Prospects of construction of facilities for processing and storage of radioactive waste of the NPP

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Abstract. Use of nuclear fuel on the nuclear power plants (NPP) requires special attention at the further order of radioactive waste (RW). Therefore there is a requirement of innovative and perspective approaches of construction of facilities of processing and storage of RW to protect the environment from a large number of radiation. Relevant the question of prospects and new approaches to construction of these objects arises at design, construction and operation where high requirements of objects of nuclear sector are considered. Nuclear sector, occupies one of key positions in the 21st century. Solvable tasks in the field of the analysis of methods of processing and storage of radioactive waste of the NPP, will allow to make construction of facilities of nuclear power safer and eco-friendly that in the international practice is one of priority tasks for these objects.

1. Introduction

The increasing deficiency of organic fuel and steady growth of energy consumption in the countries of the world community dictate need of development of alternative energy sources, the most real of which is nuclear fuel. The nuclear power occupies one of key positions on obtaining useful energy, both thermal, and electric now. Operation of the nuclear power plants working due to division of kernels leads to the serious problems connected with formation of a huge amount of radioactive waste and has the extreme world importance. By the available estimates so far about 300 thousand tons of the fulfilled nuclear fuel around the world are saved already up, and by 2030 this volume will increase up to 500 thousand tons [1]. In this article the key problem of nuclear power is creation of objects of storage and processing of radioactive waste of the NPP with a possibility of their further use.

In this article key research problems are considered:

- to make the analysis of methods of processing and storage of radioactive waste of the NPP;
- to make comparison of the Russian and international experience in the sphere of construction of these objects;
- to offer relevant ways of storage and processing of radioactive waste of the NPP.

It should be noted that the question of development of theoretical bases and methodical approaches to formation of effective mechanisms at design, construction and operation of objects of nuclear power in the field of storage and processing of Russian joint stock company, is a key position for the world energy companies.
2. Scientific work

Now there are three fundamental problems defining the relation of society to development of nuclear power and construction of facilities of this appointment as to potentially dangerous technology:

1) risk of severe accidents;
2) treatment of radioactive waste (including with fulfil nuclear fuel);
3) non-proliferation of the sharing materials (risk of global nuclear terrorism).

From the listed problems in public consciousness the problem of treatment of radioactive waste (RW) - the waste containing radioactive isotopes of chemical elements prevails. The nuclear power bears full responsibility for all the waste and completely pays works on their contents and utilization. Radioactive isotopes on the NPP are formed at division $^{235}\text{U}$ and $^{239}\text{Pu}$ and activation by neutrons and protons of constructional materials, impurity of the heat carrier, delay mechanism and fuel. Energy, a half-life period and a type of radiation are important characteristics of degree of danger of isotope [2]. One waste can be diluted and dissipate in the environment, others – to concentrate and be isolated, and the third – only to be isolated and be maintained in storages. Now in the Russian Federation the Federal target program for the address with RW adopted by the resolution of the Government of the Russian Federation in 1995. The program provides: equipment of all NPPs of Russia technical complexes for conditioning of all types of RW; reconstruction and construction on the NPP of storages of the firm and cured RW providing safe storage; development of technology and creation of the equipment for processing of the RW which are formed at a conclusion of operation of power units of the NPP and nuclear facilities; reconstruction acting and a construction in territories of the NPP of the new storages providing compact and safe storage of spent nuclear fuel during all term of operation of the concrete NPP. The processing purpose - extraction from the fulfilled fuel of the sharing nuclides formed during the operation of the reactor (for example, in fuel with burning out of 33 MW • days/kg mass contents $^{235}\text{U}$ makes about 0.83%, and the content of the sharing plutonium isotopes – about 0.68%). Besides, processing of the spent nuclear fuel (SNF) is the intermediate stage on the way of removal of highly active radionuclides from a field of activity of the person [3].

Allocation from SNF of long-living radionuclides allows to make processing products less dangerous and to considerably reduce their volume. As a result of processing receive new nuclear fuel that reduces the need for natural uranium and, besides, simplifies a problem of burial of the received RW as the volume of the cured highly active waste received after processing of SNF is only about 30% of initial volume of SNF [4].

