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Electron beam technologies for highly effective welding and surface hardening of engine and gear components

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PTR Präzisionstechnik GmbH, Germany

ENGINE EXPO – Stuttgart, 22 June 2010

Global Beam Technologies AG (GBT)

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Maintal, Frankfurt

SST STEIGERWALD STRAHLTECHNIK GMBH



Maisach, München

PTR PRECISION TECHNOLOGIES INC.



Enfield, USA

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Some automotive related customers of PTR


























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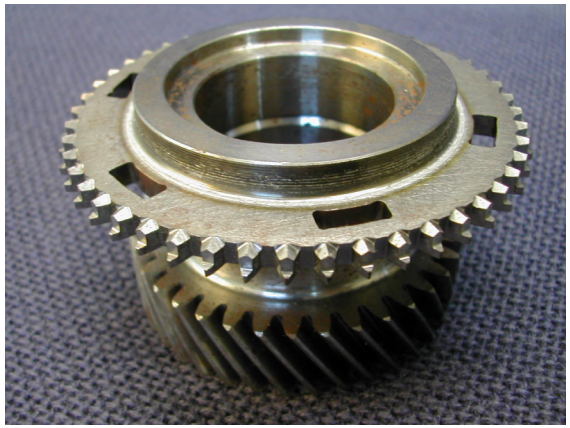
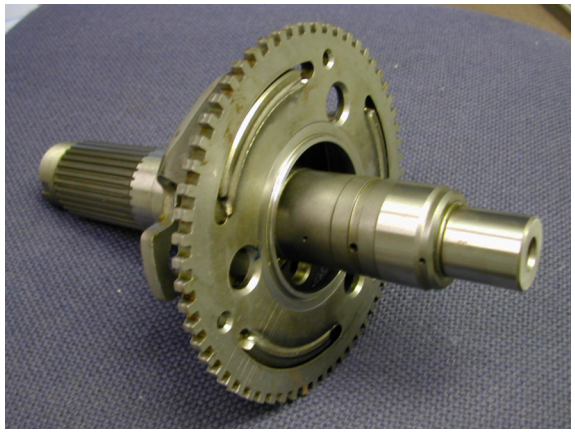
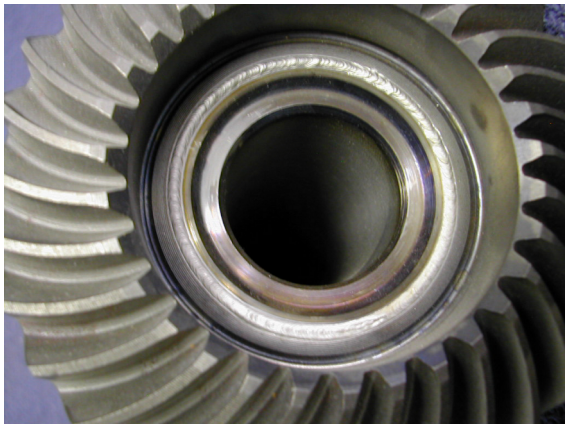
Examples of EB welded Gear Parts

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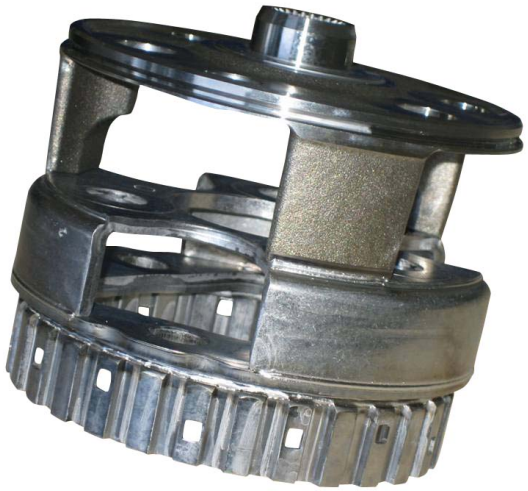
Examples of EB welded Gear Parts







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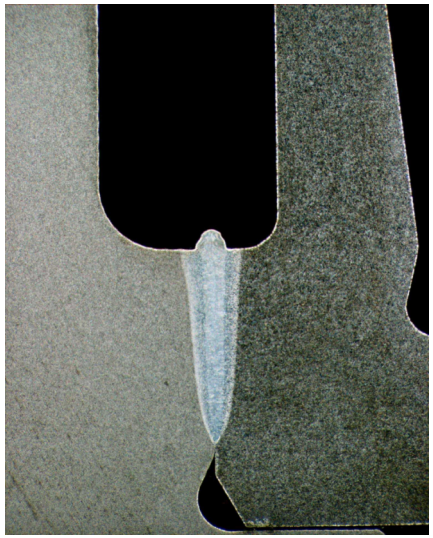
EBW of Gear Wheel and Synchronising Ring







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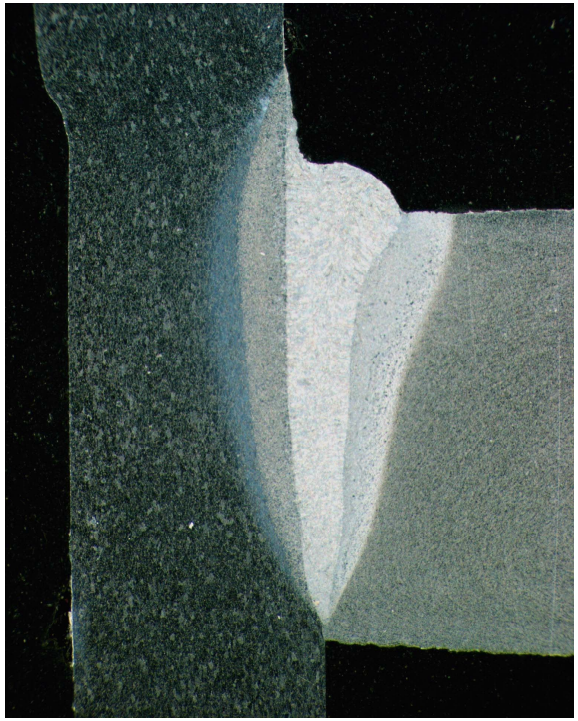
Planet Carrier (Detail: radial Partition Weld)







