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 accelerator-years
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 +/-2%.
## Parameters of the ELV accelerators

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

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.
ELV accelerators

H/V Generator: Rectifying Sections Column

Accelerating tube and Primary winding
ELV accelerators

ELV-8 accelerator after assembling of H/V rectifier
ELV accelerators

ELV-8 accelerator
Operator controls accelerator through PC
4-side irradiation system
Extraction device equipped with 4-side 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Энергия электронов, МэВ</td>
<td>1.15</td>
</tr>
<tr>
<td>Ток пучка, мА</td>
<td>30</td>
</tr>
<tr>
<td>Скорость, м/мин</td>
<td>225</td>
</tr>
<tr>
<td>Остаток З/Г кабеля на П6, м(мин)</td>
<td>-3423(-15)</td>
</tr>
</tbody>
</table>
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
<table>
<thead>
<tr>
<th>Power (kW)</th>
<th>Price (M$)</th>
<th>Cost for 1 kw (10^4$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.5</td>
<td>2.5</td>
</tr>
<tr>
<td>40</td>
<td>0.8</td>
<td>2</td>
</tr>
<tr>
<td>100</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>200</td>
<td>1.5</td>
<td>0.75</td>
</tr>
<tr>
<td>400</td>
<td>2</td>
<td>0.5</td>
</tr>
</tbody>
</table>
ELV accelerators

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, 2-coils and cores of the beam scanning system, 3-protection cylinder flange, 4-protection 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.
Wastewater Treatment Facility in Daegu Dyeing Industrial Complex

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\textsubscript{Cr}; c-COD\textsubscript{Mn}; d-BOD.

1- after EB treatment
2- without EB treatment
Removal efficiency of electron beam treatment with ELV-12 accelerator

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>PH</th>
<th>BOD</th>
<th>COD(Mn)</th>
<th>COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>INFLUENT</td>
<td>12</td>
<td>2,000</td>
<td>900</td>
<td>1,000</td>
</tr>
<tr>
<td>EFFLUENT</td>
<td>7</td>
<td>40</td>
<td>70</td>
<td>200</td>
</tr>
</tbody>
</table>

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 mA
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 electron beam into atmosphere
Producing of nanopowders

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

\[ \text{WC, W, W}_2\text{O}_5, \text{Y}_2\text{O}_5, \text{Bi, Bi}_2\text{O}_3, \]
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