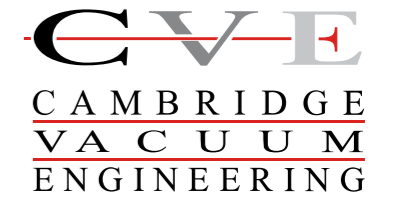
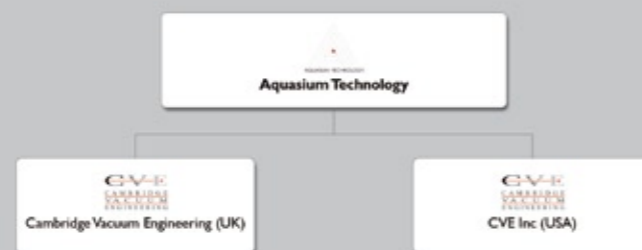


Our world class after sales service is second to none and includes installation, commissioning, training, spare parts, contract maintenance, calibration to National Standards, upgrades and refurbishments.



Electron Beam Welding Technology



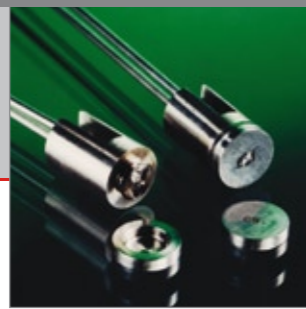
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CVE is ISO 9001 - 2008 approved company



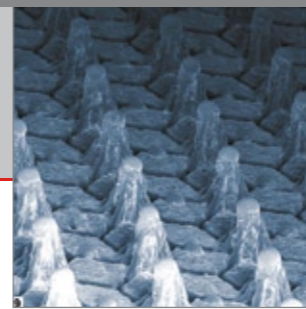
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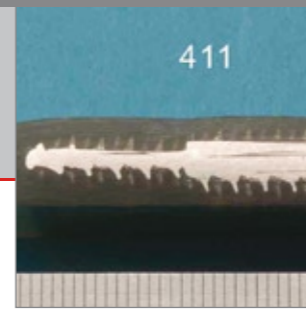
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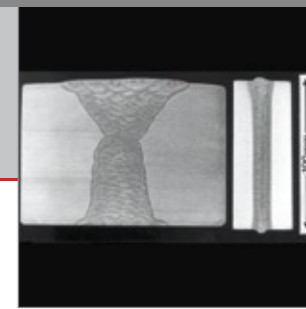
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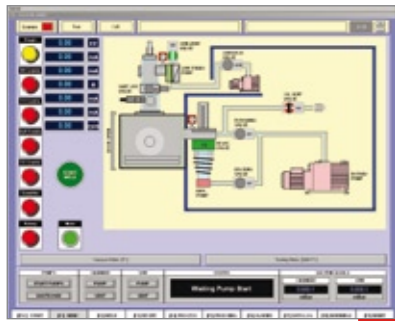
Introduction

Cambridge Vacuum Engineering (CVE) designs and builds process solutions and has more than 40 years experience manufacturing Electron Beam (EB) systems and Vacuum Furnaces (VF's) from its base in Cambridge.

In collaboration with TWI (formerly known as The Welding Institute) CVE's range of equipment includes systems ranging from 50 to 200 kV with beam powers up to 100 kW.

All EB welding machines are tested in accordance with BS EN ISO 14744 parts 1-6 Acceptance inspection of electron beam welding machines.

CVE operates a Quality Management System which complies with the requirements of BS EN ISO 9001:2008.



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- 1 Small components including aneroid capsules, relays and transducers
- 2 Sensors welded with low heat input by EB
- 3 Automotive parts such as gears, airbag inflators and turbochargers
- 4 Mimic screen of the PC based HMI
- 5 Weld screen of the PC based HMI

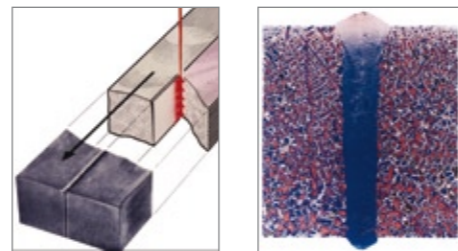
Process

Advantages of EB welding include a high power density with very low overall heat input and therefore minimum distortion. EB welded parts require a minimum of post weld machining and heat treatment and unlike other fusion welding processes EB requires no shielding gases.

The weld quality is exceptional, the process is extremely efficient (typically 95%), all the process parameters are carefully controlled and the process fully automated.

