High Power ELV Electron Accelerators for Industrial and Environmental Application

BINP, Novosibirsk, Russia 2012



- BINP develops and manufactures ELV accelerators since 1970.
- These accelerators initially were developed for application in industries



By now over 140 ELV accelerators had been delivered inside Russia and abroad. They are well known in the world. ELV accelerators are the most popular accelerators not only in former USSR but in China and Korea also.

 Total operation time of these accelerators is over 100 acceleratoryears



INP proposes a series of electron accelerators of the ELV-type covering:

•the energy range 0.4 - 2.5 MeV with a maximum beam current up to 100 mA and maximum beam power 100 kW

• the energy range 0.6 -1.0 MeV with a maximum beam current up to 0.5 A and maximum beam power 400 kW

The main features of ELV-accelerators are as follows:

- 1. High power of electron beam in wide energy range
- 2. High efficiency of conversation of electricity to electron beam power.
- 3. Simple procedure of accelerator control.
- 4. Accelerator itself has simple design and high reliability.
- 6. Warranty and after warranty service.
- 7. A set of additional equipment (such as transportation line, ring or double side irradiation system, 4-side irradiation system) increases the accelerator possibility.
- 8. ELV accelerators are stable in operation. The energy and beam current instabilities practically do not exceed $\pm -2\%$.

Parameters of the ELV accelerators

	Energy range,	Beam power,	Maximum
	MeV	kW	beam current,
			mA
ELV-mini	0.2-0.4	20	50
ELV-0.5	0.4-0.7	25	40
ELV-1	0.4-0.8	25	40
ELV-2	0.8-1.5	20	25
ELV-3	0.5-0.7	50	100
ELV-4	1.0-1.5	50	100
ELV-6	0.8-1.2	100	100
ELV-6M	0.75-0.95	160	200
ELV-8	1.0-2.5	90	50
ELV-12	0.6-1.0	400	400
Torch	0.5-0.8	500	800



- Parameters of typical delivered accelerator Last 38 signed contracts required: 34 accelerator with power 100 kW 1 accelerator with power 70 kW. 1 accelerator with power 50 kW 2 mobile accelerators with power 20 kW
 - 12 accelerators with max. energy 2.5 MeV
 14 accelerators with max. energy 1.5 MeV
 12 accelerators with max. energy <1.0 MeV



Delivery place of last 30 accelerators:

- 3 accelerator India
- 1 accelerator Kazackstan
- 2 accelerators Russia
- 6 accelerators Korea
- 27 accelerators China





The ELV accelerators are designed with use of the unified systems and units enabling thus to adapt them to the any specific requirements of the customer by the main parameters such as the energy range, beam power, length of extraction window, etc.



H/V Generator: Rectifying Sections Column

Accelerating tube and Primary winding







ELV-8 accelerator after assembling of H/V rectifier







ELV- 8 accelerator



Operator controls accelerator through PC





4-side irradiation system





Extraction device equipped with 4side irradiation system



Synchronization of accelerator and technological equipment

- Accelerator is used only together with technology equipment. Control systems of accelerator and technologies are combined.
- As accelerator control code are master code, in spite of technology control code can be more complicate.
- Parameters of processing are controlled from accelerator control console.
- Usually one accelerator is used for some pay off and take up devices simultaneously.

Monitor for technology hall

Ускоритель ЭЛВ-4 Комплекс Пб Энергия электронов, МэВ 1.15 Ток пучка, мА 30 Скорость, м/мин 225 Остаток 3/г кабеля на Пб, м(мин) -3423(-15)

SAMSUNG

Underbeam transportation system



Pay off and take up devices



Irradiation chamber for film treatment



Irradiation chamber for film treatment



Building for accelerator (Russia)



Building for accelerator (South Korea)



Building for accelerator (Turkey)



China: construction of building and accelerator assembling simultaneously



Finally: everything is O.K.





99% of EB processing require the beam power less than 100 kW and only 1% need the beam power up to some Megawatts. And this 1% is very important due to environment protection.

To compete with other processes in economic evaluation, the electron beam system should consider following points:

- Reduce the required doses
- Improve efficiencies
- Reduce the cost for Electron Beam facilities

Power (kW)	Price (M\$)	Cost for 1 kw (10 ⁴ \$)
20	0.5	2.5
40	0.8	2
100	1.0	1.0
200	1.5	0.75
400	2	0.5





Requirements to accelerators for environmental application

- Energy range 0.6 1.0 MeV (flue gas)
- Energy range 1.0 2.0 MeV (waste water)
- Power of electron beam up to some MW
- It should consist of some hundred kW units
- Efficiency 85 95%
- Continuously operation
- Computer control system
- High reliability in operation

ELV-12 accelerator (1.0 MeV*400 kW



Accelerator ELV-12 co-manufactured with EB-Tech





Two-window extraction device





1-ion pumps, 2coils and cores of the beam scanning system, 3-protection cylinder flange, 4protection cylinder, 5- foil blow air jet cooling, 6- frame for fixation of foil, 7 extraction foils





Two-window extraction device







Control system of accelerator allows continuously monitoring of the beam position in output window

Location of **Pilot Plant Industrial plant** Wastewater Treatment Facility in Daegu Dyeing Industrial Complex



Building for Accelerator ELV-4 in Dyetec (Taegy)

Building for Accelerator ELV-12 in Dyetec (Taegy)



Control system of installation for the treatment of dying waste water



Reaction hall of accelerator





Luminescence of water by EB



Effect of irradiation and biological treatment on wastewater parameters:

a-TOC; b-COD_{Cr}; c-COD_{Mn}; d-BOD. 1- after EB treatment 2- without EB treatment



Removal efficiency of electron beam treatment with ELV-12 accelerator

PARAMETERS	PH	BOD	COD(Mn)	COLOR
INFLUENT	12	2 000	900	1000
EFFLUENT	7	40	70	200

Productivity: 10 000 M³/day

Additional activity 2009-2010

- Producing of nanopowders and nanotubes by focused electron beam
- Movable electron accelerator

There are accelerator with radiation shielding, power supply, ozone decontamination, water cooling are installed inside of trailer





Not so convenient for adjustment



Accelerator parameters: Max. energy - 0.65 MeV Max. Current — 35 мA Purpose of accelerator: Electron beam treatment of waste water



Irradiation chamber is open

Movable accelerator was developed by BINP together with firm EB-TECH from South Korea. Accelerator before transportation



Accelerator passed 140 km during 4 hours. After transportation it was put in operation after 15 min



Device for extraction of focused electronbeam into atmosphere





Producing of nanopowders

There was many experiments with different institutions. The new nanopowders were obtained:

WC, W, W_2O_5 , Y_2O_5 , Bi, Bi_2O_3 ,

Nanoparticles of W, TEM picture



Bi nanopowder



TEM picture of nanotubes.



Conclusion

- ELV accelerators according to the set of parameters and possibilities for users are one of the best in the world for today.
- We are open for collaboration. From consulting to delivery. You are welcome

Thank You

for attention