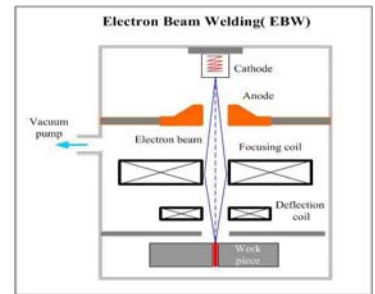


Electron Beam Welding

Process description:

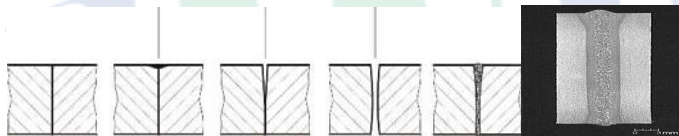
Electron beam welding (EBW) is a welding process which produces coalescence of metals with the heat obtained from a concentrated beam composed primarily of high-velocity electrons impinging upon the surfaces to be joined. Heat is generated in the workpiece as it is bombarded by a dense stream of high-velocity electrons. Virtually all of the kinetic energy of the electrons is transformed into heat upon impact.



Deep-Penetration Effect:

If the energy density in the beam spot was comparable to the energy density of conventional welding methods, the obtainable penetration depth would be a few mm higher with, at the same time, a relatively large weld width. In electron beam welding, however, the energy density is above 105 W/cm^2 . This causes the material to melt and to evaporate in the centre of the beam cross-section.

This happens so fast that the heat dissipation into the cold material practically shows no noteworthy effect. The developing vapour is overheated and expands at temperatures of above approx. 2700 K. The obtained vapour pressure is sufficiently high to press the molten metal down and towards the sides. A depression develops where the electron beam impinges on the material which has not evaporated yet and heats it further. This way a capillary forms which, in its core, consists of overheated vapour and which is covered by a shell of fluid material. When the energy supply is sufficiently high, the developing capillary penetrates the entire work piece. This procedure is called the deep penetration effect. By means of this effect, weld depths of up to 150 mm (steel materials) and of up to 400 mm (aluminium materials) can be obtained.



Process-Specific Characteristics of Electron Beam Welding:

- A high energy concentration in the focal point of the electron beam and thus the power density is by 100 to 1000 times higher than in arc welding methods.
- Welding in vacuum leads to a special purity of the welded seam and to the minimization of weld defects.
- Automated welding in vacuum with electrically well controllable welding parameters guarantees a high reproducibility of the weld quality.
- The high power density of the electron beam allows working with very high welding speeds.
- The high welding speeds and the favorable total efficiency allow high productivity with a relatively low energy consumption.
- The high automation level allows to integrate the method into flexible machine systems.
- It is possible to weld different materials with each other.
- The electron beam is, by means of the electromagnetic fields, deflected almost without inertia which leads to the generation of extremely high-frequency oscillation movements which entail different welding advantages.
- Through the high power density of the electron beam the energy input into the part is relatively low, which leads to the almost distortion-free joining of finished products.
- Only electrically conductive materials can be processed with the electron beam.
- Fixing of the joining members must be made in a gap free manner. The components must be cleaned prior to welding.
- The developing X-radiation which is caused by the impingement of the electron beam onto the work piece requests a radiation-tight shielding of the electron beam equipment.



EBW Limitations:

- Expensive equipment
- Work chamber size constraints
- Time delay when welding in vacuum
- High production expenses
- X-ray irradiation
- Rapid solidification rates can cause cracking in some materials



EBW Applications:

EBW became viable, as a production process, in the late 1950's. At that time, it was used mainly in the aerospace and nuclear industries. Since then, it has become the welding technique with the widest range of applications, ranging, for example, from high speed welding of band saw blade materials to the joining of thick section marine components. Ultra thin deep-drawn vanadium cells have been welded to pure titanium