Electron Beam Welding

Electron Beam Welding (EBW) is a fusion welding in which coalescence is produced by heating the workpiece due to impingement of the concentrated electron beam of high kinetic energy on the workpiece. As the electron beam impinges the workpiece, kinetic energy of the electron beams converts into thermal energy resulting in melting and even evaporation of the work material.

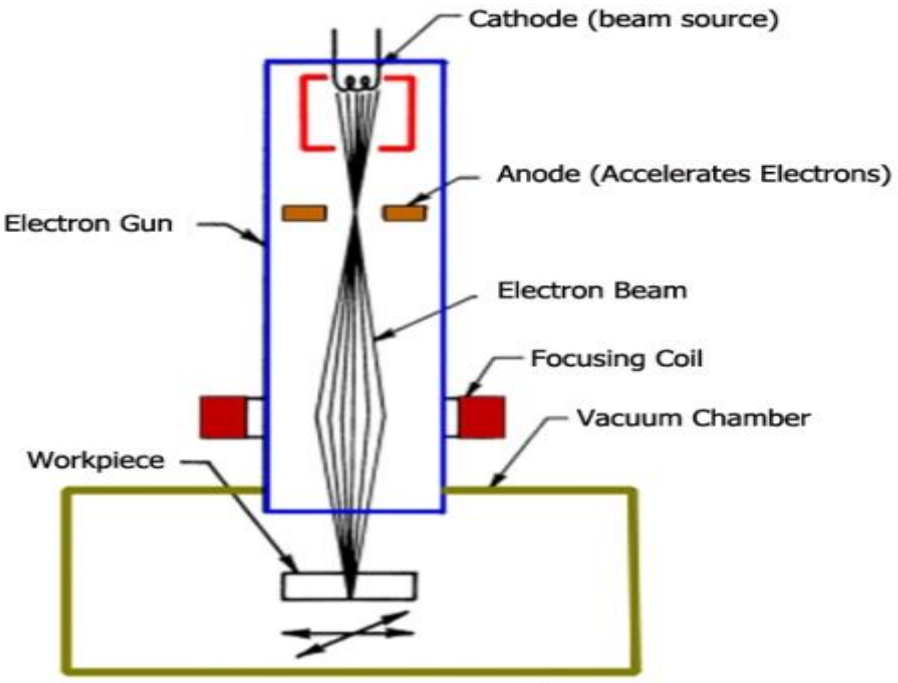
Principles:

In general, electron beam welding process is carried out in vacuum. In this process, electrons are emitted from the heated filament called electrode. These electrons are accelerated by applying high potential difference (30 kV to 175 kV) between cathode and anode. The higher the potential difference, the higher would be the acceleration of the electrons. The electrons get the speed in the range of 50,000 to 200,000 km/s. The electron beam is focused by means of electromagnetic lenses. When this high kinetic energy electron beam strikes on the workpiece, high heat is generated on the work piece resulting in melting of the work material. Molten metal fills into the gap between parts to be joined and subsequently it gets solidified and forms the weld joint

