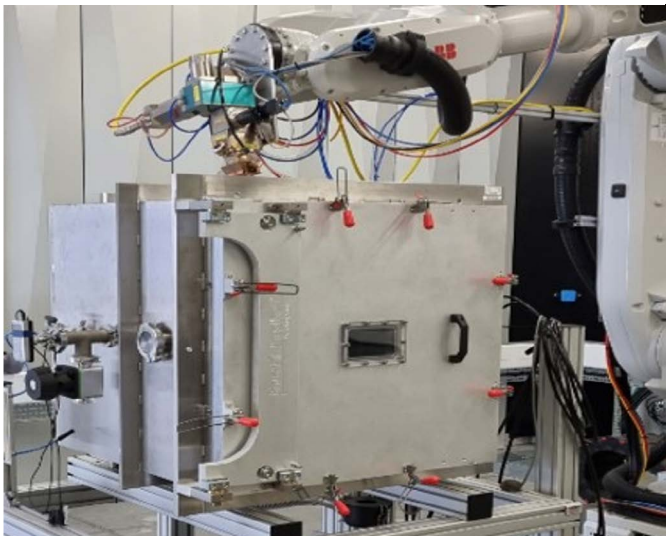
Market Sector:
AEROSPACE / NUCLEAR / DEFENCE

Technology Theme:
LASER PROCESSING / FUSION WELDING

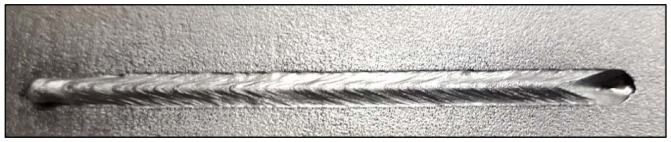
LASER WELDING IN VACUUM:
PROCESS DEVELOPMENT

Vacuum chamber



Open air

In vacuum (5 mbar)



Material: 304 Stainless steel
(Power = 3kW, Travel speed = 15 mm/s)

PROCESS DEVELOPMENT

The MTC has developed a revolutionary welding process in a vacuum chamber using an IPG's D50 wobble laser head. The new process can produce defect free welds, with a 50% increase in weld penetration depth. This has resulted in a significant reduction in weld time for 304 stainless steel and exotic materials.

> The work completed by MTC has developed and demonstrated laser in vacuum welding capability that manufacturing sectors can easily access to overcome the traditional limits associated with welding of exotic materials.
>
> **Mugove Rutsito, Advanced Research Engineer, MTC**

THE CHALLENGE

Laser beam welding (LBW) has been widely adopted across most industrial sectors. The advantages include ease of automation, small heat affected zone, high efficiency, high welding speed (productivity) and good flexibility. However, thicker section high value or critical components of jet engines, transmission components, superconductive material components are often electron beam (EB) welded as they benefit from deep penetration high aspect ratio welds. Aerospace component weldments in titanium and nickel based alloys also benefit from zero oxygen pick up and consequent weld embrittlement.

A COLLABORATIVE APPROACH

- The MTC has developed a laser welding process under sub atmospheric pressure vacuum by manufacturing a low cost 1m³ portable chamber with a PC controlled Cartesian motion system for component manipulation, which enables the use of externally mounted process tools.
- The process tool (IPG D50 wobble head with programmable scanning parameters) is externally mounted with the energy being delivered via a sacrificial anti-reflective coated window.
- Optical contamination is a key barrier to long term production, the solution is an inert gas feed purge allowing multiple welds without intervention.

THE OUTCOME

Welding trials using the developed system have shown:

- High penetration depth (increase up to 50%) similar to EB welding.
- High integrity welds free from oxidation, internal defects, spatter with little or no porosity.
- Wider weld beads (than standard laser) through optimisation of wobble head parameters to control heat input in the weld.

BENEFITS TO THE CLIENT

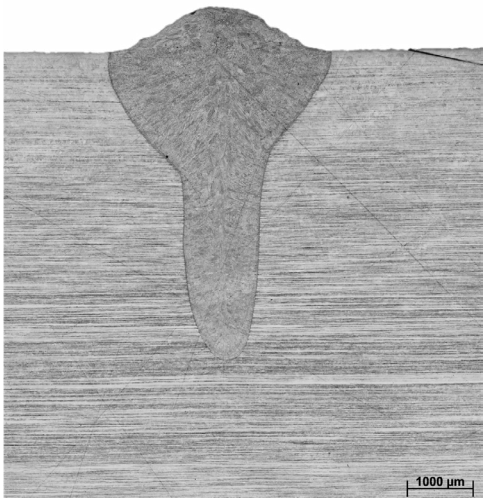
- Access to a capability with the potential for significant cost and time savings when compared to EB welding.
- Expanding the use of laser welding for sectors and new applications.
- Ability to tackle some of the limitations of the more established welding solutions (e.g. EB welding) whilst realising all the advantages (e.g. flexibility of fibre delivery) associated with laser welding.
- Not susceptible to deflection by residual magnetism that invariably exists in EB welding of thicker steel sections.

> Not only has this work developed a unique capability for the MTC that our customers can now access, but it has demonstrated that high integrity, high penetration depth welds are achievable with laser in a vacuum. This will open up many applications previously not appropriate for laser technology, and therefore allow potentially significant cost savings for industries such as aerospace and defence, where processes such as EB welding can be reduced.
>
> **Bethan Smith, Technology Manager, MTC**

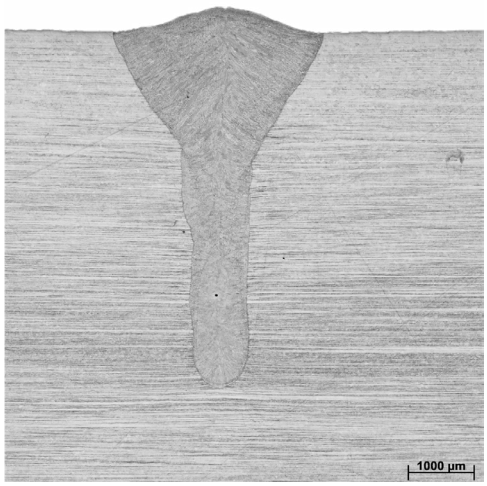
↑50%
Penetration depth

↑40%
Cost and risk relative to EB welding

<8 min
Chamber pump down time



Open air



Partial Vacuum (5 mbar)

Weld penetration depth comparison for 304 stainless steel

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