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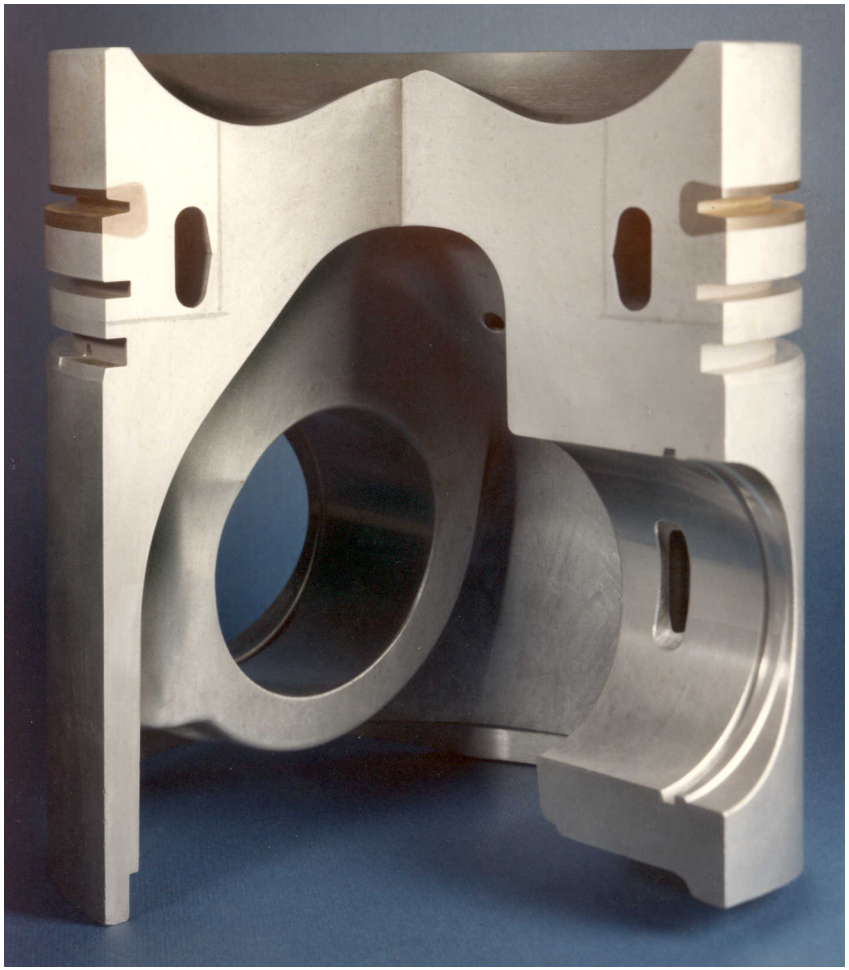
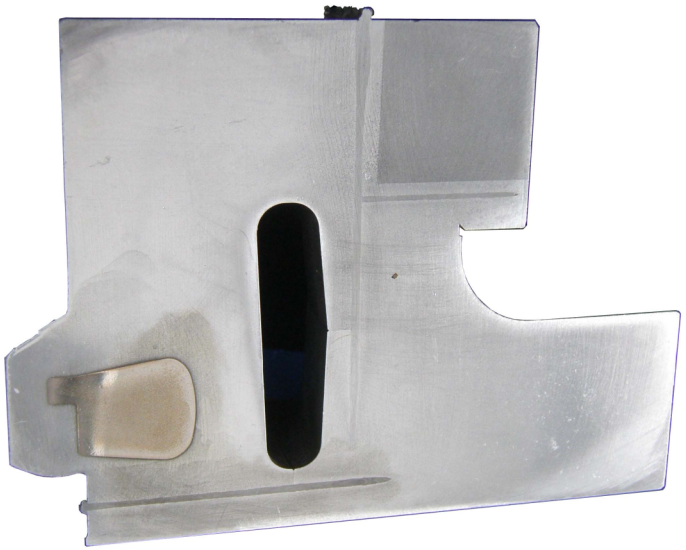
Diesel Engine Pistons, EB welded (radial + axial)