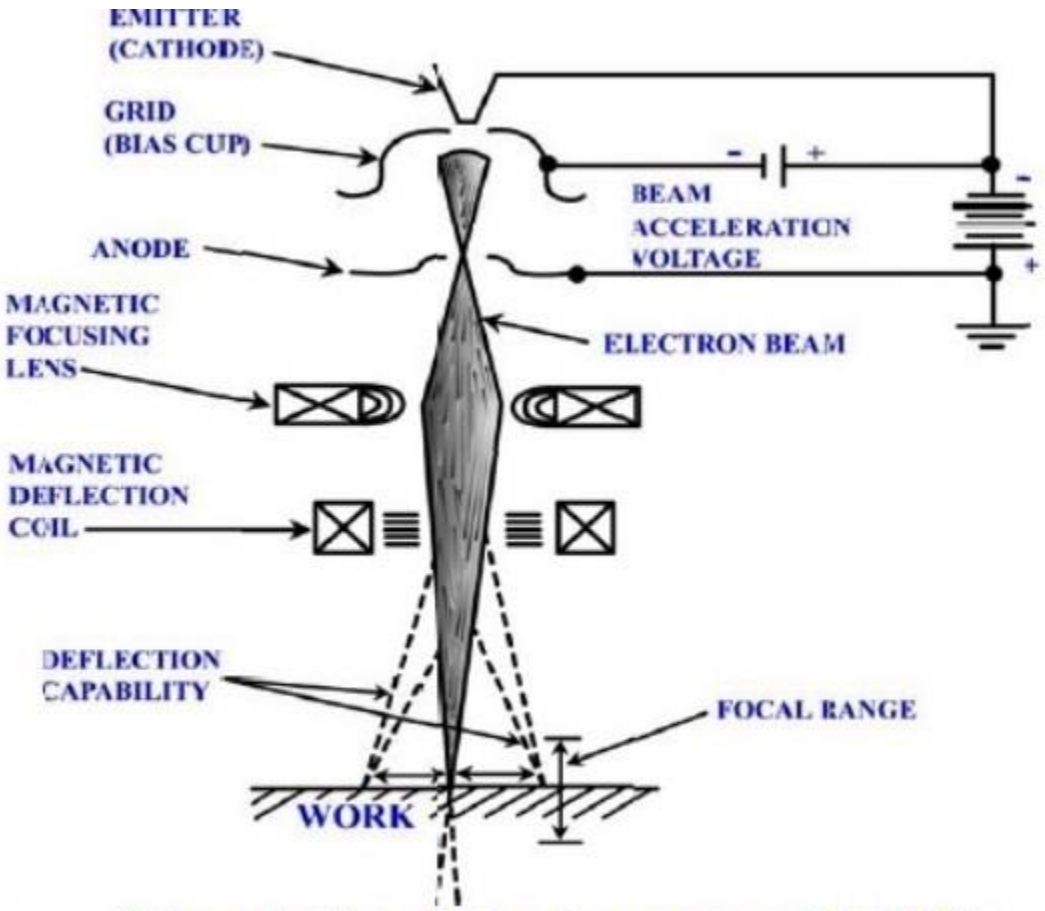
EBW Equipment:

An EBW set up consists of the following major equipment:

a) Electron gun,
b) Power supply,
c) Vacuum Chamber, and
d) Work piece handling device



Electron-Gun: An electron gun generates, accelerates and aligns the electron beam in required direction and spots onto the workpiece. The gun is of two types: Self accelerated and work accelerated. The work accelerated gun accelerates the electrons by providing potential difference between the work piece and cathode. In the self accelerate gun, electrons are accelerated by applying potential difference between the cathode and the anode. The anode and cathode are enclosed within the gun itself. The control of electron density is better in this type of electron gun. A schematic of an electron beam gun used in EBW is shown in Fig. 4.5.1. Major parts of an electron gun are briefly introduced in the following sections.



Schematic of an electron beam gun used in EBW.

Emitter/Filament: It generates the electrons on direct or indirect heating.

Anode: It is a positively charged element near cathode, across which the high voltage is applied to accelerate the electrons. The potential difference for high voltage equipment ranges from 70-150 kV and for low voltage equipment from 15-30 kV.

Work Piece Handling Device: Quality and precision of the weld profile depends upon the accuracy of the movement of work piece. There is also provision for the movement of the work piece to control the welding speed. The movements of the work piece are easily adaptable to computer numerical control.

Advantages of EBW:

1) High penetration to width can be obtained, which is difficult with other welding processes.
2) High welding speed is obtained.
3) Material of high melting temperature can be welded.
4) Superior weld quality due to welding in vacuum.
5) High precision of the welding is obtained.
6) Distortion is less due to less heat affected zone.
7) Dissimilar materials can be welded.
8) Low operating cost.
9) Cleaning cost is negligible.
10) Reactive materials like beryllium, titanium etc. can be welded.
11) Materials of high melting point like columbium, tungsten etc. can be welded.
12) Inaccessible joints can be made.
13) Very wide range of sheet thickness can be joined (0.025 mm to 100 mm)

Disadvantages of EBW:

1) Very high equipment cost.

2) High vacuum is required

3) High safety measures are required.

4) Large jobs are difficult to weld.

5) Skilled man power is required.

Applications of EBW:

1. Electron beam welding process is mostly used in joining of refractive materials like columbium, tungsten, ceramic etc. which are used in missiles.

2. In space shuttle applications wherein reactive materials like beryllium, zirconium, titanium etc. are used.

3. In high precession welding for electronic components, nuclear fuel elements, special alloy jet engine components and pressure vessels for rocket plants.

4. Dissimilar material can be welded like invar with stainless steel.

References:

Books:

1. Ghosh A. and Mallik A. K., Manufacturing Science, EWP Pvt. Ltd.

2. Manufacturing Technology, vol. II by P.N. Rao, Tata McGraw Hill, New Delhi

Web Links:

1. https://nptel.ac.in/courses/112105212/

2. https://nptel.ac.in/courses/112/103/112103244/