4.4 Utilization of Low-energy Electron Accelerators in Korea

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There are more than 20 electron accelerators in Korea. Most of those are installed in factories for heat-resistant cables, heat-shrinkable cables, radical tires, foams, tube/films, curing, etc.. Four low-energy electron accelerators are in operation for research purposes such as polymer modification, purification of flue gas, waste water treatment, modification of semiconductor characteristics, etc..

1. Status of Low-energy Electron Accelerators in Korea

The first electron accelerator in Korea was installed at the Korea Atomic Energy Research Institute (KAERI) in 1975. The energy and the current of the electron beam of the accelerator are 0.3 MeV and 25 mA, respectively. The accelerator was dedicated for researches on polymer modification. The accelerator, together with the Co-60 irradiation facility at KAERI, has been the key utility in Korea for research on the industrial application of radiation technology.

From the early 1990s, more than 20 electron accelerators have been introduced into the Korean industry for the production of heat-resistant cables (9 installed / 8 operating),, shrinkable cables (1/1), radical tires (5/3), foams (3/3), tube/films (1/1), etc.. The energy range of the accelerators is from 0.5 MeV to 1 MeV. The average current ranges 40~150 mA. The accelerators have contributed very much to the Korean economy. For example, Korean companies supply more than 40 % of e-beam treated heat-resistant cables in the world. EB Tech, a private company, has started its business on electron accelerators since 1994, and has supplied a many accelerators to the Korean companies and foreign companies.

Table 1. List of γ -ray irradiation facilities in Korea

Institution Name	Year established	Shielding capacity	Source Activity	Purpose of irradiation	Remarks
KAERI	1975 (1998)	176 cm	130,000 Ci	Research	
Greenpia Tech	1986	~ 180 cm	1,000,000 Ci	Commercial	

There are four accelerators in operation dedicated to research purposes: one at KAERI, two at EB Tech, and one at YoungNam University. These accelerators are now being used for research activities such as polymer modification, purification of flue gas, waste water treatment, modification of semiconductor characteristics, etc.. One of these accelerators is a RF linac with energy of 2 MeV, and the others are electrostatic accelerators with energy ~ 1 MeV. The 2-MeV linac at KAERI will be upgraded to 10 MeV.

Table 2. List of low-energy electron accelerators in Korea

Name of company / Organization Installed	Year Installed	Maker	Accelerator Voltage	Beam Current	Purpose of Use
LG Cables DongYang Cables Daewon Cables Daeryuk Ind. KDK KyungShin Co.	'84-'00 '96 '91 '97	3 NHV 2 EB Tech. 1 EB Tech. 1 RDI 1 RDI 1 BINP 1 NHV	~ 1 MeV	50~100 mA	Cables and Heat shrinkable tubes
Hankook Tires KumHo Tires		3 NHV 2 RDI	0.5 MeV 0.8 MeV	~ 100 mA ~ 100 mA	Tires
YoungBo Chemicals TongIl Co.		2 NHV 1 NHV	0.5~1 MeV	50~100	Foam Sheet
Korea TetraPack		1 ESI	0.175 MeV	300 mA	Coating
Ceratech Co.		1 EB Tech.			Polymer
Dyeing Complex		1 EB Tech.			Waste water
KAERI	1975 2000	1 HVEC 1 BINP	0.3 MeV 2 MeV	25 mA 45 mA	Research
EB Tech.		2 EB Tech.	~1 MeV		Research
YoungNam Univ.		1 BINP	0.8 MeV		Research

In Korea, the regulation for electron accelerator is very strict. Any electron generator with voltage above 50 kV is under regulation. For "production", "import", "sale", and "use" of radiation generator with voltage above 50 kV, it is necessary to get approval of the Ministry of Science and Technology.

At the present time, as far as the author knows, there is no electron accelerator in operation with energy lower than 250 keV (soft electron beam) in Korea. Even though it is expected that soft electron beam technologies will give a strong impact to the industries in Korea, the technology has not been introduced into the Korean industries. The above-mentioned accelerators dedicated for research could be used, after some modification, for the development of technologies of soft electron beam.

