NEW DEVELOPMENT STAGE OF CHINA'S URANIUM INDUSTRY

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Abstract

From the early 1980s China adjusted its uranium industry to better meet the market economy requirements. Until 1997, the adjustment has been completed. The technical and managerial improvements result in a more efficient uranium production. In 1996 a series of events related to the nuclear power development of China manifests very favorable situation for the uranium industry. The first two nuclear power plants with a total installed capacity of 2100 MW in the mainland of China have been operating safely and steadily for several years. The additional nuclear power projects to be constructed for the rest of this century are implemented in an all-round way. Four plants with eight reactors of a total of 6900 MW have entered their construction period in succession. In 1996 a commercial ISL mine in Xinjiang with annual capacity 100 tU was completed, and the larger scale of ISL mine is expected to be constructed by 2000. The Benxi uranium mine in northeast China was put into production. It applies some new mining and processing technologies and improved management, which might serve as a new model of uranium mines in China.

1. INTRODUCTION

China's uranium industry was founded in the 1950s. Through over 20 year effort it became a comprehensive industrial system with about 50 enterprises and institutions, including uranium mines and mills, machinery factories, construction and installation companies, research and design institutes, technical schools etc. The uranium output increased year after year. It was a rapid development period of China's uranium industry.

In the early 1980s, following the national strategic decision, the China's nuclear industry placed emphasis on developing nuclear power and promoting a diversified economy. The uranium production, as a part of nuclear industry, faced many organizational, technical and economic problems originated by the former economic system. It had to carry out a series of adjustment activities and form a new uranium community to meet the nuclear power requirement in the condition of market economy.

Over the last decade many progresses have been made in the uranium industry as well as the nuclear power development in China. As a historical review, China's uranium industry will have a new development stage to meet the coming new century.

2. COMPLETION OF URANIUM INDUSTRY ADJUSTMENT

In the period of adjustment and reform the uranium industry should shift its military production to civilian production with emphasis on the peaceful applications for nuclear power.

Most China's uranium deposits in the early days were small in size, low in grade and distributed extensively in many provinces. As a whole, the capital and operating costs were rather high. It was very important to take account of the economic effect of uranium production, that is to lower the costs of uranium products and overcome many difficulties in former uranium industry.

The basic targets and tasks of adjustment and reform of uranium industry might be summarized as follows:

- The main target of uranium production must be based on meeting domestic needs within the framework of the country's nuclear power programme, following the policy of "self-sufficiency of uranium" to fuel the nuclear power plants.

  During the period of adjustment there was only a little demand for uranium and China reduced uranium production and closed uranium mines and mills with comparatively high production costs. From 1980, China also started exporting uranium.

  However, to meet uranium demand around the turn of the century, in the recent years three uranium mines, Yining, Lantian and Benxi, were put into production. In 1996 Yining ISL mine reached annual output 100 tU. The other two mines have the same capacity. Their production is limited in capability, but the improved experiences of uranium production technology and management are very important for the further development of industry.

- Special effort has been put on improving technology with the objective of reducing production costs.

  The renovations using more advanced techniques in Hengyang and Renhua uranium plants are nearly completed.

  The former uranium purification facility in Hengyang plant went into production in the early 1960s. It must be updated to produce nuclear grade UO_2 for domestic nuclear power reactors. Now the technical assistance from IAEA on this project is of vital importance. The feed materials are ADU and SDU pulps with lower uranium content and higher impurity contents from other uranium mills. A new pretreatment process was established for the high concentration uranium extraction. The uranium oxide from pretreatment is dissolved using HNO_3. The uranium extraction is conducted in pulse sieve-plate column under the condition of 95% saturation of uranium in organic phase and two-stage scrubbing of loaded organic phase. The UO_2 product is obtained through ADU precipitation by ammonium hydroxide and reduction calcining of ADU. The technology improvement of uranium ore processing was carried out in Renhua mine. The new flowsheet abolished resin-in-pulp process and employed belt filter for liquid-solid separation. The whole process has been simplified.

  In 1997, the construction of new Uranium Extraction Laboratory and In-Situ Leaching Laboratory will be completed and put into work, respectively, in Beijing Research Institute of Chemical Engineering and Metallurgy and Hengyang Research Institute of Uranium Mining. They will develop more advanced techniques for uranium mines and mills.

  In the last decade in-situ leaching, surface heap leaching, underground in-place leaching after blasting and acid-curing followed by ferric-trickle heap leaching have been used successfully in uranium production. In 1996, the in-situ and heap leaching technology produced about 2/3 of total uranium.

- The important point of adjustment and reform of uranium production management is to appraise and reduce the direct employment in uranium industry. Ten years ago the total staff for uranium production amounted to 45,000 persons. This figure was reduced to 8,500 in 1996. The margin of employment reduction is much larger than the production decrease. A total of 26,000 employees formerly involved in uranium production have been transferred to diversified products. Another 10,000 employees have gone to other industries.

3. FAVORABLE SITUATION OF NUCLEAR POWER DEVELOPMENT

The first two nuclear power plants Qinshan and Daya Bay Nuclear power plants, with a total installed capacity of 2,100 MW in the mainland of China have been operating safely and steadily for several years. It is widely acknowledged that construction of nuclear power plants is an important solution to the problem of energy shortages and the nuclear power is a safe, economical and clean energy source. The successes of these 2 plants would lay a solid foundation for China to further develop its nuclear power industry.

