Pnomarev-Stepnoj

The construction of the world's first atomic power station in the Soviet Union in 1954 not only marked the beginning of a new trend in power engineering but also clearly demonstrated the practicability of human utilization of the vast resource of nuclear energy.

The discovery of the fundamental possibility of using the energy released by the chain reactions associated with fission of heavy nuclei and fusion of light nuclei was a stupendous gift of science.

The full significance of these revelations will appear later, at the end of this century, but it is already clear that the widespread use of nuclear energy from fission and fusion is inevitable, as the only technically and economically satisfactory way of overcoming the shortage of cheap fuels such as oil and gas.

The large-scale development of atomic power engineering for various purposes – electric power, process heat and district heating, heat and power supplies for the metallurgical industry, power and heat for different branches of the chemical industry and radiation stimulation of chemical products – will help to save oil and gas so that they can be used for purposes where they are most difficult to replace.