Characteristics of electron beam welds include:

- o Deep penetration
- o Narrow fusion zone
- o Inert atmosphere (vacuum)
- o Near parent metal strength



CVE & TWI

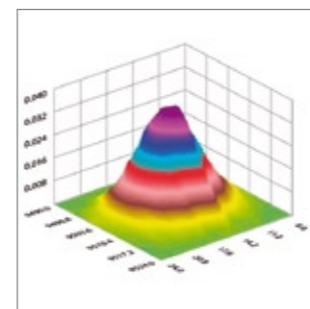
CVE has had a long association with TWI, and since 2003 has a licence agreement to supply, manufacture and support systems designed by TWI including the following:

- o Mathematical modelling
- o Beam probing
- o Rapid deflection for surface modification and Surfi-sculpt™
- o Joint finding & seam tracking systems
- o Reduced pressure EB welding
- o Near net shape fabrication
- o Electron gun design and cathode life
- o High powers up to 100 kW at 200 kV

Beam probing

Beam probing enables the characteristics of the electron beam to be confirmed prior to welding and is a very useful weld diagnostic tool.

Measurement and control of the beam energy distribution can be as important as control of the main parameters such as the accelerating voltage, beam current, welding speed etc.



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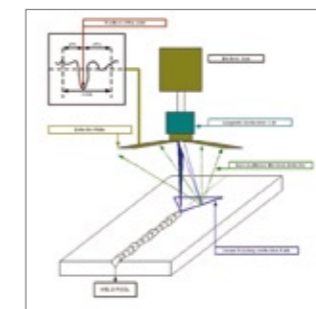
Rapid deflection technology

TWI has developed and patented a technique using electron beam called Surfi-sculpt™ that enables the creation of a wide variety of surface textures through the manipulation of the electron beam.

TWI is developing Comeld™ - an advanced technique to exploit this potential for composite to metal joining

Rapid deflection can also be used for surface modification, integral heat treatment during welding, beam probing, welding with an integral cosmetic pass and real time seam tracking

Seam tracking by backscattered electrons automatically aligns the beam and the joint line enabling tracking and correction can be carried out during welding however special joint preparation may be necessary.



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Reduced Pressure EB (RPEB) Welding

Compared with conventional EB Welding performed in high vacuum (10⁻⁴ mbar range) RPEB welding is performed at pressures ~ 1 mbar. **This means evacuation times and capital costs can be greatly reduced by having small, localised vacuum chambers.**

The key components of the system are TWI's high-powered diode gun and RF excited cathode.

The picture compares a multi-pass arc weld compared to a single pass RPEB weld in 100 mm thick C-Mn steel.

Summary of RPEB Welding:

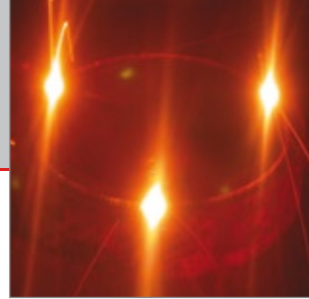
- o Thick section capability in a single pass - up to 200 mm in steel
- o Fewer constraints compared with conventional high vacuum EB welding
- o High process tolerance with standoff distances of 50 - 500 mm
- o Robust system with high reliability

- 1 Surfi-sculpt image courtesy of TWI
- 2 Comeld joining of metal to composite using surfi-sculpt
- 3 Multi-pass arc weld and single pass RPEB weld in 100 mm C-Mn Steel
- 4 Beam probing
- 5 Real time seam tracking

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60 kV Machines

Commonly used for the manufacture of small components including battery cans, medical components, aneroid capsules, latches, bellows, relays and electronic parts including transducers. The low heat input means that sensitive internal electronics packages may be sealed in the device without harm.

Applications in the automotive industry include airbag inflators, gearbox components, transmission parts and turbocharger shaft wheel assemblies.

Examples of fast cycle machines for automotive applications include: Turbocharger welder (TW) includes a 2 station rotary indexing table for high productivity and can be configured for both passenger car and commercial vehicle turbos.

The New Generation (NG) for passenger vehicle turbos has an even shorter takt time.

For EB welding a family of gearbox components for off-road vehicles the machine includes the heavy-duty electron beam column and a range of

tooling inserts for rapid change over between parts.

Electron beam columns

The standard 60 kV beam column is designed for beam powers up to 6 kW and a heavy-duty column for beam powers up to 15 kW. A range of directly heated tungsten filaments are provided depending on the power, weld profile and duty cycle.