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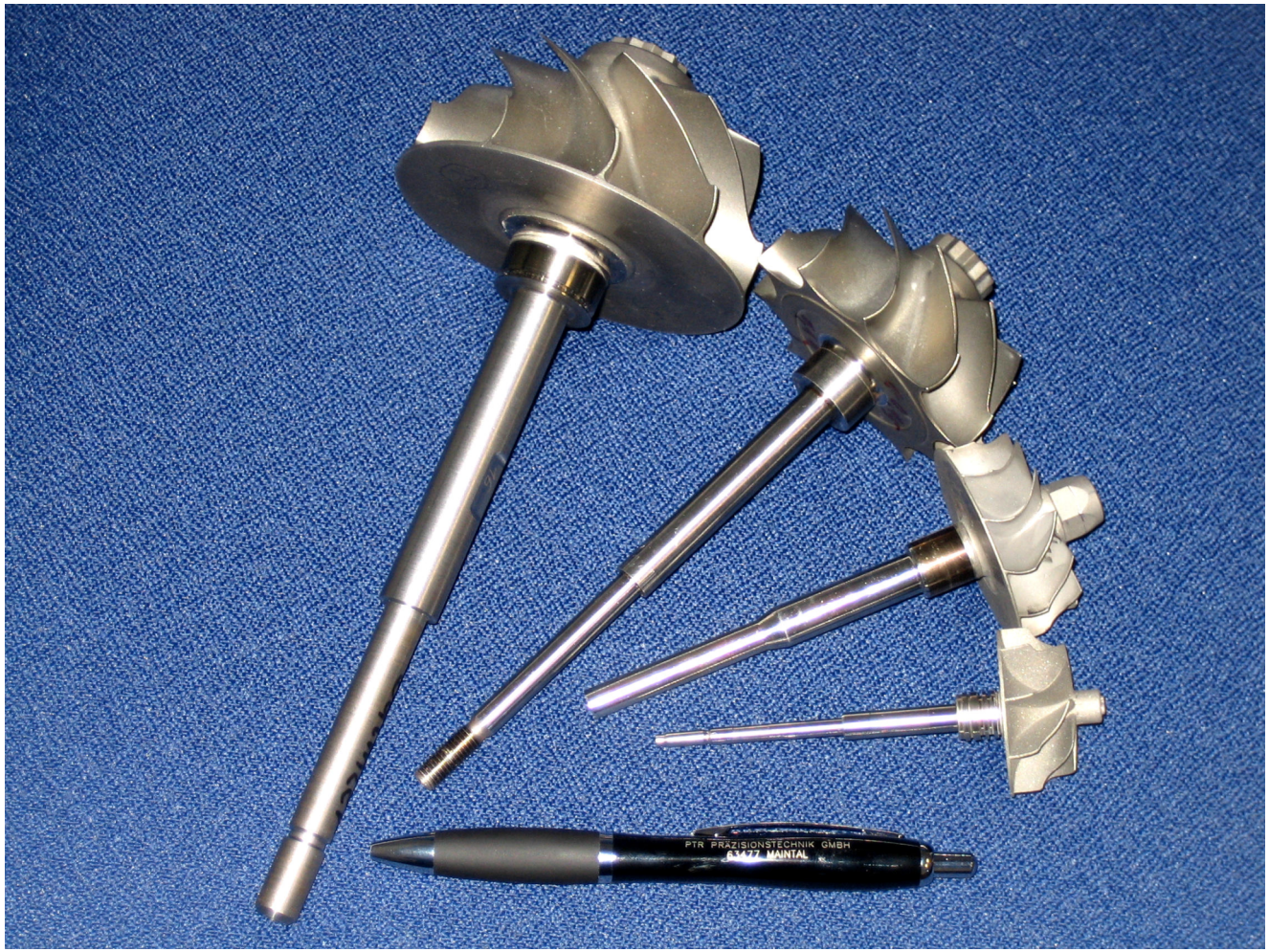
Turbo-Charger Rotors – different Examples