2. Status of Radiation Processing and E-beam Utilization Technologies in Korea

Table 3 shows the status of radiation processing technologies in Korea. Polymer modification technologies using electron beam for production of heat-resistant cables, heat-shrinkable tubes, tire cores, and form sheets have already been commercialized for the last 20 years. Recently, a new high-performance polymer switch has been developed using e-beam in Korea, and the technology has been commercialized. Curing and coating of woods, papers, etc are under development, or

commercialized. Curing and coating of woods, papers, etc are under development, or at the beginning of commercialization. Table 4 shows the list of commercialized technologies in Korea.

For food irradiation, 13 food groups are authorized in Korea; Potato, onion, garlic, chestnut, fresh/dried mushrooms, dried meats, powdered fish and shellfish, starch, dried spices and their preparations, dried vegetables, yeast and enzyme foods, powdered aloe, ginseng products including red ginseng, second sterile meals for patients, soybean paste powder, hot pepper powder, and soybean sauce powder.

Each year, 4,000 tons of foods are commercially processed by γ-ray only. There has bee no commercial activities for food irradiation be electron beam. One reason for this is that there has been no electron accelerator with energy 5-10 MeV in Korea.

Table 3. Summary of the present situation of radiation processing technologies in Korea

Applications		Status in Korea (Commercialization)
Polymer modification	Flame resistant cables	OOO
	Thermo-shrinkable tubes, sheet	OOO
	Curing of tire cores	OOO
	Foam sheet	OOO
	Artificial leather	X
	Films of coating and packaging	X
Sterilization/ Disinfection	Sterilization of medical items	OO
	Preservation of spices, food	OO
	Disinfection of grains	OO
Environmental Protection	Flue gas purification	O
	Waste/Wastewater treatment	OO
	Sludge treatment	X
Others	Curing/Coating of wood, paper, etc.	OOO
		OOO
	Semiconductors, PTC/NTC	X
	Ceramic composites	X
	Surface treatment of fabrics	

OOO: Commercialized, OO: Engineering, O: Research, X: No activity

Table 4. Electron accelerator utilization technology - for commercial use

Field	Target	From when	Remarks
Polymer modification	Flame resistant cables	1984	LG Cables Co.
	Conductive material	1999	Ceratech
	Shrinkable tubes	1997	Hankook KDK
	Tire core	1991	Kumho Tire
	PE form	1991	Tongil Industry
Curing	Curing of print	1989	Hankook Teprapack
Waste water	Purification of dyeing waste water	2002	Daegu Dyeing complex

There have been some research activities for purification of flue gas. It has been successfully demonstrated that SOx and NOx are removed efficiently by irradiating electron beam. But this technology has not been commercialized yet.

One successful demonstration of e-beam technology is purification of dyeing waste water. In 1995, about 20% of waster water discharged in Korea is from textile industry. Taegu city has been famous for textile industry for more than 30 years, and there is a huge dyeing complex near Taegu city. EB Tech demonstrated successful purification of dyeing waste water by combining electron beam irradiation together with biological treatment process. The number of treatment stages has been reduced, and the economy of the process has been verified. After demonstrating pilot scale facility, EB Tech is now constructing a commercial plant from 2001 under the financial support of IAEA (International Atomic Energy Agency), MOST (Korean Ministry of Science and Technology Laboratory), and KAERI.

3. Future Prospects

The Korean government is now promoting energetically the development of Radiation Technology. The promotion plan for utilization of radiation and radioisotopes has been established very recently by MOST. According to the plan, 30 % of nuclear R&D budget shall be devoted to the development of radiation technology. A new "Research Center for Advanced Utilization of Radiation" is now being constructed, and will open at the end of 2004. On of the major research facility is high power electron accelerator with energy 5~10 MeV. The 2-MeV RF linac at KAERI will be upgraded to 10 MeV by the end of 2002. It is expected that the use of electron beam in Korea will increase very much in a few years. Especially, sterilization of medical products by ~10 MeV electron beam and irradiation on foods will be activated. The use of ~1 MeV electron accelerator for polymer modification, waste water treatment, etc.