PROSPECT OF SPENT FUEL REPROCESSING AND BACK-END CYCLING IN CHINA IN 1990's

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ABSTRACT

According to the Chinese Program of nuclear energy in 1990's, the amount of spent fuel by the year 2000 is estimated in this paper.

Reprocessing is considered as an important link in the back-end fuel cycle. A pilot plant is scheduled for hot start up in 1996. The main goal of the study is LWR spent fuel reprocessing. We will use the experience gained from reprocessing of production reactor fuel and last research results. The advanced foreign technigue and experience will be introduced. The study emphasizes on the test of technology. equipments, instrumentation and automation, development of remote maintenance and decontamination. China will start to demonstrate the way for fuel cycle.

I. INTRODUCTION

Since the commission of the first nuclear power plant in 1954, exploitation of nuclear energy has made great strides over thirty years. It has been admitted that nuclear energy is a safe, economic and clean source. Today most countries attach great importance to it. Many of them and the international energy source research agencies recognize that the development of nuclear energy in large scale is an important measure for solving energy problem. Even those countries with rich coal, petroleum, natural gas and water resources, such as the United States, Soviet Union and Canada, have tremendous programs for developing their nuclear power. According to the recent forecast made by Japan the world generating capacity of nuclear power plants will reach a total of five hundred million kilowatts by the year 2000.

Internationally, nuclear power plant has developed into commercial stage, mature in technique, safe and economical in operation. All these make it a new source, full of promise to meet the pressing need in industry and other public uses. China's energy consumption ranks third in the world, but the percapita is only about one-tenth of that in the developed countries. In our country the distribution of water and coal resources is uneven. Electricity shortage is severe in many areas. We expect to quadruple the national annual gross value of industry and agriculture products in 1980 by the end of this century. The development of the electricity generation is required to keep pace with the set tempo.

In order to reach this objective we must accelerate the exploitation of various energy resources, especially the nuclear. To construct nuclear power plant in the areas short of energy supply is one of the important ways.

In China through thirty and odd years efforts. The foundation for developing nuclear energy has taken shape. We have established an integrated system for industry and research purposes.

PWR is adopted as the main type for first generation of China nuclear power plants. The 300 MW Qinshan nuclear power plant is under construction. So is the Guangdong nuclear power plant with twin 900 MW units. They will probably go into operation in 1991 and 1992 respectively.

The authous estimate that the capacity of nuclear generation will reach 4500 MW by the year 2000. The amount of spent fuel is shown as table 1.

Based on this estimation, the spent fuel will amount to 620 tons by the year 2000. How to treat and dispose the 620t spent fuel is a key problem in back-end

Table 1

Year	1991	1995	2000
estimated nuclear generating capacity (10MW)	30	330	450
spent fuel accumulated (t)	0	187	620
plutonium accumulated (kg)	0	1600	6238

cycle. Nowadays there are two ways: First, reprocessing and recycling the fissionable materials in the light water reactors. Second, storing the spent fuel for 20 to 50 years, and then deciding whether it will be reprocessed or as once-through used fuel directly stored forever.

Nevertheless, from the point of reasonable use of the uranium resources or safety and security concern, reprocessing is better than once throuth use of the spent fuel.

A. By way of once through use of uranium can only less than one percent of the fission energy in uranium resource be developed. If all the spent fuel is reprocessed, and the recovered uranium and plutonium reused in LWR, a conservation 20-30% of natural uranium resource can be expected. The verified uranium resource in China can supply, besides military uses, power plants of 15 gigawatt runing for 30 years. In view of low grade in average and high mining, so that the conservation uranium source and by recycling the recovered uranium and plutonium is of great importance to China.

B. To store the spent once forever means to bury up a huge plutonium mine unexploitable. The half-life period of Pu-239 is 26,000 years. Its storage is a potential disaster. From view-point of envirinment protection it is also necessary to have the spent fuel reprocessed before final disposal. In addition the costs for long term storage are rather expensive. Whether for economical reason or for the purpose of security, the amoumt of long terms storage should be as less as possible.

Reprocessing is a foundamental link in cycle. We have applied the purex process in reprocessing for many years, and got qualified uranium and plutonium products. Furthermore we have accumulated considerable experience in flow sheet configuration design and manufacture of equipment, liquid transfer, process control, equipment maintenance, wastes treatment etc. Along with the development and construction of our own nuclear power plants, how to reprocess the LWR spent fuel must be put on agenda. In order to improve the nuclear back-end cycle, and gain higher efficiency and lower consumption in processing all kinds spent fuel should be constantly aimed at. We will adopt the new technology and equipment, some of which may be imported as to speed up the development of our civil industrial system.

II. THE TRANSPORTATION OF THE SPENT FUEL

The spent fuel discharged from LWR needs to be transported to the reprocessing plant. We are lacking experience in long distance transportation. The main way is by railroad. In transportation enough protection must be provided against personnel damage, the radioactivity leakage. The construction of the transport vessel is the core of this problem. The vessel must pass a series of experiments or tests, such as falling down, heavy collision, sealing, heat transmission exam, high temperature endurance and so on. A qualified transport vessel is also required be safeguarded against some unforeseen cases. Facilities or devices for packing, transporting, discharging maintenance handling must be deliberately developed.

