

# PROMOTING LOCAL ECONOMIC DEVELOPMENT BY AN INTEGRATION OF INDUSTRY, TEACHING AND RESEARCH OF COMPACT LOW ENERGY ACCELERATORS

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## Abstract

Huazhong University of Science and Technology has been carrying out R&D of compact low energy accelerators by integrating industry, teaching and research to promote local economic development supported by both national and provincial government and local enterprises. Currently, the projects include: compact medical cyclotron, electron irradiation accelerators, etc. The industry of non-power nuclear energy based on low energy particle accelerator has also drawn attention from the government of Hubei province and of Xianning city. Meanwhile, a series of lectures about nuclear science and nuclear safety were hosted to help the public better understand nuclear technology and to wipe out fears of nuclear energy. At the moment, the application of non-power nuclear energy based on compact low energy accelerator is developing into an industry chain in the area of central China.

## INTRODUCTION

The application of particle accelerators has always been tightly connected the promotion of living, health and environment of human beings ever since its invention. Since 1950 with an enormous impetus the radiation industry based on particle accelerator has been developing into a booming industry — the non-power nuclear energy technology for civilian use, featured with energy-saving, high-efficiency and environment-friendliness by its combination with other industries, such as manufacturing, farming, medicine, environmental protection etc. Starting from the beginning of 21 century, this industry has become an important portion in the annual report of International Atomic Energy Agency. The perspective of the development of radioactive isotope in production and application, etc. covered the most of the nuclear technology review of IAEA, with an emphasis on the progress of electron beam processing industry based on the particle accelerator [1]. The over 15000 accelerators in use around the world today make an essential contribution to our well-being, and to many products used in daily life. Over 97% of these accelerators are used for dedicated commercial applications [2].

According to statistics provided by China Isotope and Irradiation Association [3], the number of electron accelerator radiation equipment has increased by 160 in 2010, the production capability of radiation processing equipment was quadrupled compared with that of a

decade ago, indicating a rapid developing momentum. Compared with the cobalt source, the electron accelerator with merits of energy controllable, operation efficient, no radioactive waste treatment, and non-radioactive when machine stop etc. have been widely adapted in radiation processing industry.

## CHALLENGES OF THE APPLICATION OF COMPACT LOW ENERGY ACCELERATOR IN CHINA

The electron beam processing of accelerators should be used widely and inclusively in national economy, but in China the application is not in satisfied situation. The processing areas are still limited in a few traditional fields like cable crosslinking, thermal shrinkage or foam materials and food sterilization, etc. The reasons are as follows:

(1) The electron beam processing industry based on compact low energy accelerators bears the merits of energy-saving, environmental friendliness, high-efficiency, etc., but it also has the limitations caused by expensive equipment, demanding operator with skill, high cost of maintenance, low conversion efficiency (from electric energy to irradiation energy), etc. Besides, the scanning method of electron beams also exclude the irradiation from irregular-shape objects, in which cobalt source still holds an irreplaceable position. Therefore, to expand application area of compact low energy accelerator, efforts should be made for improvements of energy conversion efficiency, safety, lower cost, easy operation and maintenance, enlarge irradiation range, improving irradiation evenness, etc.

(2) The role of electron radiation processing in a product line can be defined as a process. It might have more operations should be done before or after that process in the product line. The equipment of the product line usually is more complicated than an accelerator only. Besides, the irradiation technology for a different product is quite complicate which need a lot of R & D to make radiation useful for the product.

To achieve the purpose, the accelerator experts should work together with the engineers of other fields to make the product line acceptable for the industry. Besides, they must cooperate with related research groups closely, like radiochemistry, organic chemistry and so on in order to satisfy both the irradiation requirements of product quality and the layout, procedure requirement of the product line.

(3) Recent years the electron beam processing industry seems growing faster in China, but still lacks the impetus in innovative and core technology as well as irradiation product criteria. In order to improve the situation, except for an effective combination of related technologies, a positive interaction of government, industry and research is also indispensable in collecting and optimizing resources for a collaborative innovation.

### **PROMOTE THE INTEGRATION OF INDUSTRY, TEACHING AND RESEARCH OF COMPACT LOW ENERGY ACCELERATOR APPLICATION TO BOOST THE DEVELOPMENT OF LOCAL ECONOMY**

Huazhong University of Science and Technology (HUST) is located in central China, Hubei province. Compared with coastal areas, the development in central districts of China lags relatively in behind. As one of the national key university, Huazhong University of Science and Technology (HUST) shoulders responsibilities to enhance the high and new technology of the province. In past few years, the Nuclear Technology Research Group of HUST, has been focusing on the research and application of compact low energy accelerator under the support of the government and university to explore an innovative mechanism to boost the local economic development.

