INFORMATION

AEROSPACE MANUFACTURING TECHNOLOGY

High Energy Density Metal Joining

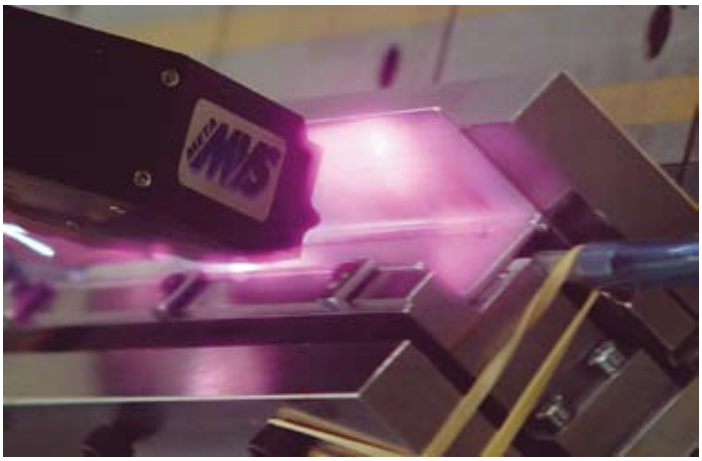
The NRC Institute for Aerospace Research (NRC Aerospace) investigates and develops procedures to join metallic products using high energy density technologies. Studies are currently underway to develop laser and electron beam welding of aerospace components.

Laser-based technologies
Expertise in laser welding and cutting of aerospace materials is being developed using a 4 kW robotic Nd-YAG laser welding system and a 2.7 kW CO_2 laser processing centre. The technology, which can be used for welding, cladding, and precise cutting of flat sheets or 3-D parts, offers many advantages. It creates a narrow heat-affected zone having little distortion, and smooth cut edges that don't require post-processing treatment due to the high energy density of the laser beam. It is faster and more precise than conventional methods, flexible, highly automated, and easily integrated into other processes. Projects are currently underway to investigate its applicability for welding and repair of fusela ge and engine components.

Equipment specifications:

- 4 kW robotic Nd-YAG laser using fibre optics
  - ABB 4400 industrial robot
  - MVS seam tracking system
  - AB wire feeder
  - Electronically controlled magnetic table for fixturing.

- CO_2 laser processing centre
  - TRUMPF TLC 1005 Lasercell with TLF 2700 laser
  - RF-excited 2.7 kW fast axial flow CO_2 laser
  - TEM00 beam mode (Gaussian ener gy distribution)
  - High beam quality: K=0.67
  - Frequency modulation: 0.1-100 kHz



Nd-YAG laser welding

  - Fully programmable 6-axis computer numerically-controlled machine with Siemens Sinumerik 840D controller and teach panel
  - Programmable to 0.001 mm, accurate to ±0.1 mm
  - Linear travel speeds: X & Y axes: 50 m/min; Z axis: 30 m/min
  - Rotary travel speeds: A, B, C axes: 360°/sec
  - Equipped with 0.5 m diameter rotary table
  - Large 3-D working area: X: 1.25 m, Y: 1.5 m, Z: 0.5 m
  - Head positioning via C (360°) & B (±120°) axes
  - Can cut up to 15 mm thick steel, 6 mm thick stainless, 4 mm thick aluminum at up to 10 m/min
  - Kerf tolerances to 0.05 mm
  - Hole drilling as small as 0.3 mm diameter.

Electron beam technologies
Electron beam processing studies are conducted using a 42.5 kW electron beam welder whose large chamber can accommodate large components or multiple parts.

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Electron beam processing centre

Assemblies are processed using a beam of electrons to generate heat at the joint and cut a keyhole into which molten metal then flows. The high energy density of the electron beam and the vacuum environment result in narrow heat-affected zones, deep welds with little distortion, and high-quality welds with very little porosity or contaminants. It can be used to join reactive and refractory metals, high thermal conductivity metals, dissimilar materials, and large sections or complex joint designs, with or without filler metal. Studies are currently underway to develop procedures for joining and free-form manufacturing of nickel-based superalloys and titanium alloys.

Equipment specifications:

- Thermionic electron emission from a tungsten filament
- Output voltage: 0-60 kV; output current: 0-700 mA
- Power range: 0-42 kW
- High vacuum (1-100 µTorr) 68” x 68” x 84” chamber
- Wire feeder 0.020, 0.030, 0.035 and 0.046 wire; 0-100”/min
- 19” gun-piece clearance on perpendicular welds
- CNC-controlled 30” diameter welding table
- Five mechanical axis of motion:
  - X - table; 33” displacement, 0-100”/min
  - Y - gun; 50” displacement, 0-100”/min
  - Z - table; 30” displacement, 0-100”/min
  - R - table; 0-10 rpm
  - T1 - table; -10 to 90°, 0-6°/sec (1 rpm)
  - T2 - gun; -10 to 90°, 0-30°/sec (5 rpm).

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