Un-conventional machines (Laser, Electron Beam etc.)

Electron Beam Machining (EBM) and Laser Beam Machining (LBM) are thermal processes considering the mechanisms of material removal. However electrical energy is used to generate high-energy electrons in case of Electron Beam Machining (EBM) and high-energy coherent photons in case of Laser Beam Machining (LBM). Thus these two processes are often classified as electro-optical-thermal processes. There are different jet or beam processes, namely Abrasive Jet, Water Jet etc. These two are mechanical jet processes. There are also thermal jet or beams. A few are oxyacetylene flame, welding arc, plasma flame etc. EBM as well as LBM are such thermal beam processes. The mechanism of material removal is primarily by melting and rapid vaporisation due to intense heating by the electrons and laser beam respectively.

Electron Beam Machining – Process Electron beam is generated in an electron beam gun. The construction and working principle of the electron beam gun would be discussed in the next section. Electron beam gun provides high velocity electrons over a very small spot size. Electron Beam Machining is required to be carried out in vacuum. Otherwise the electrons would interact with the air molecules, thus they would loose their energy and cutting ability. Thus the work piece to be machined is located under the electron beam and is kept under vacuum. The high-energy focused electron beam is made to impinge on the work piece with a spot size of 10 – 100 μm. The kinetic energy of the high velocity electrons is converted to heat energy as the electrons strike the work material. Due to high power density instant melting and vaporisation starts and "melt – vaporisation" front gradually progresses. Finally the molten material, if any at the top of the front, is expelled from the cutting zone by the high vapour pressure at the lower part. Unlike in Electron Beam Welding, the gun in EBM is used in pulsed mode. Holes can be drilled in thin sheets using a single pulse. For thicker plates, multiple pulses would be required. Electron beam can also be maneuvered using the electromagnetic deflection coils for drilling holes of any shape.

Laser Beam Machining –Laser Beam Machining or more broadly laser material processing deals with machining and material processing like heat treatment, alloying, cladding, sheet metal bending etc. Such processing is carried out utilizing the energy of coherent photons or laser beam, which is mostly converted into thermal energy upon interaction with most of the materials. Nowadays, laser is also finding application in regenerative machining or rapid prototyping as in processes like stereo-lithography, selective laser sintering etc. Laser stands for light amplification by stimulated emission of radiation. The underline working principle of laser was first put forward by Albert Einstein in 1917 though the first industrial laser for experimentation was developed around 1960s. Laser beam can very easily be focused using optical lenses as their wavelength ranges from half micron to around 70 microns. Focussed laser beam as

indicated earlier can have power density in excess of 1 MW/mm2 . As laser interacts with the material, the energy of the photon is absorbed by the work material leading to rapid substantial rise in local temperature. This in turn results in melting and vaporisation of the work material and finally material removal.

Laser can be used in wide range of manufacturing applications • Material removal – drilling, cutting and tre-panning • Welding • Cladding • Alloying Drilling micro-sized holes using laser in difficult – to – machine materials is the most dominant application in industry. In laser drilling the laser beam is focused over the desired spot size. For thin sheets pulse laser can be used. For thicker ones continuous laser may be used.

Advantages

In laser machining there is no physical tool. Thus no machining force or wear of the tool takes place.

Large aspect ratio in laser drilling can be achieved along with acceptable accuracy or dimension, form or location

Micro-holes can be drilled in difficult – to – machine materials

Though laser processing is a thermal processing but heat affected zone specially in pulse laser processing is not very significant due to shorter pulse duration.

Limitations

• High initial capital cost

• High maintenance cost

• Not very efficient process

• Presence of Heat Affected Zone – specially in gas assist CO2 laser cutting

• Thermal process – not suitable for heat sensitive materials like aluminium glass fibre laminate