In order to get support from the provincial government, in 2008 the research group handed in a report entitled of "Suggestions of developing non-power nuclear energy industry in Hubei Province" to the provincial government, and carried out a project on a strategic research on non-power nuclear energy industry development in Hubei Province with the support of the Department of Science and Technology of Hubei Province. In 2009, an advisory research report on "Roles of non-power nuclear energy technology in the promotion of national economy development and construction of resource-saving and environmental-friendly society" was completed and submitted to Chinese Academy of Engineering. In the meanwhile, it also organized numbers of lectures and forums in order to spread the technological knowledge of nuclear science and technology to eliminate the public nuclear fear (see Fig. 1).



Figure1: Forum on Roles of non-power nuclear energy technology in the promotion of national economy.

development and construction of resource-saving and environmental-friendly society.

Ever since then, it also combined the local conditions of industrial development in Hubei province and proposed a suggestion of promoting the application of non-power nuclear energy technology by make breakthrough out in areas of polymer, agricultural products and nuclear medical diagnosis at the first step. All these suggestions have been attached by the provincial government with a clear order to give due support for the development of non- power nuclear energy industry.

Under such a solid support, related universities, research institutes, as well as enterprises have been echoing actively to the proposals. The municipal governments of Xianning city and Xiaogan City have successively published special policies for the development of industry of non-power nuclear energy. Hubei University of Science and Technology (HBUST) has actively created professional disciplines related to irradiation chemistry and established a research center of non-power nuclear energy technology application. Dayu Electric Corporation in Xiaogan City asked to undertake the manufacturing of accelerator-related equipment and invested a research fund to Huazhong University of Science and Technology for construction of an R&D Building of Accelerator Technology (Fig. 2). With all these combined strengths, an industry-teaching-research team has come into being, with three pillars, namely, Huazhong University of Science and Technology, Hubei University of Science and Technology and Dayu Electric Corporation, each shouldering specific responsibilities.



Figure 2: R&D Building of Accelerator Technology, Huazhong University of Science and Technology.

The non-power nuclear energy technology research group of Huazhong University of Science and Technology undertakes the R & D of compact low energy particle accelerators based on a platform of "Electromagnetism Theory and Charged Particle Research Center". With a consideration to specific clients' requirements of the electron beam quality and performance, thus the R & D covers electron beam transportation, expansion and electron beam handling equipment. Therefore, the research group developed a "permanent magnet electron beam spread equipment", by which the electron beam, like  $\gamma$ -ray from cobalt source radiates a product with a solid angle to make an even irradiation for the irregular shaped objects. Based on theoretical computation and

simulative analysis, a permanent magnet electron beam expanding equipment [4] was designed with advantages of no electricity consumption, simple structure and low cost compared with classical electron beam scanner. More importantly, it effectively improves the evenness of spread electron beam and enlarged the cross area of the electron beam. As a result, the electron accelerator will not only be used for the irradiation of wires, strips and woods, but also be used for large size objects with irregular shapes. What's more, it also minimized the risk of titanium film melt of the window.

As talk above, the role of electron radiation processing in a whole production process is just a processing operation. It might have more operations should be done before or after that operation in the production line. The equipment of the production line is more complicated than an accelerator only in general. And the irradiation technology for a different product is quite complicate which need a lot of R & D to make radiation useful for the product. R & D of related irradiation technology is essential in non-power nuclear energy industry. Hubei University of Science and Technology with a relatively solid foundation in chemistry undertook R & D of the subjects, like adsorption material, the follow-up products of natural cellulose and chitosan, the vulcanized rubber used for mobile parts, wires, cable, surface treatment and coating solidification etc. Except chemical constitutes, the identification of optimized irradiation dose is fumbled.

Hubei University of Science and Technology has invested 120 million RMB in building up a "R&D center of non-power nuclear energy technology" which was inaugurated in September 16th, 2011. The first phase of the center construction was completed, covering an area of 100 mu (6.67 hectares), including a laboratory building of 10,000 m<sup>2</sup>, a high voltage accelerator vault and pilot plant of 2400 m<sup>2</sup> (Fig. 3-1). In this R&D center, a series of accelerators with different energy will be functioned as radiation source. The first 1 MeV high voltage machine and its beam handling device already put into operation.



Figure 3-1: The Research Center of Non-power Nuclear Energy Technology of Hubei University of Science and Technology.