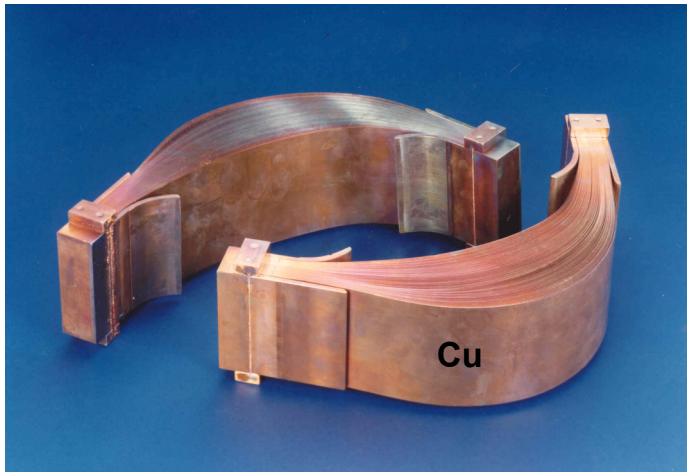


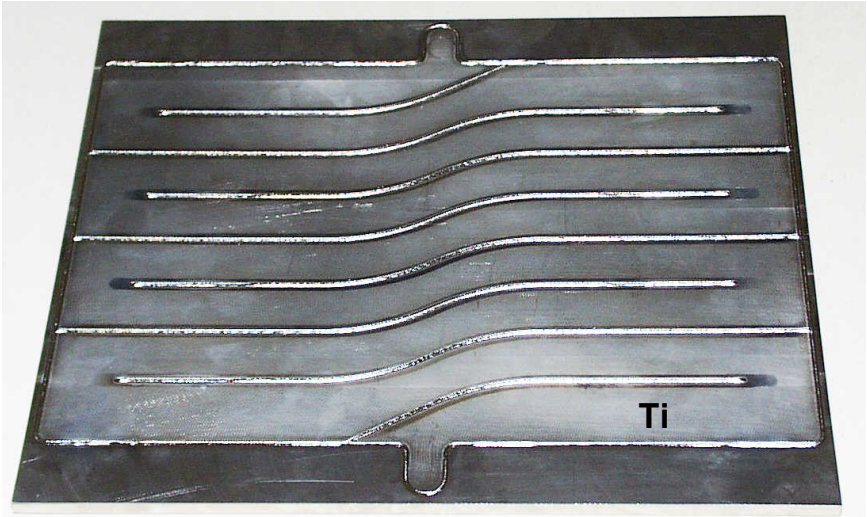
EB hardened surfaces

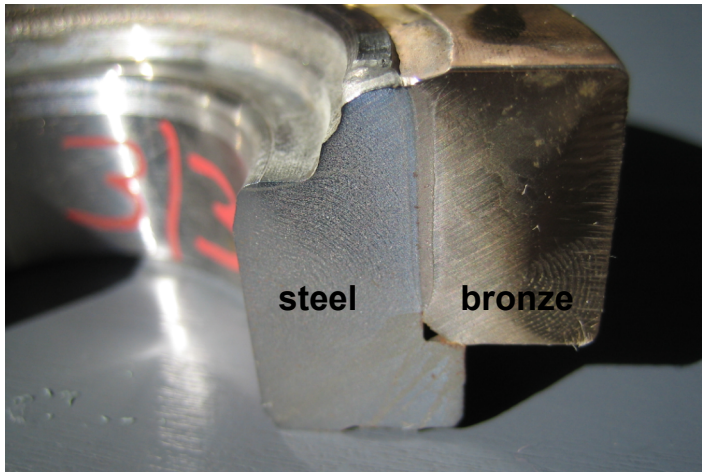


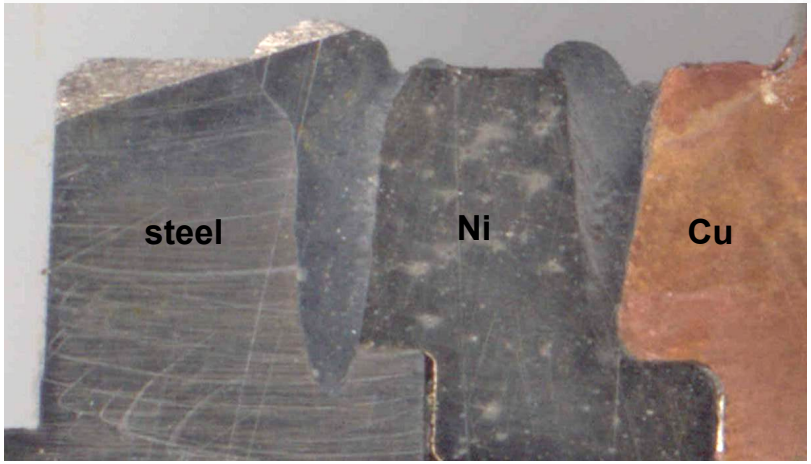


Variety of EB welding

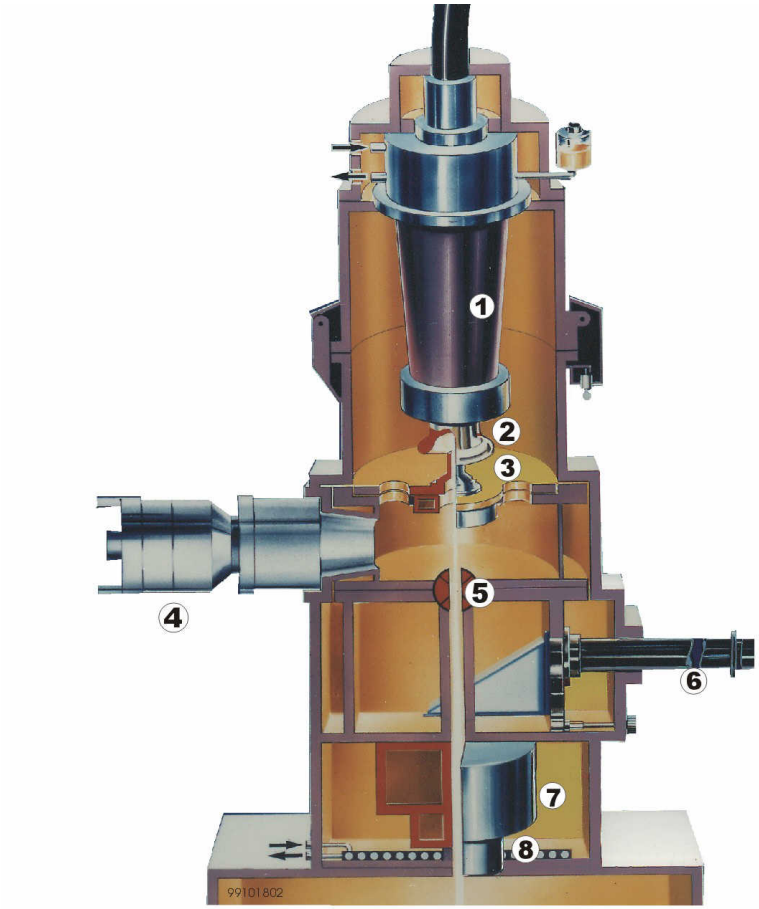


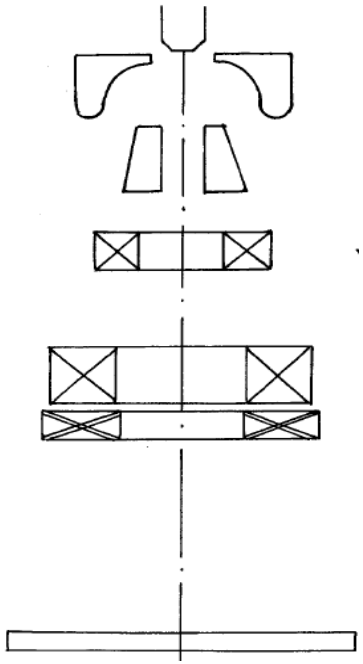






PTR EB Generator 60 kV (schematic)





filament

grid cap

anod

alignment coils

focus coil

deflection coils

workpiece

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PTR EB Generator (60 kV)



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PTR EB Generator (opened for System Exchange)



