ELECTRON BEAM WELDING VERSUS LASER WELDING

Foreword

When comparing electron beam welding (EBW) to laser welding (LW) it should be understood that both processes fall under a general heading of "Power Beam" welding.

EBW uses a finely focused stream or beam of electrons and lasers use monochromatic coherent light, photons. In both cases the kinetic energy of the electrons or photons are turned into heat energy when they impinge upon the surface of metal.

Of the two techniques EB is probably known to a lessor extent than lasers. This is not because it is an inferior process to laser but more probably due to people's perceptions. Most have heard about or have seen Star Wars, James Bond and a host of other hi-tec Sci-fi films which have bombarded our screens over many years, and coupled with the high profile many respected institutions have been putting forward, unfortunately, EB has taken a back seat.

So, is EB inferior to lasers? The following table looks at the advantages and disadvantages of both processes.

	Electron Beam Welding	**Laser Welding**
Single pass welding of thick sections	60 kV 6 kW beam power gives over 20 mm penetration Weld depth to width ratio up to 40:1	Nd-YAG lasers have lower power resulting in restricted penetration Weld depth to width ratio 10:1
High welding speed	High speed deep penetration welds possible	High welding speeds achievable but lacks penetration
Automated process	Can be highly automated with evacuation time of the chamber in a few seconds. Typical cycle times found within the automotive industry 40 seconds per component Time is dependent upon length/complexity of weld	Can be highly automated with production rates higher than those for EB as the evacuation time is removed (non-vacuum process)
Component size	Component size is restricted by the size of vacuum chamber In most high production systems component size does not alter to a great degree. Chamber volumes are kept to a minimum to reduce evacuation times	Not restricted by component size Nd-YAG fibre optic delivery systems can be used allowing the welding head to be remote from the power source

Weld quality	High quality weld due to inert atmosphere, very stable and repeatable. Deep penetration welds on a wide variety of materials including dissimilar metal combinations can be made	Some porosity is normally found within the weld bead and root, as the shield gas does not totally eliminate air from the weld area Inferior weld quality
Vacuum environment	Vacuum aids in the weld quality as it has a tendency to pull contamination out away from the weld pool	Not applicable - no vacuum Laser uses atmosphere with additional shielding gas
Filler gas or shielding gas	Not required	Needs the shielding gas normally nitrogen or argon to stop oxidisation of the weld area and weld pool
Wearing components	Filaments Metal vapours can deposit on viewing prism with no effect on weld characteristics Prism can be cleaned	Optical devices such as mirrors and lenses can be coated by metal vapour produced during the welding process leading to drop in beam power impinging on work surface resulting in reduced penetration. Laser or shielding gas Optical elements Mirrors
Running cost	Cooling water (normal quality) Pump oils Electricity Compressed air (for valve actuation)	Requires high purity water in cooling system to cool beam source Water must be held at $\pm 1^{o}$C constant temperature Consumption of shield gas high Electricity
Power efficiency	80-90%	7-10%
Cost Comparison	More expensive than TIG, MIG etc	More expensive than TIG, MIG & EB
Price (approximate prices)	60 kV 4 kW (610 mm^3) electron beam welder including CNC controlled work manipulation systems £220,000.00	4 kW laser £250,000.00 excluding work manipulation system

Conclusion

It should not be forgotten that you have to decide which of the two processes are best suited for a given application. However for welds that requires a penetration of 5 mm or more EB is usually the best solution and for welds exceeding 10 mm EB is by far the more cost- effective method.