Standard features

- o Turbomolecular pumping system
- o Isolation valve maintains vacuum
- o Down beam illumination
- o Viewing prism (pneumatically operated)
- o Beam focus and deflection system (static and dynamic deflection in X & Y $\pm 3^\circ$)
- o Low cost tungsten filament that is quick and easy to change
- o Cathode replacement does not affect mechanical alignment of the column
- o Filament jig ensures accurate and repeatable filament change in less than 10 minutes

Higher productivity is achieved using rapid beam deflection to "split" the beam to reduce the welding time and reduce distortion of the welded gear.

The major components are described below and can be used to configure the desired system specification

Standard Chamber Sizes							
Internal dimensions	9" 225 mm	12" 300 mm	14" 350 mm	18" 450 mm	24" 610 mm	30/40" 750/1015 mm	55" 1400 mm
Length "X"	9" 225 mm	12" 300 mm	14" 350 mm	18" 450 mm	24" 610 mm	40" 1015 mm	55" 1400 mm
Width "Y"	9" 225 mm	12" 300 mm	14" 350 mm	18" 450 mm	24" 610 mm	30" 750 mm	39" 1000 mm
Height "Z"	9" 225 mm	12" 300 mm	14" 350 mm	18" 450 mm	24" 610 mm	30" 750 mm	43" 1100 mm
Volume	0.4 ft ³ 11 L	1.0 ft ³ 27 L	1.5 ft ³ 43 L	3.2 ft ³ 91 L	8 ft ³ 227 L	20 ft ³ 563 L	54 ft ³ 1540 L

Note: These dimensions are approximate and intended for guidance. Other chamber sizes are available on request

Switch mode power supplies

- o Oil free high voltage system (4 kW at 60 kV)
- o Standard power supplies for 4, 6, 8, 12 & 15 kW
- o The control system consists of two analogue loops, kV and mA
- o IGBT technology operating at 20 kHz frequency
- o High stability output with low ripple
- o Low stored energy with automatic shutdown in the event of over voltage

Control options

PLC/CNC/PC based control systems are fully integrated with either rack mounted touch screen or keyboard based Human Machine Interface (HMI).

All machines can be run in automatic or supervisor mode and the dynamic change function is used for initial set-up of the machine in manual mode.

Viewing system

CCTV & conventional optical systems can be provided with a splitter box that enables both to be used but not simultaneously.

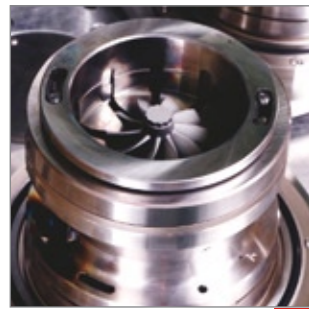
- 1 Series 2010 with 300mm chamber
- 2 CW604 (12) with shuttle system
- 3 CW604 (18) with chamber extension



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- 1 TW welder for PV and CD turbochargers
- 2 Automotive gear using 'split' beam
- 3 Gearbox components for off-road vehicles
- 4 NG Welder for PV turbochargers
- 5 Welded Shaft wheel assemblies
- 6 "Dual drive" housing option includes quick-change precision tooling

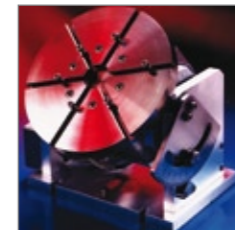
A comprehensive range of manipulators, tooling and fixtures is available including:



XY tables



Rotary Manipulator



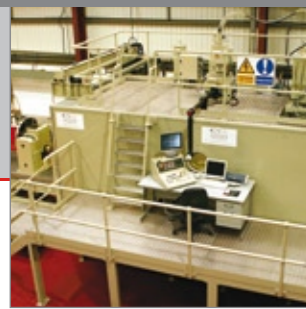
Rotary Tilt



Carousel Tooling



Indexing Unit



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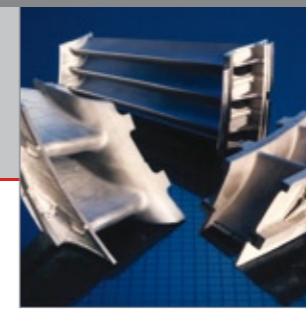
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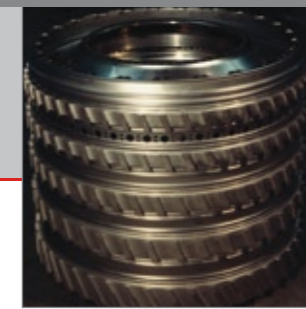
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150 kV Machines

- 1 General layout
- 2 Rotary on run-out platform
- 3 1.4x1.1x1.0m chamber
- 4 Beam column
- 5 Manipulator
- 6 Control console

150 kV machines are used extensively in the aero engine, aerospace and power generation industries. With 150 kV systems it is possible to weld at distances up to 1.5 m.