Cathode for EB generation

Ribbon Filament BK 1.4

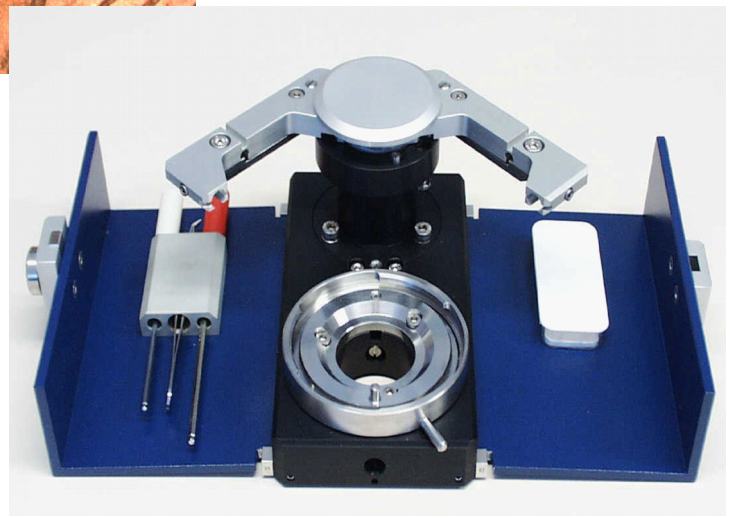
Tungsten

Thickness 0.1 mm

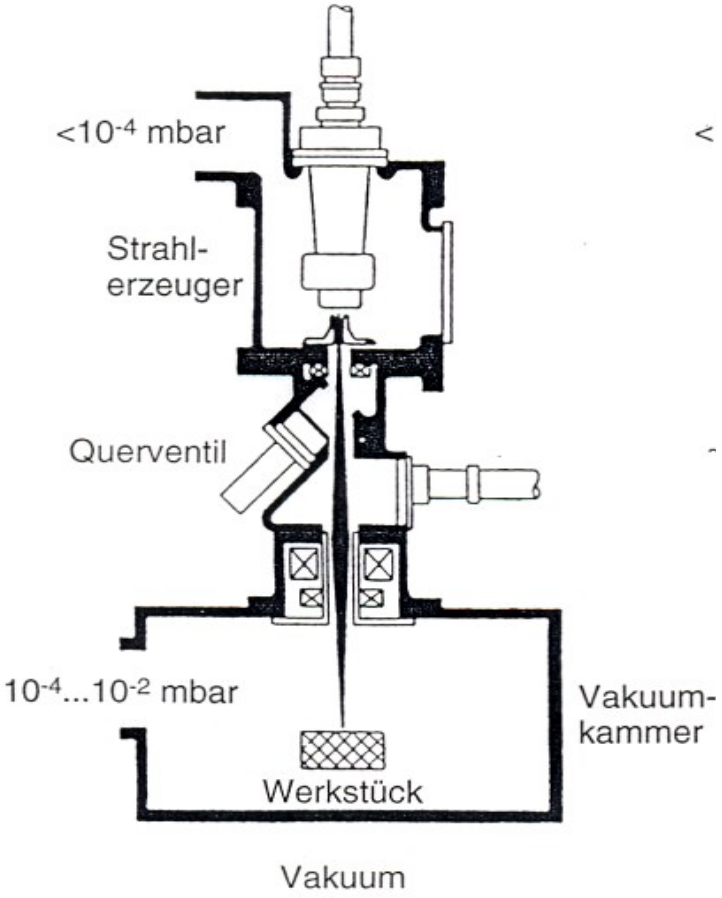
Emission area 2 mm^2



Precision Tool
for Cathode Assembling



EB welding in vacuum



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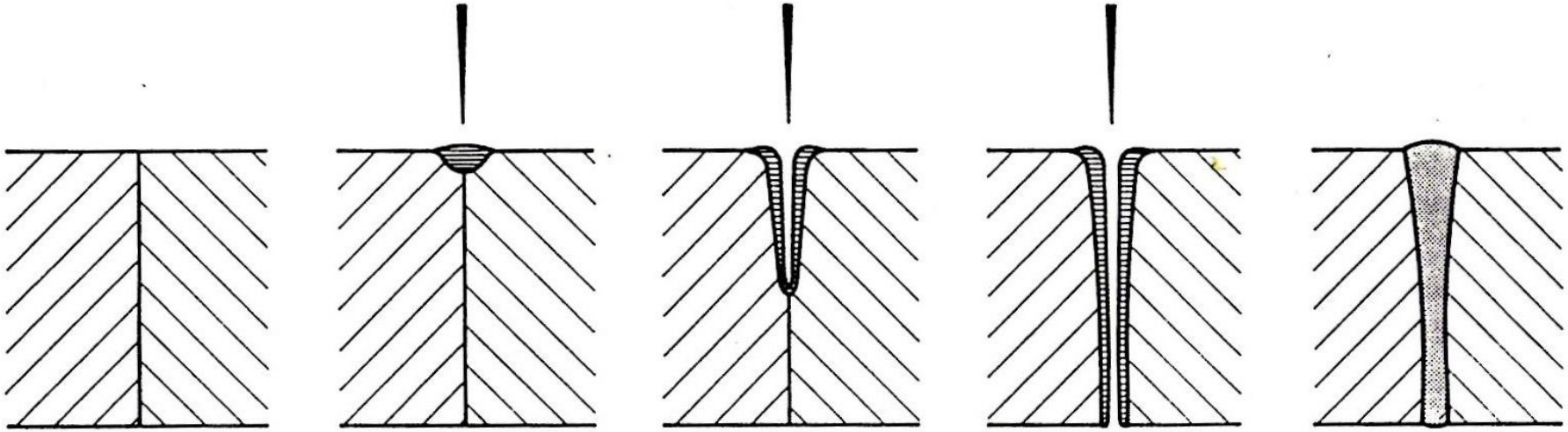
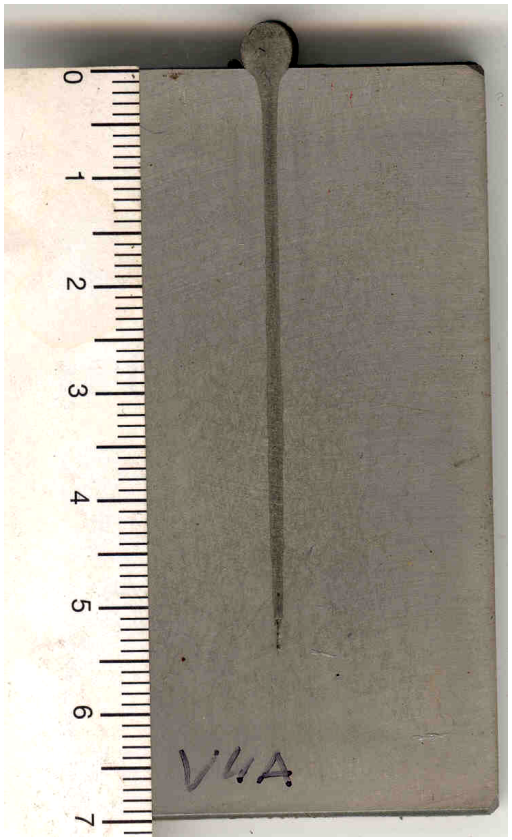
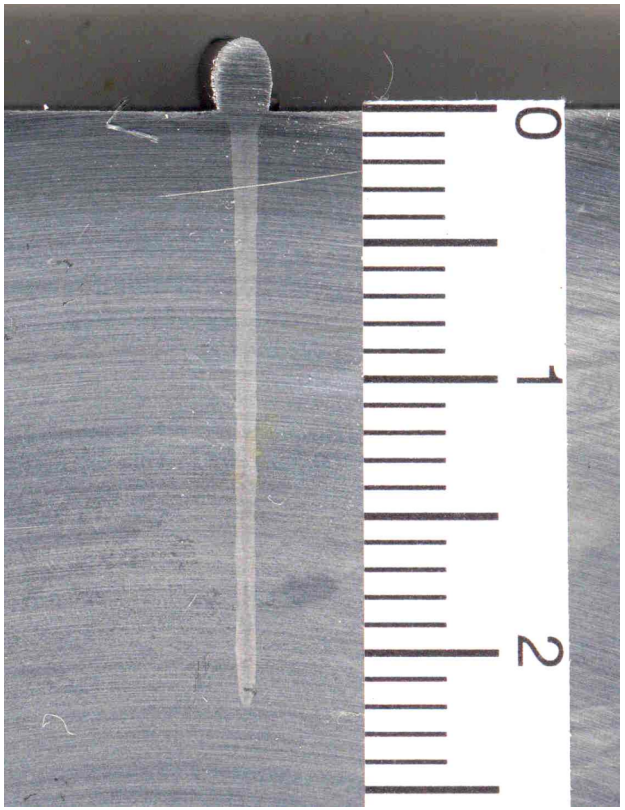
Formation of the Key-Hole Effect



