Advertisement for Incubation of Technology

Title of the technology	150kV, 20kW EB Gun for welding applications

Current state of Technology

- ✓ Basic principles observed
- ✓ Technology concept formulated
- ✓ Experimental proof of concept
- ✓ Technology validated in lab
- ✓ Demo system available (12kW, 80kV EB Welding Machine is available at BARC)

General Information

The electron beam (EB) system has been developed in-house for thermal applications such as melting and welding. The major components of EB system are EB gun, Power source, Vacuum chamber and Job handling system. A brief description of each sub system is given below.

- **EB gun:** It consists of three electrodes such as wire type tungsten filament as cathode, focusing and beam control electrode namely grid and anode for beam acceleration. The thermionically generated electrons from cathode are accelerated towards anode by applying an electric field between the electrodes. The flow of electron is regulated by varying the potential of control grid. This grid potential also helps in converging the electrons that are diverted due to Coulomb repulsion.
- **Power source:** The EB power source consists of high voltage power source and auxiliary power supplies dedicated to specific functions. The cathode heating power supply is required for heating the filament so that the electrons can overcome the work function. For the acceleration of electrons from anode to cathode, it also needs a HV power supply. Similarly for beam control and focusing, a power supply with controlled terminal voltage is connected to grid. However, the cathode heating and beam control power supplies are floated at acceleration potential. Besides, there exist many auxiliary low voltage power supplies for beam focusing, deflection and oscillation. Moreover, separate motor drives are also required for handling of the target inside a vacuum chamber.
- **Vacuum chamber:** In thermal application like welding and melting, the generation, transmission and utilisation of electron beams are carried out inside the vacuum environment. In the EB gun, the generation of the electrons from a thermionically heated cathode is carried out at a vacuum level better than $1x10^{-5}$ mbar to prevent the filament from oxidation and hence the life of filament increases. The transmission of the electrons is also through a vacuum channel, which facilitates the smooth flow of electron with minimum losses by avoiding number of successive collisions. Similarly, the job to be welded is also housed in a vacuum chamber at an optimum vacuum of $1x10^{-5}$ mbar to prevent the oxidation of the weld joints.
- **Job handling system:** Inside the work chamber, a work table with four motorised movable directions (X, Y, Z, θ) with precise position and speed control are essential to accomplish the welding process. Here a stationary beam is made to target a moving joint in a pre-defined axis.

The expected process is to be fully automatic, so that a pre-programmed path can be defined for welding a job having complex geometry.

Features/Specification of Current system

The important features and specifications of the 150k, 20kW EB welding systems are listed in the following table.

S No	150kV,20kW EB welding Machine components	Current System	Target System
1	Cathode type	Tungsten **/ Tantalum**	Tungsten **/ Tantalum**
2	EB gun type	Directly heated	Directly heated
3	Beam power density on target	$10^6 W/cm^2$	$10^6 W/cm^2$
4	Filament heating supply	**20V,50A,DC**	**20V,70A,DC**
5	Acceleration supply	**80kV, 150mA, DC**	**150kV, 150mA, DC**
6	Grid supply	3kV,100mA, DC	3kV,100mA, DC
7	Beam focusing	50V, 4A, DC	50V, 4A, DC
8	Beam deflection	30V,2A, DC	30V,2A, DC
9	Beam Oscillation	30V,1A, ac	30V,1A, ac
10	Gun vacuum	$1e^{-6}$mbar	$1e^{-6}$mbar
11	Chamber Vacuum	$1e^{-5}$mbar	$1e^{-5}$mbar
12	**Chamber size**	**0.8mX0.8mX0.8m**	**2mX2mX2m**
13	System Leak Rate	$<1e^{-9}$mbarlit/sec	$<1e^{-9}$mbarlit/sec
14	**Throw distance**	**0.8 m**	**1.5 m**
15	Job movement	Four axis X, Y, Z & θ	Four axis X, Y, Z & θ
16	Beam viewing feature	Online With Digital camera	Online With Digital camera
17	Operation console	SCADA and HMI	SCADA and HMI
18	Control and interface	PLC control	PLC control

Working of the System (with schematic block diagram)

Electron Beam welding is carried out when highly focused high energy beam of electrons impinges on the target surface and loses all its energy in multiple collisions. Figure 1 shows the schematic view of an electron beam welding machine.