The schedule of input of capacities according to the NPP-2006 program

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Rostovskaya | | | | | | | | | | | | | |
| Kurskaya | | | | | | | | | | | | | |
| Kalininskaya | | | | | | | | | | | | | |
| Novorossiyskaya | | | | | | | | | | | | | |
| Beloyarskaya | | | | | | | | | | | | | |
| Leningradskaya | | | | | | | | | | | | | |
| Severskaya | | | | | | | | | | | | | |
| Nizhegorborskaya | | | | | | | | | | | | | |
| Yuzhno-Uralskaya | | | | | | | | | | | | | |
| Tsentalinskaya | | | | | | | | | | | | | |
| Tver | | | | | | | | | | | | | |

Figure 1. The schedule of input of capacities according to the NPP-2006 program.

Therefore, the tasks presented in a research need to be considered in more detail, including the problems described above.
The analysis of methods of processing and storage of radioactive waste of the NPP consists in the following examples: Kursk NPP-2. Let's consider the main space-planning solutions of the building of processing and storage of Russian joint stock company. The building consists their two main functionally various units and auxiliary facilities:

- block of processing of radioactive waste (BP);
- block of storage of radioactive waste (BS);
- and auxiliary constructions:
  - reception construction of diesel fuel;
  - constructions of a tank of emergency discharge of diesel fuel from the building;
- air-channel [5].

The building of processing and storage of radioactive waste with the air-channel is structurally executed in the form of a monolithic box-shaped design with the external and internal monolithic bearing walls leaning on a base plate. The building consists of several sections of various number of storeys divided by deformation seams. Level of a clean floor of the first floor is taken for relative mark 0,000 that corresponds to absolute mark 158,70. The bearing framework of the building is accepted monolithic reinforced concrete. Need of monolithic reinforced concrete designs is caused by features of technology solutions and requirements of biological protection [6].

The spatial rigidity and stability of the building is provided:

- creation of uniform system, the monolithic reinforced concrete cross, longitudinal walls and monolithic reinforced concrete disks of overlapping which are rigidly connected among themselves;
- tough seal of walls in base plates through anchor cores;
- rigidity of a covering on steel farms, the provided system of communications on the lower and top belts of farms and also fastening of a flooring to runs.

Such constructive scheme of the building provides preservation it from the general progressing destruction at single local refusal of the bearing structural element (for example, parts of a wall). It is also necessary to note that the bearing elements of the constructive scheme have the increased reliability as calculated on extreme natural and emergency technogenic influences taking into account a number of conservative prerequisites:

- small probability of emergence – 10000 years for maximum settlement earthquake;
- use of conservative values of loadings from extreme and emergency influences;
- accounting of wide range of physicomechanical properties of the soil basis;
- use of conservative characteristics of properties of materials (both strength, and dissipative), etc [5].

Besides, in use buildings monitoring of a condition of building constructions (visual, tool) which with guarantee provides impossibility of sudden refusal of the bearing building construction is carried out.

In the building on processing and storage of radioactive waste the complex according to treatment of radioactive waste is placed. The block of processing of RW is intended for reception and processing at the modern level of liquid radioactive environments and waste, and solid radioactive waste (low-active and medium-active) for the purpose of reduction of volume of radioactive waste and their transfer to a form safe at storage, transportation and burial [6]. The block of storage of RW is intended for reception and storage firm and cured (low-active and medium-active) the waste which is formed in ten years of operation of two power units of the NPP (with a possibility of the subsequent expansion of volume of storage for 50 years of operation of nuclear power plant) and also the highly active waste which is formed in 60 years of operation of four power units of the NPP. A reception construction of diesel fuel - the separate construction intended for reception of a tanker truck with diesel fuel. A construction of a tank of emergency discharge of diesel fuel from the building - the buried construction intended for intake of diesel fuel from a tanker truck in the reception capacity and its giving in the system of burning and pyrolysis and return of diesel fuel to emergency capacity in case of accident [7].
Under the terms of responsibility for radiation safety on AE-5.6 PIN the building of processing and storage of RW belongs to the II category; a reception construction of diesel fuel - to the III category; a construction of a tank of emergency discharge of diesel fuel from the building of processing and storage of RW - to the III category [1].

Space-planning decisions are executed taking into account:
- modular principle of configuration of buildings and rooms;
- rational blocking of groups of rooms by the technological principle;
- climatic conditions of placement NPP;
- reductions of utilities of total structural volumes and building area;
- parameters of external natural and technogenic influences;
- implementation of health and fire-prevention requirements;
- reductions of terms of construction and labor costs;
- conveniences of the organization of construction;
- divisions of buildings and constructions into construction and technological modules from the point of view of their responsibility for safety;
- divisions of buildings and constructions into buildings of the main production and all-station buildings [8].

