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ATOMIC ENGINEERING

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Atomic engineering is the area of technology based on the use of reaction of division nuclear cores for development of heat and for production of electric power. In 1990 atomic power stations in the world (APS) made up 16 % of generated electric power. Such power stations were operating in 31 countries and have still been being built in 6 countries. The nuclear power sector is the most considerable in France, Belgium, Finland, Sweden, Bulgaria and Switzerland, i.e. in those industrially developed countries, where there are insufficient natural power resources. These countries produce from one fourth to half of the electric energy by the atomic power stations. The USA produces by the atomic power stations only one eighth part of the electric power, but it makes the country the first world producer.

The atomic engineering remains a subject of sharp debate. Supporters and opponents of atomic engineering sharply disperse in estimations of its safety, reliability and economic efficiency. Besides, there is widespread opinion on possible leakage of nuclear fuel from sphere of electric power manufacture and its use for manufacture of the nuclear weapon.

1. Nuclear fuel cycle. The atomic engineering is the difficult manufacture including set of industrial processes which together form a fuel cycle. There are different types of fuel cycles depending on the type of a reactor and how the final stage of a cycle proceeds.

Usually fuel cycle consists of the following processes: uranium ore is extracted in mines. Ore is crushed to get a dioxide of uranium, and a radioactive waste goes to a sailing. Received uranium oxide is transformed into uranium hexafluoride. For concentration increase uranium -235, uranium hexafluoride is enriched at factories on division of isotopes. Then the enriched uranium is converted again in a firm dioxide of uranium of which fuel tablets are made. Tablets are collected to form heating elements (“twels”) which are united in assemblages for placement in an active zone of a nuclear reactor of the atomic power station. The remains of the fuel, taken from the reactor, have high level of radiation and after cooling on the territory of power station goes to special storehouse. Waste disposal with low level of radiation is collected during operation and station maintenance service. After service life the reactor should be taken out of service (with deactivation and removal in a waste of knots of the reactor). Each stage of a fuel cycle is regulated so that safety of people and environment protection were provided.

2. Nuclear reactors. Industrial nuclear reactors were originally developed only in the countries possessing the nuclear weapon. The USA, the USSR, Great Britain and France actively investigated different variants of nuclear reactors. However, three core types of reactors began to dominate subsequently in atomic engineering, differing, mainly on fuel, the heat-carrier applied to maintenance of the necessary temperature of an active zone, and a delay mechanism, used for decrease of neutrons speed, allocated in the course of disintegration and necessary for chain reaction maintenance.

Among them the first (and the most widespread) type is a reactor on the enriched uranium in which both the heat-carrier, and a delay mechanism water (easy-operate the reactor is usual, or "light"). There are two basic versions of “light” reactors: the reactor in which steam is rotating the turbines, is formed directly in an active zone (the boiling reactor), and the reactor in which steam is formed in external, or the second, a contour connected with the first contour by heat exchange and steam and gas generators (the water-water power reactor – WWPR). The reactor has been used under programs of armed forces of the USA. So, in 1950 the company «General electric» and "Westingaus" developed “light” reactors for submarines and aircraft carriers for the Navy of the USA. These firms also were involved in realization of military programs of working out technologies of regeneration and enrichment of nuclear fuel. In the same decade the boiling reactor with a graphite delay mechanism was developed in the Soviet Union.

The second type of the reactor, which found practical application, – gas-cooled reactor (with a graphite delay mechanism). Its development also was closely connected with early programs of working out the nuclear weapon. In the late forties – the beginning of 1950th Great Britain and France, aspiring to create their own nuclear bombs, paid the basic attention to develop gas-cooled reactors which develop effectively enough weapon plutonium and besides can work on natural uranium.

The third type of the reactor making commercial success is a reactor in which both the heat-carrier, and a delay heavy water mechanism is used. At the beginning of a nuclear century potential advantages of heavy water reactors were investigated in a number of countries. However, manufacture of such reactors has been concentrated mainly in Canada, partly because of its extensive stocks of uranium.

3. Development of the nuclear industry. After the Second World War in electric power industry all over the world were invested ten billion dollars. This construction boom has been caused by fast growth of demand for the electric power, on the rates which considerably surpassed growth of the population and the national income. The basic emphasis was made on thermal power stations (TPS), burning coal and, to a lesser degree, on oil and gas, and also on hydroelectric power stations. There were no atomic power stations of industrial type till 1969. By1973 practically in all industrially developed countries were used resources of large-scale water-power. Sharp increase of the prices for energy carriers after 1973, fast growth of the requirements to the electric power, and also growing concern in possibility of national power independence loss – all it promoted the statement of a sight at atomic engineering as a unique real alternative energy source in the foreseeable future. Embargo on the Arabian oil 1973–1974 moved an additional wave of orders and optimistic forecasts of atomic engineering development.

But each next year the corrective amendments in these forecasts were introduced. On the one hand, the atomic engineering had the supporters in the governments, in the uranium industry, research laboratories and reduced the influential power companies. On the other hand, there was a strong opposition in which the groups protecting interests of the population, cleanliness of the environment and the right of consumers have united. Disputes which have proceeded and, have concentrated mainly round questions of an adverse effect of various stages of a fuel cycle on environment, probability of failures of reactors and their possible consequences, the organization of building and operation of the reactors, comprehensible variants of a burial place of a nuclear waste, potential possibility of sabotage and an attack of terrorists on the atomic power station, and also questions of multiplication of national and international efforts in the field of non-distribution of the nuclear weapon.