At the heart of the 150 kV machine is the electron beam column.

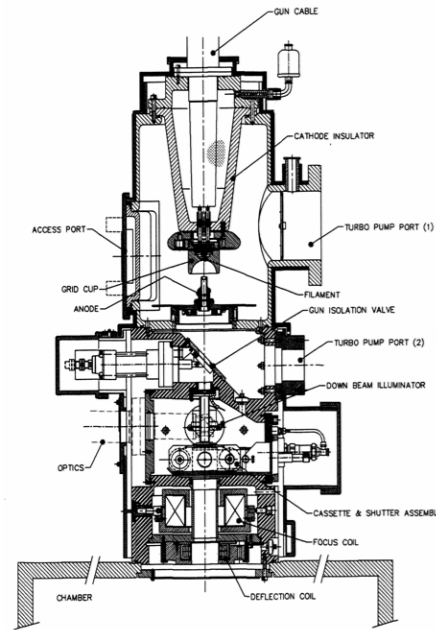
Features include

- o Up to 30 kW beam power at 150 kV
- o Twin turbomolecular pumping system
- o Long filament life, easy and quick to change

Work piece manipulation

CVE has a comprehensive range of standard and bespoke systems to manipulate the piece part under the electron beam including:

- o XY tables
- o Run out platforms
- o Rotary manipulators with or without a tailstock
- o Rotary tilt, 0-90° or 0-180° manual or motorised
- o Multi-station carousel
- o Custom designed tooling



Control system

Typical desk mounted PC based control system with conventional keyboard and mouse.

- o Colour monitors for PC and CCTV (conventional optics are optional)
- o CNC controls
- o QA data logging and printer/plotter options
- o Ethernet connection enables network connection and remote diagnostics

Power supplies

- o Switch mode IGBT technology operating at 20 kHz frequency
- o High stability output with low ripple
- o Low stored energy with automatic shutdown in the event of over voltage
- o Powers up to 30 kW with 6 kW, 8 kW, 15 kW as standard

Pumping systems

Sized to suit the size of the chamber, operating vacuum level and performance required. The picture above shows the mechanical and Roots type pump within an acoustic enclosure and a conventional diffusion pumped chamber. Alternative pumping systems are available on request.

Standard Chamber Sizes

Length "X"	55" 1400 mm	79" 2000 mm	236" 6000 mm	157" 4000 mm	197" 5000 mm
Width "Y"	39" 1000 mm	79" 2000 mm	83" 2100 mm	118" 3000 mm	118" 3000 mm
Height "Z"	43" 1100 mm	79" 2000 mm	94" 2400 mm	118" 3000 mm	134" 3400 mm
XY table size "X" x "Y"	26" x 19" 660 x 475 mm	35" x 35" 900 x 900 mm	118" x 46" 3000 x 1180 mm	102" x 47" 2600 x 1200 mm	142" x 47" 3600 x 1200 mm
XY table stroke "X" x "Y"	24" x 19" 610 x 480 mm	39" x 39" 1000 x 1000 mm	110" x 28" 2800 x 700 mm	47" x 39" 1200 x 1000 mm	87" x 39" 2200 x 1000 mm
XY table speed "X" x "Y"	2 in/s 50 mm/s	2 in/s 50 mm/s	1 in/s 33 mm/s	1 in/s 33 mm/s	1 in/s 33 mm/s
Maximum weight including manipulator	1100 lb 500 kg	4400 lb 2000 kg	6600 lb 3000 kg	8360 lb 3800 kg	8800 lb 4000 kg
Height above the table	28" 720 mm	49" 1250 mm	65" 1650 mm	87" 2200 mm	102" 2600 mm

Note: Other chamber sizes are available on request



150 kV applications include:

- 1 Steam turbine diaphragms
- 2 Nozzle guide vanes
- 3 Compressor rotors

Complete 150 kV system configured with beam column, power supply, work piece manipulation and control system. The customer at Cambridge witnesses assembly and testing before delivery and installation on the customer's site.



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