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Spent nuclear fuel as a resource of future

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«Spent nuclear fuel (SNF) is a dangerous, highly radioactive "cocktail". The ingredients of this "cocktail" are a valuable energy raw material».

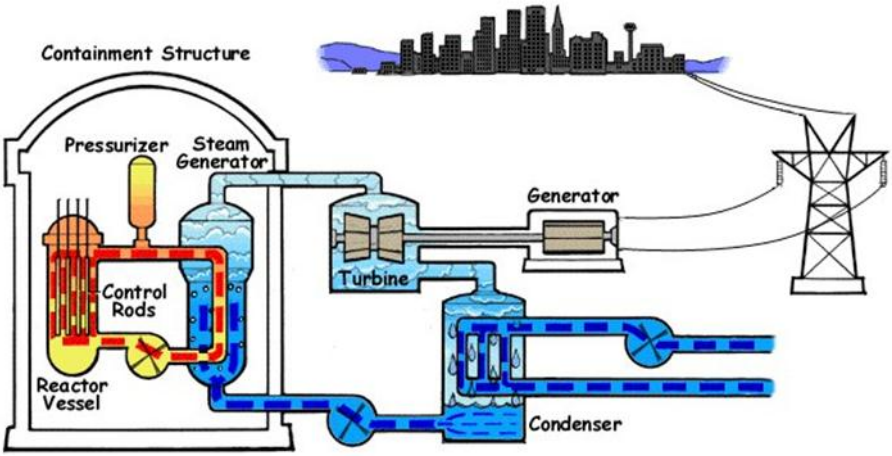
Today scientists around the world say that the 21st century is the age of nuclear technology. Every year the number of nuclear power plants is growing, and as a result, the amount of spent nuclear fuel is increasing. Every day a huge amount of spent nuclear fuel is unloaded from nuclear reactors around the world. It is the most important and continuously growing source of civil radioactive materials generated and, thus, need to be managed appropriately.

In view of the formation of the Republic of Belarus as a nuclear power state the utilization of spent nuclear fuel (SNF) is an actual problem from the point of view of ecology and further development of nuclear technologies in our country.

Nuclear power plants create electricity through controlled nuclear reactions that take place in the heart of a nuclear power plant – a nuclear reactor. This involves processing of highly radioactive materials such as uranium and plutonium. The time this fuel remains useful may vary depending on the service life of a reactor and its operation technology [1].

SNF is one of the most popular interpretations of the concept of spent nuclear fuel. SNF is a radioactive material that can be used as fuel in nuclear power reactors. Once this material has been used for a significant amount of time, it loses

its efficiency as fuel and should be replaced with «fresh» fuel [2].



Picture 1. Nuclear cycle

Modern nuclear power facilities can employ fuel for three to six years before the material deteriorates to a point that it is no longer useful. After this point, the material is considered to be SNF. Then the fuel is discharged from the reactor and sent for some time to Spent Fuel Pools or Dry Cask Storage. Over the next five years SNF is stored in the basins. Further it is placed in special containers and taken to warehouses. In this manner, there will be an accumulation of SNF.

Today the most efficient technology for reprocessing SNF is the PUREX one used to purify fuel for nuclear reactors or nuclear weapons. It is an acronym standing for Plutonium Uranium Redox EXtraction. PUREX is the de facto standard aqueous nuclear reprocessing method for the recovery of uranium and plutonium from used ("spent", or "depleted") nuclear fuel. This technology is based on liquid–liquid extraction ion-exchange.

The actinoid elements (or elements that have a high atomic weight) in this case consist primarily of the largely unconsumed remains of the original fuel (typically U-238 and other isotopes of uranium). There are also smaller quantities of other actinoids created when one isotope is transmuted into another by a reaction involving neutron capture.

The PUREX process is a liquid-liquid extraction ion-exchange method used to reprocess spent nuclear fuel and to extract primarily uranium and plutonium, apart from each other, and other constituents. The irradiated fuel is first dissolved in nitric acid. After the dissolution step it is normal to remove the fine insoluble solids since otherwise they will disturb the solvent extraction process by altering the liquid-liquid interface. It is known that the presence of a fine solid can stabilize an emulsion.

In order to extract the uranium an organic solvent composed of 30% tributyl phosphate (TBP) is used. Plutonium is separated from uranium by treating the kerosene solution with aqueous ferrous sulphamate that selectively reduces the plutonium to the +3 oxidation state. The plutonium passes into the aqueous phase. The uranium is stripped from the kerosene solution by back-extraction into nitric acid.

The first cycle lowers the radioactivity of the mixture allowing the later extraction cycles to be kept cleaner in terms of degradation products.

The term PUREX raffinate describes the mixture of metals in nitric acid which are left behind when the uranium and plutonium have been removed by the PUREX process from a nuclear fuel dissolution liquor. This mixture is often known as high level nuclear waste.

Two PUREX raffinates exist. The most highly active raffinate from the first cycle is the one which is most commonly known as PUREX raffinate. The other is from the medium-active cycle in which the uranium and plutonium are

refined by a second extraction with tributyl phosphate. Currently PUREX raffinate is stored in stainless steel tanks before being converted into glass.

The first cycle PUREX raffinate is very radioactive. It has almost all of the fission products and corrosion products such as iron/nickel, traces of uranium, plutonium and the minor actinides. However, it has not received wide application due to its high cost.

By analyzing PUREX technology we assume that the cost of fuel processing should fully justify itself. Therefore, SNF can be a valuable potential source of raw materials for important isotopes. Many radionuclides are of practical value in various spheres of human life, i.e. in industry, scientific research, medicine, etc. Many of these elements are in demand today and some are still awaiting their application in the future. Among the isotopes there are elements that are not found in nature. SNF has valuable long-lived cobalt and cesium widely used as industrial radiation sources, and some precious metals such as ruthenium, rhodium, palladium that can be used in many high-tech fields of technology.

It follows that SNF from the above, is not a waste of production. Spent nuclear fuel is our future resource!

References:

1. Electronic version of a book titled “Razvitie atomnoj jenergetiki I ob’edinjonnyh jenergosistem” [Electronic resource]. – Mode of access: http://energetika.in.ua/ru/books/book-4/part-1/section-8/8-2/. – Date of access: 31.03.2017.