Beads on Plate using different High Voltage



150 kV



60 kV

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EB Weld in Steel: 170 mm deep



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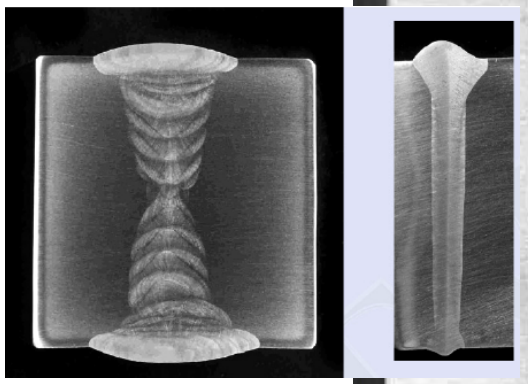
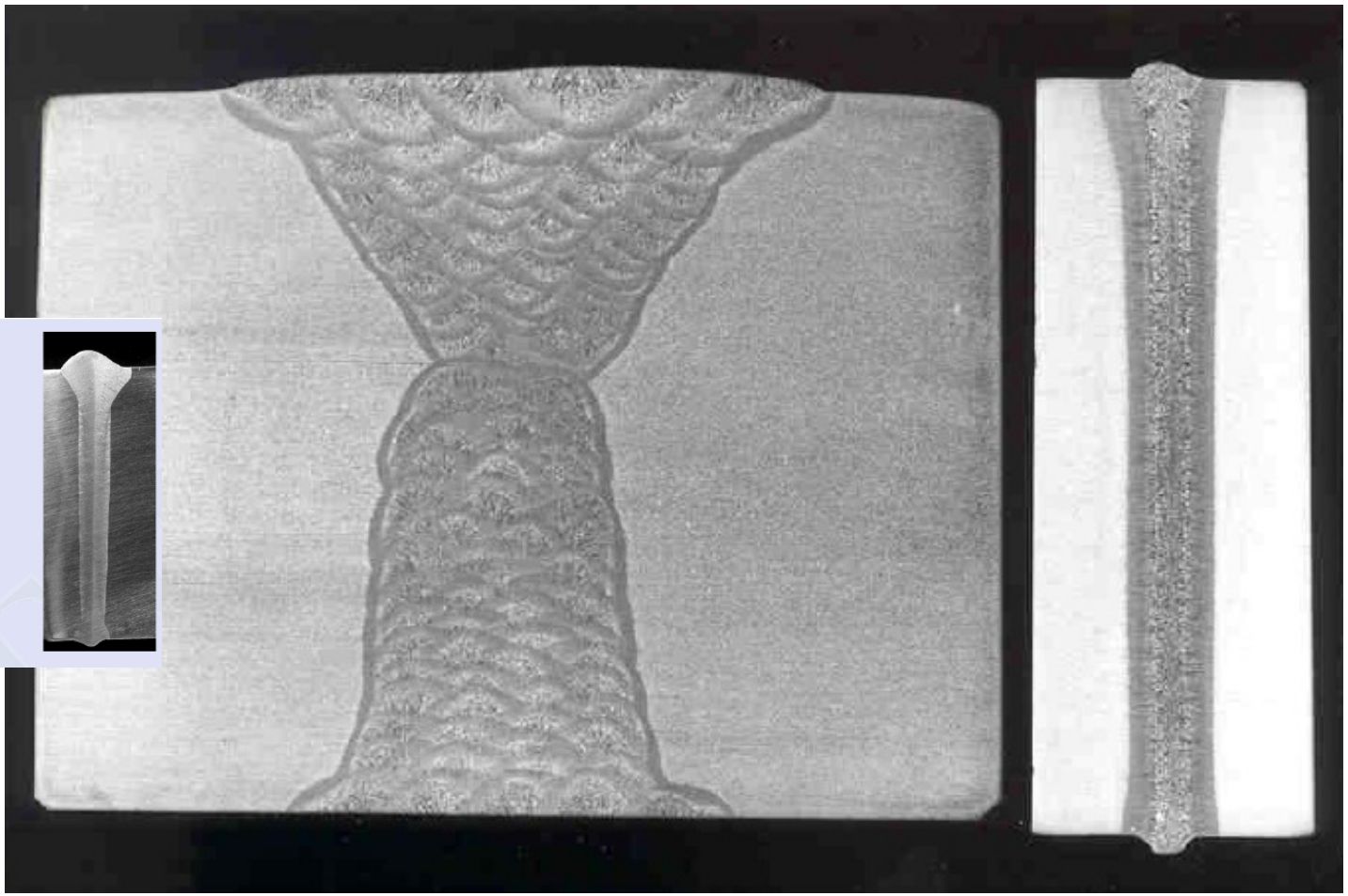
Comparison SAW and MIG vs. EB welds