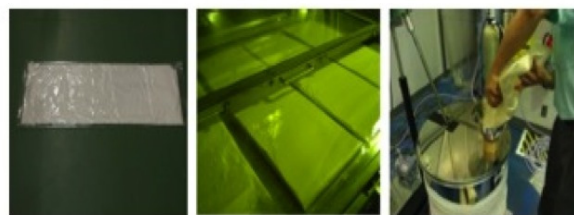


Figure 3-2: The Adsorbent developed by the research center.

Figure 3: R&D Center of Non-power Nuclear Energy Technology, Hubei University of Science and Technology and its research products.

The non-power nuclear energy industry park was listed as one of the "Major Construction Project Plan of Xianning City". The municipal government of Xianning city is to appropriate a land of 1000 mu (66.7 hectare) for the construction of a non-power nuclear energy industry zone, which might be enlarged to 3000-5000 mu (200-333.5 hectare) in future depending on the needs of the market.

Based on the superiority of advanced equipment and qualified faculty Hubei University of Science and Technology also shoulders tasks of talents cultivation in majors of irradiation chemistry (Fig. 6). The university started to enroll students in nuclear-related majors, namely, nuclear power engineering and irradiation chemistry engineering in 2009. The enrollment plan was approved by the Ministry of Education in 2010. In 2011 the base and related major was included in "Strategic New and Developing (backbone) Industry Talent Cultivation Project" by the Department of Education, Hubei Province. The major of Nuclear Science and Technology was identified as a key (cultivation) major by the Department of Education of Hubei Province, the innovative group of non-power nuclear energy technology industrialization, which invited famous scholars at home and aboard in the field of irradiation chemistry engineering, was named as one of "Key Industrialization Innovation Team of Hubei Province".

The Union Hospital, Tongji Medical College of Huazhong University of Science and Technology, undertook the medical diagnosis application task, currently in PET research and application. Fig. 4 displays the PET research and application center building of Union Hospital. Fig. 5 is the PET camera. Dated back to the October of 2003, the Union Hospital completed the construction of the PET research and application center--the Molecular Imaging Research Center of Huazhong University of Science and Technology, which was the first one at that time in central China. Ever since then, it not only saved many people's lives but also accomplished great scientific achievement, created favorable social and economical benefits. Fig. 6 shows the cases diagnosed by the center in recent years.





Figure 4: The PET research and application center building of Union Hospital.



Figure 5: The PET camera in the center .

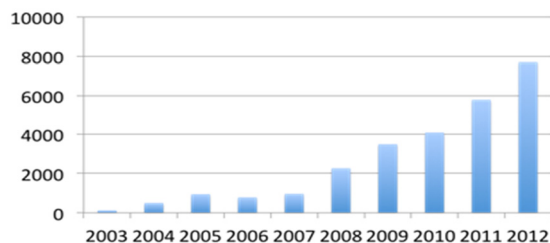


Figure 6: The cases diagnosed by the PET center of Union Hospital in recent years.

Many enterprises, like Huate Wires, Huajian Rubber, Huashan Aquatic, Stds Environmental Technology, etc., are interested in irradiation processing to improve their product quality. Based on the requirements from society the team with integrated efforts of industry, teaching and research also carried out specific research to effectively address difficulties.

The Hubei Aerospace Cable Company, by adapting irradiation technology to improve its products quality , has kept a 30% increase of annual sale income in the past five years (See Fig. 7). In order to meet the increasing demand from the market, it recently not only constructed a new workshop but also installed another accelerator (See Fig. 8).

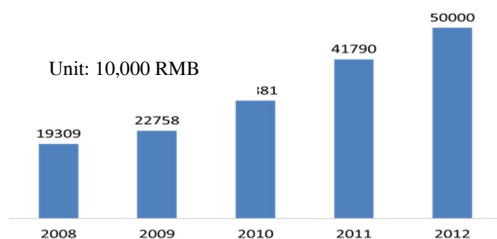


Figure 7: The Hubei Aerospace Cable Company has kept a 30% increase of annual sale income in the past five years.



Figure 8: A new workshop of the Hubei Aerospace Cable Company. In this figure, the above picture is the old workshop.

## CONCLUSION

As we entered into 21 century, terrorism and environmental deterioration are becoming the common enemies around the world. We are seeking a new collaborative mechanism, that is to integrate the roles of government, industry, university and research institute to facilitate the non-power nuclear energy industry, on the basis of low energy accelerator application, to contribute effectively to the environment protection and a low carbon economy.

Confronting with such a challenge and opportunity, it is an inexorable trend to effectively allocate resources by means of integrating industry, teaching and research in different fields to sharp a brand new cooperative mode for the future development of non-power nuclear energy industry.

## REFERENCES

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