III. SPENT FUEL STORAGE

Storage may be wet or dry, wet storage has been used for 30 years. Only in recent years develops dry storage. It becomes attractive in many countries. Our choice depends on the further demonstration. However we prefer to adopt wet storage before 1990's. Most spent fuel will be stored in pools nearby the power plants till the building up a commercial reprocessing plant early in 21 century. In this interval we are going to study the storage racks containing neutron

poison and array or form in storage. The constructure of storage pool with enough mechanical strength against earthquake and other accidents will be under consideration.

IV. REPROCESSING

The reprocessing for PWR fuel is more complicated than that for military reactor. Though we have performed considerable researches for reprocessing PWR fuel since the seventies, a lot of items remain untackled. Many technical and engineering problems and equipment must be demonstrated in hot operation in pilot plant. We will construct a pilot plant with the capacity of one hundred kilograms, its hot operation is expected probably in 1996. The pilot plant will serve the following purposes: Through experimental reprocessing to verify the soundness of the main equipment, instrument and automatic control systems and thus to accumulate a host of parameters to act as demonstrating facilities for constructing a commercial reprocessing plant on early in 21 century. The fuel will be reprocessed in the pilot plant with the highest burnup of 33,000 MWD/TU. Its cooling time should be over five years. The three cycle purex process is adopted. In order to acquire experience for building the commercial reprocessing plant as mentioned, the pilot facilities must be sophisticated and flexible enough. In addition to the experience we have already got the following fields should be emphasized in researches:

A. Shearers: Shear-leaching is a adopted in head-end process. We shall develop the bundle shearers, which are considered as one of the most advanced types today. Its manufacture, installation, and trial operation in connection with other components of the shearing equipments will be carried out on carefully made schedule as to ensure the reliability of the system as a whole.

B. Extractor: Pulse column and mixer-setter are often used as extractor. The main defect of the mixer-setter is highly holding up and long residence time. Especially for fuel with high burn up the operation becomes worsen owing to the accumulation of interface crude. So select pulse column im PWR fuel reprocessing. Since 1981, we have tried the pulse column in reprocessing plant. Its performance has been proved excellent. The researches in next step will aim at column constructure as to improve the mass transmission, to decrease the vertical mixing and emulsion through extractant degradation and to ease the removing of crude.

C. Remote maintenance: The investment in direct maintenance is less than that in remote maintenance, but direct maintenance takes longer time in decontamination and produces more influent. A pilot plant must be flexible enough as to meet the needs in research, trail production and treating fuels from various reactors. It will demonstrate how to perform remote maintenance and provide experience for the construction of the commercial plant early in 21 century. The equipment for remote maintenance should be fixed in racks easy and fast handling as blocks. We will develop and introduce suitable maintenance tools such as cranes, powered manipulators, slave manipulators etc.

D. Critical safety: The measures for countering the possible critical accident are taken such as geometry safety control, concentration control, mass control, and solid neutron poison control.

E. New processes: In new process the liquid waste should be as low as possible. We will continued research electro redox -processes in place of redox chemicals and use nitrous gas to adjust the valuence of plutonium.

F. Automation and instrumentation: In the pilot plant, the small space for equipment and high radioactivity in environment bring some difficulties. For convenient replacement and maintenance, the instruments on equipments as remote maintenance requires must be easy to dismantle and of good sealing. The automatic control way must meet the experiment and operation requirement, and also facilitate the information gathering, on which the design of a commercial plant depends. Nowadays computer system has been well developed quickly. Micro-computer control is also within the scope of our study through which we shall be experienced in its application.

For researches in fuel shearing hydraulic and mass transmission of equipment, technique of remote maintenance, automatic control system, treatment of waste etc. by 1990's we shall construct an experimental shop working in cold conditions.

V. RECYCLE OF THE PLUTONIUM

Once we adopt reprocessing as basic

method for spent fuel treatment naturally the recycle of plutonium must be taken in consideration. In long terms view, plutonium should be used in FBR. But the development of FBR is correlated to the development in many branches of industry. A lot of work must go ahead. China plans to construct a small experimental FBR around the year 2000. Commercial FBR will be built in years a little remote. The recovered plutonium will be stored for long time before recycling in FBR. It is known that before fabricated into FBR fuel, besides some loss in fissionable plutonium, Am-241 must be separated. Long storage is economically unreasonable. Fissionable materials recovered from PWR fuel will increase along with the development of nuclear power plants and the reprocessing of the spent fuel, so at the end of the nineties, China will start to demonstrate the way of fuel cycle.

Waste treatment and disposal: Through the researches we have gained lots of experience in treating the low and medium level wastes, and the solid wastes of low and medium wastes produced are now stored in repositories. Volume reduction by pressing or incineration and shallow burial will be applied according the radioactive level of the wastes. Foe high level liquid wastes vitrification process is resorted to, including researches and building facilities of industrial scale.

In order to quarantee the safety of the public, and the protection of the environment, the vitrified product must be isolated in a deep geologic formation. For this purpose, a R and D program has been established and implemented in China.

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