30 mm dick





100 mm dick

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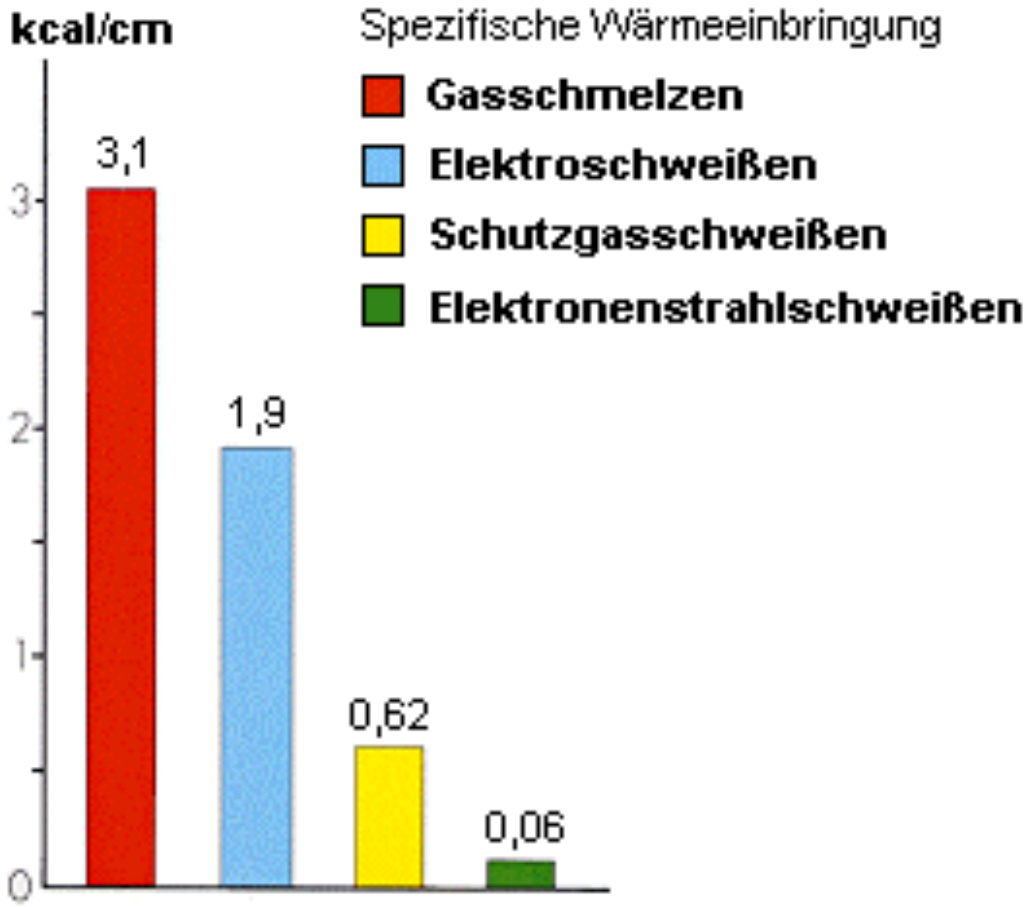
Comparison energy per length