4. Safety problems. Chernobyl accident and other failures of nuclear reactors in 1970 and 1980th have made it clear that such failures are often unpredictable. For example, in Chernobyl the reactor of 4th power unit has been seriously damaged as a result of the sharp jump of the capacity which has arisen during its planned reenergizing. The reactor was in a concrete cover and has been equipped by system of an emergency after cooling and other modern systems of safety. But nobody realized that during reactor reenergization there can be a sharp jump of capacity and the gaseous hydrogen formed in the reactor after such jump, having mixed up with air, would blow up so that will destroy a reactor building. As a result of

failure were lost more than 30 people, more than 200 000 people in Kiev and other areas received big doses of radiation, the sources of water supply of Kiev were infected. In the north beginning from an accident place – directly on a way of a radiation cloud – there were the extensive Pripyat bogs having the vital value for ecology of Belarus, Ukraine and the western part of Russia.

In the United States the enterprises building and maintaining nuclear reactors, too have faced set of problems of safety that slowed down building, forcing to make numerous changes to design indicators and operational specifications, and led to increase in expenses and the electric power cost price. Apparently, there were two basic sources of these difficulties. One of them – a lack of knowledge and experience in this new branch of power. Another – development of technology of nuclear reactors in which course there are new problems. But remain also old, such, as corrosion of pipes of steam and gas generators and cracking pipelines of boiling reactors. Aren't solved up to the end and other problems of safety, for example the damages caused by sharp changes of the expense of the heat-carrier.

5. Atomic engineering economy. Investments into atomic engineering, like investments into other areas of manufacture of the electric power, are economically justified, if two conditions are satisfied: cost of kilowatt-hour is no more, than at the cheapest alternative way of manufacture, and expected requirement for the electric power, high enough that the made energy could be on sale at the price exceeding its cost price. In the early seventies world economic prospects looked very favorable for atomic engineering: quickly grew both requirement for the electric power, and the prices for fuel principal views – coal and oil. As to cost of building of the atomic power station almost all experts have been convinced that it will be stable or even begins to decrease. However it became clear in the early eighties that these estimations are erroneous: Growth of demand for the electric power has stopped, the prices for natural fuel not only didn't grow any more, but even started to decrease, and atomic power station building managed much more expensively, than it was supposed in the most pessimistic forecast. As a result the atomic engineering everywhere has entered a strip of serious economic difficulties, and the most serious they appeared in the country where it had arisen and developed most intensively, – in the USA.

It becomes clear if to carry out the comparative analysis of economy of atomic engineering in the USA why this industry has lost competitiveness. From the beginning of 1970th years expenses for the atomic power station have sharply grown. Expenses on usual HPS develop of direct and indirect capital investments, expenses for fuel, working costs and expenses on maintenance service. For service life TPS, burning coal, expenses for fuel average 50–60 % of all expenses. In an atomic power station case capital investments dominate, making about 70 % of all expenses. Capital expenses for new nuclear reactors on the average considerably exceed expenses on fuel coal TPS for all term of their service, than advantage of economy on fuel in case of the atomic power station is brought to nothing.

Among those who insist on necessity to continue search of safe and economic ways of development of atomic engineering, it is possible to allocate two basic directions. Supporters of the first believe that all efforts should be concentrated to elimination of mistrust of a society to safety of nuclear technologies. For this purpose it is necessary to develop new reactors, more safe, than existing “easy”. Two types of reactors here are of interest: «technologically extremely safe» the reactor and "the modular" high-temperature gas-cooled reactor.

The prototype of the modular gas-cooled reactor was developed in Germany, and also in the USA and Japan. Unlike light water reactor, the design of the modular gas-cooled reactor is that that safety of its work is provided passively – without direct actions of operators or electric or mechanical system of protection. In technologically limiting safe reactors the system of passive protection is applied too. Such reactor, which idea was offered in Sweden, apparently, hasn't promoted further design stages. But it has got serious support in the USA among those who sees at it potential advantages in front of the modular gas-cooled reactor. But the future of both variants is foggy because of their uncertain cost, difficulties of working out, and also the disputable future of the atomic engineering.

Supporters of other directions believe that until new power stations are required in the developed countries, there is not enough time for working out of new reactor technologies. In their opinion, the priority consists in stimulating investments in atomic engineering.

But besides these two prospects of development of atomic engineering was generated absolutely different point of view - fuller recycling of the existing energy, renewed power resources (solar batteries etc.) and power savings. According to supporters of this point of view if the advanced countries switch to working out of more economic light sources, electrical household appliances, the heating equipment and conditioners, saved electric power will be enough to manage without all existing atomic power stations. Observed considerable reduction of current consumption shows that profitability can be the important factor of restraint demand for the electric power.

Thus, the atomic engineering hasn't sustained tests for profitability, safety and public recognition yet. Its future depends on its effectiveness and reliability, control over construction and atomic power stations operation, and also on a number of other problems. Such as the problem of radioactive wastes removal, it depends on how successfully the problems will be solved. Future of the atomic engineering depends also on viability and development of its strong competitors – TPS, burning coal, new energy saving technologies and renewable power resources.