



## **2.2. The Present Situation and Prospect of Industrial Irradiation Accelerator Industry in China**

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### **Summary**

Accelerator technology and the machines are an important part of the nuclear technology and also are the system integration of modern science technology. The application of accelerator technology has made the important breakthrough in many science research fields, in the development course of particle physics, several milestone developments are closely related to accelerator developments. In 1960s, accelerators gradually transferred from the science research to the national economy and society application fields. In 1970s, accelerators applied in many fields involved the industry, medical hygiene, agriculture, environmental protection, and proceed the development of new technique, new craft, new product, and developed lots of newly arisen edge industries, such as the medical equipments, no damage examination, ion injecting, radiation processing. Now accelerators have become a firmly established industry. This paper primarily reviewed the application of industrial radiation accelerators by the 20 years developments of accelerators in China.

### **1. Developments and characteristics of the radiation processing industry in China**

China had a good foundation of nuclear science technology and nuclear industry to develop the radiation processing. The radiation processing industry started late, only 20 years history, 10 - 15 years later than developed countries. The development of radiation processing industry in China generally passed three stages:

In 1980s, it was the stage of the market exploitation and technology transfer. Technicians in relevant research institute and university were the earliest knowing the success and experience of the development of radiation processing industry in the USA, Japan, Europe, etc., immediately taking productions of their many years researches, expanded the local market, and visited the enterprise, utilized the technique demonstration and sample display, a handful of enterprises in Jiangsu, Shandong and Shanghai, combined technology with business enterprise. The radiation processing industry was founded.

In the early and middle of 1990s, it was the stage of beginning of radiation processing industry. Because the earliest enterprise for radiation processing obtained good economic performance, influenced by the demonstration and pushed by the nation policy, many small enterprises embarked upon radiation processing, the number of radiation

processing enterprise increased from 20 to more than 100 in 5 - 6 years. The production value of radiation processing increased from 200 million Yuan (RMB) to 800 million Yuan. In this period, the scale of enterprise was small, unsteady operation, single product, bad resist-risk ability, but it was the basis for later development.

In the late of 1990s, and up to now, it is the stage for industry development. Analyzing the present situation and development trend, the radiation processing industry in China that involves the industry scale, product structure and equipment construction, is in the newly industry development period. Especially after the National Development and Reform Committee listed the radiation processing industry to the support item in 2003, there will be achieved new larger breakthrough in the future.

In recent 20 years, the radiation processing industry in China presented the following characteristics: the market need is booming, and also increase quickly, especially in the radiation cross-linking cables/wires and the heat shrinkable material for electron power and communication. Technicians assembled to the enterprises that have high return on assets in developed areas such as Jiansu province, Guangdong province and Zhejiang province. Big and industrial scale radiation processing Co-60 facilities (500 kCi to 2 MCi) were built, investment exceeded 30,000,000 Yuan, loading source capacity up to 3 - 5 MCi have already built in Suzhou, Shanghai and Beijing.

## **2. Constructs and application of radiation accelerators in China**

Before 1980s, all accelerators in China were built in the national institute or university laboratory, primarily engaged in science research or education. In the early of 1980s, Shanghai Electron Cables Works succeeded to produce radiation cross-linking wire, then, cooperation with Kefu company of China Academy of Science and Shangdong Yantai Wires Works, completed a demonstrate line for producing radiation cross-linking wire. From then on, accelerator equipped to the factory, and became the important equipment. There are 93 accelerators for radiation processing, total power is up to 5657 kW, 73 accelerators are completed and 20 under construction. Table 1 and Table 2 list the distribution of radiation accelerators by province and economic area, respectively.

The electron accelerators installed in China were made by several countries. Table 3 shows the countries of manufacture accelerator in China. The domestic accelerators occupy 54.8 %. Russia is the biggest import country, totally 28, occupy 30 %, but the average power exceeds the power of the domestic machine by 70 %. The accelerators made in USA and Japan, are big power machines and mainly used for flue gas remove sulfur, but small power machines are very few in market.

**Table 1. Province distribution of accelerators in China**

Province	Numbers	Province	Numbers	Province	Numbers
Shanghai	11	Hebei	3	Shandong	3
Jiangsu	13	Liaoning	1	Yunnan	1
Zhejiang	11	Jilin	5	Tianjin	3
Jiangxi	1	Heilongjiang	1	Gangsu	1
Anhui	1	Sichuan	10	Beijing	10
Hubei	1	Henan	2	Shanxi	1
Guangdong	11	Shannxi	1	Fujian	1

**Table 2. District distribution of accelerators installed in China**

Economic Area	Numbers
The Delta of Yangtze River	37
The Delta of Zhujiang River	11
Area around Bohai Sea	9
The Middle and West Area	19
Northeast Area	7
Total	93

**Table 3. Circumstance of accelerator manufacture country**

Country	Numbers	Total power (kW)
China	51	1787
Russia	28	1670
USA	5	490
Japan	3	1310
Europe	3	340
Korea	1	60
Total	93	5657

Table 4 lists application fields of accelerator in China.

Figure 1 shows the number of electron accelerator installed in China from 1994 to 2004.