Two years ago, when we prepared the last issue of "Red Book", the China's nuclear power programme seemed less certain than it does today. In 1996 a series of events occurred. Four nuclear power plants with eight reactors of total capacity 6,900 MW have entered their construction period in succession.

- The second Qinshan NPP project with two 680 MW started construction of unit 1 in June 2,1996. It is planned to reach full power in 2002. The first concrete for the reactor building of unit 2 was poured on March 23, 1997. This project is designed and built mainly by China National Nuclear Corporation.

- The third phase of Qinshan NPP is the largest economic co-operative project undertaken by China and Canada. The main contract was signed by China National Nuclear Corporation and Atomic Energy of Canada Ltd (AECL) on Nov. 26, 1996. AECL will construct two 728 MW heavy water reactors. The project construction will start in 1998.

- The Lianyungang NPP in Jiangsu province is the project which was planned to be built in Liaoning province. The removal of the plant site was decided by the State Council of China in September 1996. This NPP with two 1,060 MW will be supplied by Russia.

  The agreement between Sino-Russian counterparts was signed in Dec. 1996. The construction is expected to start in 1998.

- The Ling'ao NPP with two 984 MW in Guangdong province is located about 1 km from Daya Bay NPP. The French government has approved of providing the favorable credit for the plant equipment which will be supplied by FRAMATOME. The construction started on May 15, 1997.

China has entered a rapid development period of its economy, that presents a new challenge to the existing energy industry which can hardly meet the needs. China has an uneven distribution of traditional hydro and coal energy resources. About 93% of the exploitable hydro power potential is concentrated in the southwest, northwest and central areas, while about 80% of the coal reserves are in the north and northwest areas. However, the major load centres are in the eastern and coastal areas. Introduction of nuclear power into a certain number of power grids is a must, especially in the coastal provinces. The development of nuclear power is the only way to optimize the national energy structure and ensure the power supply. The nuclear power capacity in China is expected to have a larger programme in the first decade of next century. Experts estimate the increase in the nuclear power generating capacity to reach 20 GW by 2010 and 25 GW by 2015. The reactor-related uranium requirements should amount to 3,000 tU in 2010 and 3,700 tU in 2015.

4. EXPERIENCE OF A NEW URANIUM MINE

The technologies and facilities of the existing uranium mines and mills in China built over 20-30 years ago have become outdated and inefficient. The employment in the uranium enterprises usually was expanded into a large number and the productivity was very low.

One factor must be emphasized that all of the mines and mills are located in remote or rural areas and typically have much shorter lifetimes than mines of other raw materials. But they all have their own towns or called residential villages, including apartments for employees' families, schools, hospitals, shops etc. The production infrastructure is always self-sufficient. As a result, the capital and operating costs would increase by a large amount. When closing the mines or mills, a lot of troublesome problems will occur.

In the last decade in addition to closing uranium mines and mills with comparatively high production costs, some new uranium mines, such as Yining ISL mine, Lantian heap leaching mine and Benxi mine were put into production one after another. Among them the Benxi mine has its own distinguishing features in respect of the improvement of production technology and management. It has taken many measures to solve above-mentioned problems.

Benxi uranium mine started production in May 1996. It can produce 100 tU in the form of yellow cake.

Benxi uranium mine is located 50 km south of Benxi city, Liaoning province. The reserve in this mine is small in scale with grade of 0.34% U. The deposit is irregular in shape and the ore bodies are of complex configuration. Both host and surrounding rock are fractured and sudden roof collapse happens often in active workings. The deposit is developed by incline shaft and the upward cut-and fill method is used for mining.

In most cases of this kind of uranium mines in China the main equipment for mining should be the hand-held pneumatic rock drills and electric scrapers. In Benxi mine, however, single boom hydraulic drill jumbo H-104 and LHD-loader ST-1.5 are adopted. A satisfactory result has been obtained in the first year operation of mining and drifting. The productivity per man-shift has reached 5.8 tonne of ore, which is higher by 2-3 times than other mines with the similar conditions. These two mining machines can be operated efficiently in very small stopes, e.g. 70-300 m^2 area, and offer a safer and more comfort working condition for miners. The new self-designed mine truck with 5 tonne capacity and service vehicle will be put into use in August 1997. Then the further completion of the trackless mining system will produce more efficiency.

Benxi mine has used a new uranium extraction technology named acid-curing followed by ferric-trickle leaching (AFL) process.

The whole technology contains ore crushing, mixing with strong acid, curing the mixture in piles, trickle leaching with ferric solution, extracting uranium from pregnant solution with tertiary amine and precipitating product. Most of the process effluent runs in a closed circuit.

In comparison with the traditional agitation leaching the AFL process eliminates the ore grinding, solid-liquid separation and simplifies the solvent extraction and disposal of residue. Therefore, the energy and water consumption is reduced a lot. The environment impact can be improved. Usually there is a little process water discharged. The tailings can be disposed of in a pile or returned to the mine for filling, eliminating the need for a tailing pond.

In respect of the development strategy, Benxi Mine has made many changes, compared to other uranium mines. The most notable change is that there is no self-constructed residential village for staff's families near the mine area. The employees work 20 days a month and have 10 day vacation to go to city Xingcheng. On the mine site hostel and canteen were built. The production infrastructure in mine is simplified and supported by local conditions.

The average productivity of closed mines is 0.15 t ore/man shift, however, Benxi mine reaches 0.75 t ore/man shift.

The projected concept for Benxi mine has become now reality and many advantages and cost savings have been recorded. Its experience can serve as a new model for other uranium mines to be constructed in China.