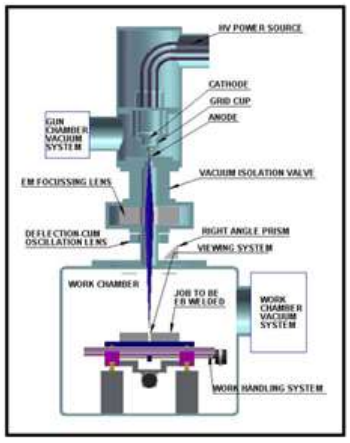

Figure 1: Schematic view of an EB welding machine

In EB, a stream of electrons is generated by heating the tungsten cathode and accelerated by applying a high voltage between cathode and anode. By careful shaping of cathode and anode the electron beam is made to pass through anode aperture and thereafter it starts to diverge. The diverging electrons are focused by electromagnetic (EM) focussing lens. The beam current is controlled by varying the potential between cathode and grid cup. Precise positioning of the beam over the joint can be achieved by looking at low power tracer beam over the joint with the beam viewing system. The fine movement of beam can be controlled along X-Y plane by the use of deflection cum oscillation coils. The

emitter assembly and the work chamber are maintained under vacuum to facilitate smooth flow of electrons with minimum loss of energy.

Applications of the System

Electron beam welding has found its applications in aerospace and nuclear engineering field. Some of the defence products also require EB welding. It can weld refractory, thin to thick section, dissimilar and highly reactive materials without any significant degradation in the material properties.

Picture/Photo of the System –

Figure 2: Photograph of 12kW, 80kV electron beam welding machine installed at BARC

An upgraded machine with a higher rated capacity (150kV, 20kW) is to be developed under the incubation program. The new development must be in line with the current technological trends.

Whether the parent product/ technology/ process is patented: ~~Yes~~/No

If yes, provide the details – N/A

Deliverables –

150kV, 20kW system will be jointly developed with the incubatee. The incubation is aimed at a complete, ready to launch, industrial EB system.

The major deliverables are

- ✓ 150kV, 20kW electron beam emitter assembly which is performance tested, suitable for use in industry with reliability.
- ✓ Work chamber with fully automated job handling system.
- ✓ Vacuum system, power supply and controls with SCADA and HMI.

- ✓ Complete set of design, fabrication, QA/QC, test, qualification, reports and maintenance schedule documents with relevant data sheets.

Justification for Incubation –

Electron beam technology is an advanced welding technology capable of producing better quality of weld with minimum heat affected zone, in comparison to the other conventional welding methods. However, its true potential is not being harnessed in the country due to limited accessibility of the technology at an affordable cost. Under the incubation program, a 150kV, 20kW EB welding machine will be systematically developed by an Indian entrepreneur mentored by BARC scientists/engineers.

Facility and Infrastructure requirements:

Facility and Infrastructure to be provided by Incubatee/BARC:

Manpower/ expertise Two turners, two fitters and one welder for mechanical workshop. One mechanical, one electronics and one electrical engineer, one certified RSO and one operator.
Machinery and Equipment Mechanical workshop with facility for fabricating high precision components compatible for high vacuum and high voltage environment as per the specified tolerance. Mass Spectrometer Lead Detector, High Voltage Megger testing set up and Dosimeter for X-ray measurement
Other
Any special requirements for plant, industry, location utilities, handling storage, safety etc. Equipment for radiation survey

Note: As per in-house technology incubation policy, the incubatee should be a licensee of the existing technology. Alternatively, the applicant will be required to take the license of the existing technology before entering incubation agreement.

If interested in Incubation, kindly ***download -> fill -> scan -> send*** the application form to -

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