By the statistics, we can make the following cognitions: during the past 15 years, about 6 accelerators were installed per year, and two peaks observed, namely the middle of 1990s and lately several years. The application develops to diversification. The accelerators made in 1990s mainly produced radiation cross-linking wire and heat shrinkable product. But the case changed in 2000, the newly accelerators present diversification trend, for example, 5 accelerators for flue gas remove sulfur, 3 for sterilization, one for sulfuration latex. Even radiation cross-linking wires and heat shrinkable products also turn into no-flue, no-halogen, and environmental friendly aspect. Adopting international standard, receiving export order, became the main object of many companies in Shanghai and Shenzhen. Customers choose the reasonable type of accelerator. By the decades of operation experience of accelerator product line in many factories, so new user usually choose the accelerator which have good beam power, the stability of long run, the suitable of system, and high automatization.

**Table 4. Application fields of accelerators in China**

Application fields	Numbers
Radiation cross-linking wire/cable	37
Heat shrinkable material	31
Foam material	2
Sulfuration latex	1
Sterilization	5
Electron instrument	3
Flue gas treatment	9
Chemical industry	2
Industry CT	3
Total	93

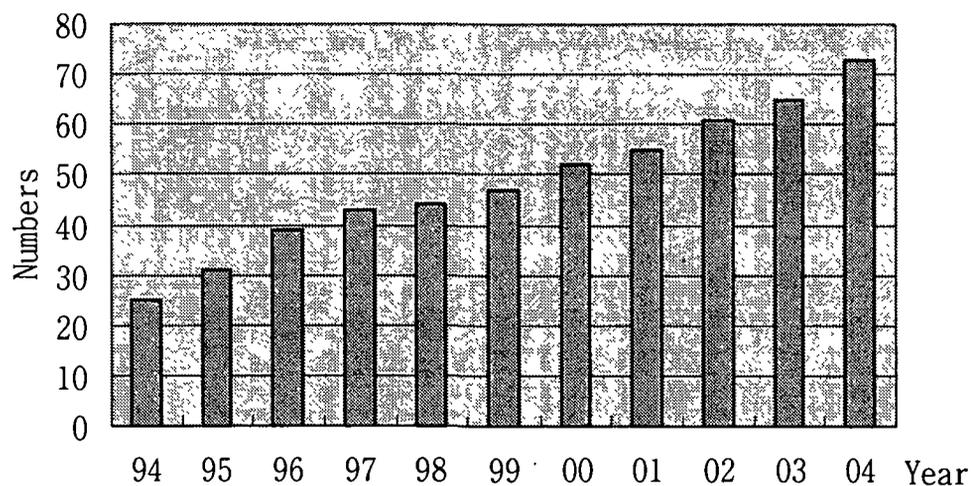


Fig.1 Number of electron accelerator

### 3. Researches and manufacture of accelerators in China

The technique foundation of accelerator concentrates in Beijing, Shanghai, Sichuan, Gansu, and Anhui province. These are Technical Physics Department of Beijing University, Engineering Department of Tsinghua University, Nanjing University and Beijing Normal University, Beijing Institute of High Energy Physics, Shanghai Institute of Applied Physics, Lanzhou Institute of Modern Physics, and University of Science Technology of China in Hefei. China Institute of Atomic Energy is the strongest institute of nuclear science. Followed by Beijing Heavy Industry Electromotor Factory and Shanghai Pioneer Electromotor Works. Therefore, China has the system arrangement for accelerator technology from education to industry production, this form the base of accelerator technology for further development. Table 6 shows the main manufactures of electron accelerators in China

**Table 6. The manufacture of electron accelerator in China**

Factory Name	Staff Number	Type	Power	Productivity per year
Shanghai Institute of Applied Physics	30	High-frequency high-voltage	40-100 kW	4-5
Shanghai Pioneer Electromotor Works	10	High-frequency high-voltage	20-40 kW	3-4
Beijing Research Institute of Automation for Machinery Industry	30	Insulation core Alter-frequency alter-type	5-24 kW	4-5
The Atom High-Technology Company	25	Linear	5-20 kW	1-2

Moreover, there are several factories have the potential to manufacture accelerator:

**Table 7. Factories that have the potential to manufacture accelerator:**

Factory Name	Type
Wuxi Elpont Institute of Accelerator	High-frequency high-voltage
Beijing Institute of High Energy Physics	Linear
Ningbo Super Energy Co., Ltd.	Linear
Nanjing University	Linear

#### 4. Problems and prospect

(1) Problems in the development of accelerators in China can be summarized as follows:

- a. Lacking young profession technicians.
- b. Low level repeat.
- c. Lacking good under beam equipment
- d. Qualities

(2) At present, the economic scale of the Chinese radiation processing is about 20 billion Yuan. It is anticipated that it will grow to 60 billion Yuan. It is also request of national and macroscopic economy. Under this background, we will have great development in this field.

Estimating from now on 5 - 7 years, China requires 60 industrial scale accelerator for radiation processing, costing 3 billion dollars, after the input, it can form economic scale of 20 billion Yuan per year.

So, China will extend the industry scale, optimize the industrial structure, and increase the social and economic on three levels.

The first level: Based on radiation wires, heat shrinkable material, and medical, promote level and enlarge scale,

The second level: Industry that has formed overseas but just start in China, such as radiation vulcanization of NR latex,

The third level: Develop some new products and new techniques to create some new industry, such as environmental friendly materials.