In a basis of the space-planning solution of the building of processing and storage of radioactive waste with the air-channel the principle of optimum use of volumes of buildings and constructions for ensuring technological processes and also the principle of safety according to normative documents is underlain.

Space-planning decisions are subordinated to purpose of the building [3]. The composite arrangement of buildings and constructions is defined taking into account compact use of the territory of an industrial site, technological communications, fire-prevention and health requirements, conditions of laying of utilities.

Foreign example is the Australian organization in the field of nuclear technologies - ANSTO (the Australian Nuclear Science and Technology Organization). She closely cooperates with the government and the public on the questions concerning use of nuclear technologies. ANSTO has wide experience in treatment of own radioactive waste which it is substantially generated in scientific research and in nuclear medicine. She also maintains close contact with the similar organizations abroad and is a permanent participant of the international forums according to treatment of radioactive waste [9].

ANSTO conducts extensive researches in the field of treatment of radioactive waste. One of developments of the organization is process of neutralization of radioactive waste (RW) with use of technology under the name isostatic pressing (hot-isostatic pressing HIP) under the ANSTO Synroc brand is hotter. Radioactive waste in combination with ceramic material compresses under the high pressure and temperature and hermetically is located in a special ceramic form and then in containers. This process is intended for safe encapsulation of waste on tens of thousands of years [5].

In December, 2009 the U.S. Department of Energy made the decision to use HIP technologies for processing and storage 4400m³ highly active waste in National laboratory Idaho.

In Australia radioactive waste (RW) is formed as a result of use of radioactive materials in scientific research, the industry, agriculture and medicine [3].

The most part of development of RW falls to the share of ANSTO. Here waste of operation of the OPAL reactor (Open Pool Australian Lightwater), decommissioning of the Moata reactor and, in the future, decommissioning of HIFAR reactors (High Flux Australian Reactor) and OPAL enter. HIFAR was operated within several decades (till 2007) and supported researches and production of radioisotopes for medical and other purposes.

Natural radioactive materials (NORM) are one more source of radioactive waste, they are of particular importance for the mining industry. Also there is a large number of so-called "historical" waste in storages which resulted from activity of various organizations. Researches of radioactive ores,
the conducted CSIRO (The Commonwealth Scientific and Industrial Research Organisation), or broad use of radioactive material of radium can serve for creation of the shining dials as examples [10].

So, comparing the Russian and foreign experience of the address of radioactive waste, it is possible to note that the volumes of waste accepted on storage in the countries of the world having nuclear heritage are tens of thousands of cubic meters a year. And volumes of the Russian storages are not comparable with foreign therefore Russia is on the threshold of the solution of problems – and, without having resolved an issue of storages, will not be able to cope with a problem of rehabilitation of the objects and territories polluted during the nuclear arms race. It is necessary to be ready to spend for researches in the field of the address about the RW of means comparable with costs of the leading nuclear countries of these purposes.

Therefore, relevant ways of storage and processing of radioactive waste of the NPP, creation of capacities for storage of the RW, the organizations having experience and the corresponding licenses for the right of treatment of radioactive waste is. It is necessary to be ready to spend for researches in the field of the address about the RW of means comparable with costs of the leading nuclear countries of the world of these purposes. It is also necessary to develop technologies of burning of low-active waste, vitrifications of the RW containing long-living and the sharing substances. It is necessary to increase by 3-4 times reception of RW by storage, and, as a result, volumes of storages. Only the specialized companies can solve these problems with highly skilled personnel. Their creation will allow to improve technologies and methods of the address with RW, will provide system approach to means of radiation and entrance control [2].

3. Conclusion
Proceeding from described above, one may say, that, having considered an object of a research of this work, design and construction of facilities of processing and storage of RW demands special approach and special measures of protection and safety. Let's note that construction of the NPP is the progressing industry, appears more and more power plants using nuclear fuel, so construction of facilities on service of objects of storage and processing of nuclear waste will also not stop but only will increase the need for the future.

The solution of research problems confirm relevance of the chosen subject, on the example of the analysis of methods of processing and storage of radioactive waste; comparisons of the Russian and international experience in the sphere of construction of these objects; offers on relevant ways of storage and processing of RW NPP.

It should be noted that these objects play a large role both in the ecological sphere, and in economic. On the one hand they protect the environment from pollution by radiation, with another – a possibility of recycling of RW not suitable for the NPP, but suitable for other industries, will allow to reduce costs of resources of fuel, and will also reduce the number of the buried RW that well affects ecology.

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