Development of Local Vacuum Technology for the Application of Power Beam Welding to Massive Structures

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Scope

- Drivers for local vacuum
- EB welding with mobile local vacuum
- Practical application
- Laser Welding with mobile local vacuum
- Summary
Why Power Beam Welding?

- Productivity
- Economy
- Quality
- Distortion
- Residual Stress
- Metallurgical
Since EB welding first used - 1957
- Vacuum chambers
  - Asset
  - Hindrance
- Non-vacuum developed for automotive
- Mobile sealing attempts
- Laser developments
High vacuum chamber - 230m³
Vacuum

- Ideal welding atmosphere - prevents oxidation of reactive metals
  vacuum re-melted weld metal
- No plasma effects
- Easy to generate
- Low cost: e.g. £20/day
  - for 150 m³ (10⁻³ mbar)
- Control
  - fume, convection, containment
Why Local Vacuum?

- Size of structures
- Transportation issues
- Site welding
Vacuum considerations

- High vacuum $10^{-3} - 10^{-4}$ mbar
- Partial vacuum $10^{-1} - 10^{-2}$ mbar
- Non-vacuum 1000 mbar

REDUCED PRESSURE $\sim 1$ mbar
Vacuum Pressure units

- 100 Pa = 1 mbar = 1.33 torr
- 10 Pa = $10^{-1}$ mbar = 1.33 x $10^{-1}$ torr
- 1 Pa = $10^{-2}$ mbar = 1.33 x $10^{-2}$ torr
- 0.1 Pa = $10^{-3}$ mbar = 1.33 x $10^{-3}$ torr
Non-Vacuum EB welding
Reduced Pressure 350mbar

350mbar
Electron Beam 350mbar

350mbar, 200kV, 300mA, Helium
Reduced Pressure 60mbar

60mbar (Concorde)
Electron Beam at 5mbar

5mbar, 200kV, 300mA, Helium
Electron Beam at 1mbar
Reduced Pressure (1mbar) EB Weld
Local vacuum box
Industrial Need

Large diameter forged flanges:
- Expensive (~€35k)
- Few suppliers
- Long lead times

A forged flange from a Chinese supplier, Kinhi
Local box vacuum system
Local Vacuum Flange welder
Potential Applications
J-Lay Pipe Welding
RPEB welding - local seal for tubular
RPEB local chamber for pipe welding
Local Mobile sealing
Local Vacuum for RPEB Welding
Local vacuum EB - application
Prototype local vacuum head
Curved Sliding Seal - 2350mmØ