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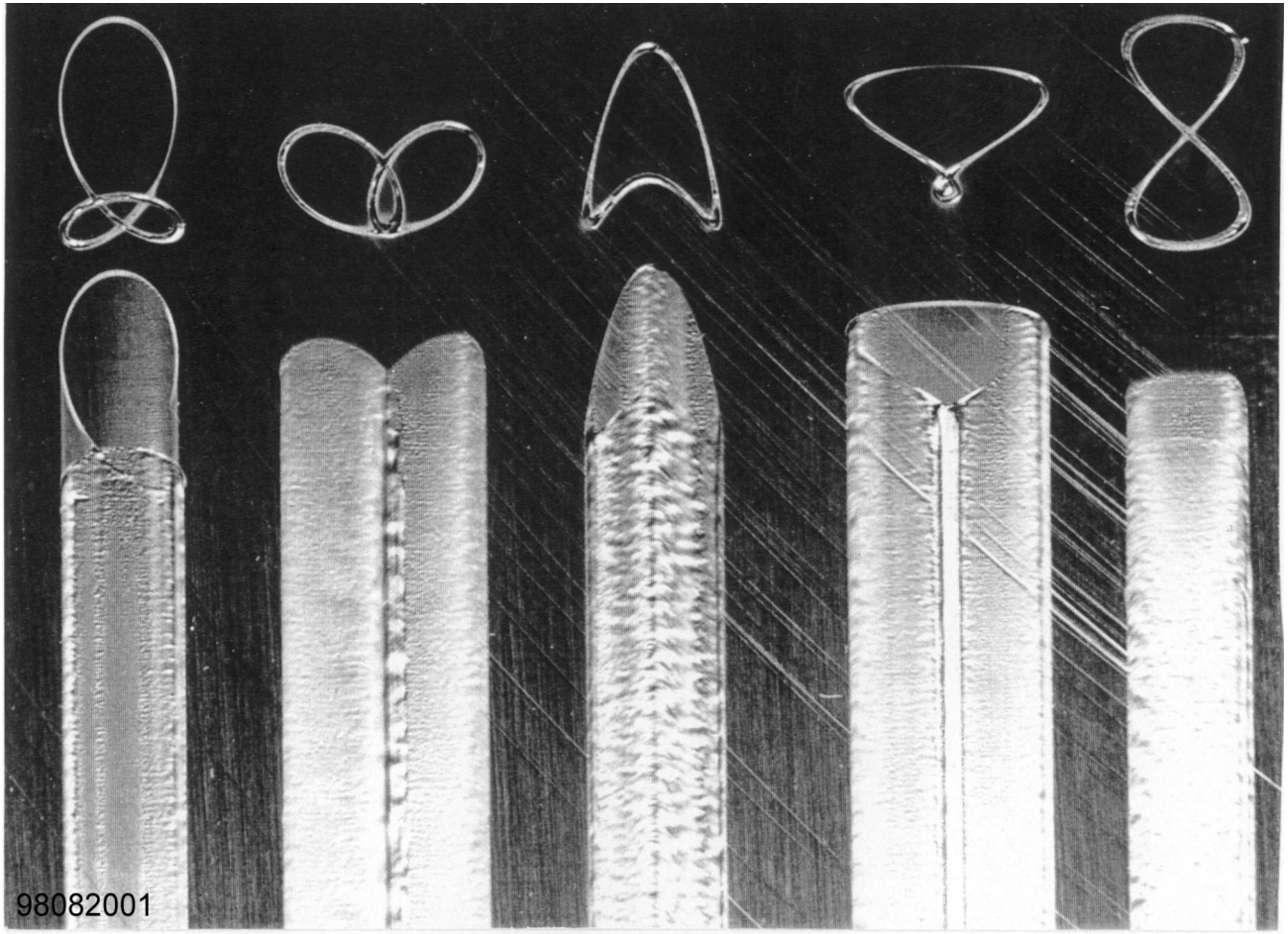
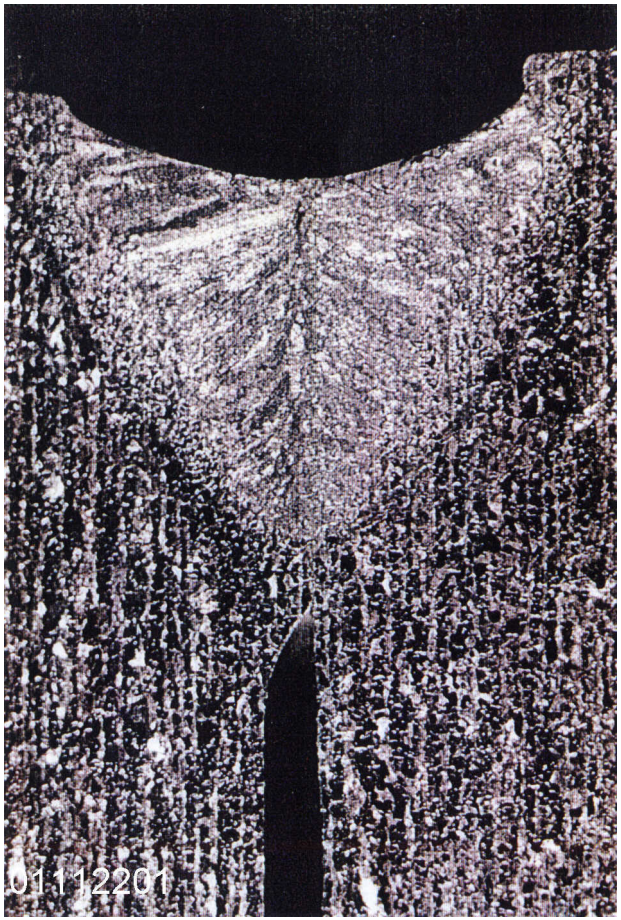
Beam Oscillation Figures



EB Weld: Wide Profile



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EB Welding Machines by PTR

- possible beam parameters: **60 - 175 kV** and up to 60 kW (and more)
- **universal machines**: large or small sized chambers for different use
- **production type machines**: work-piece adopted chambers and short cycle times for mass production
- **stand-alone machines** or EB welding **production lines** including handling etc.

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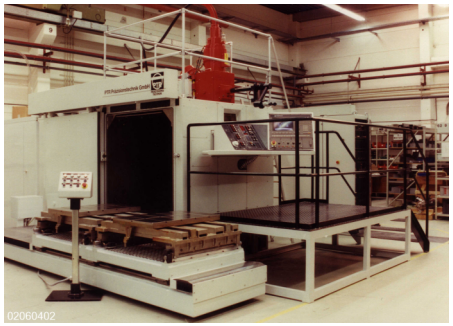
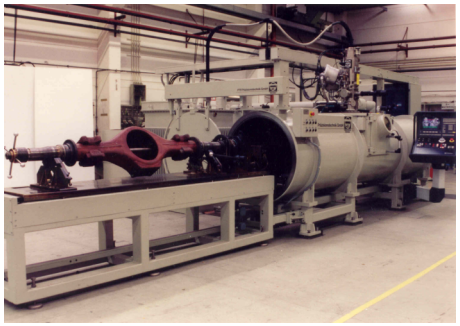
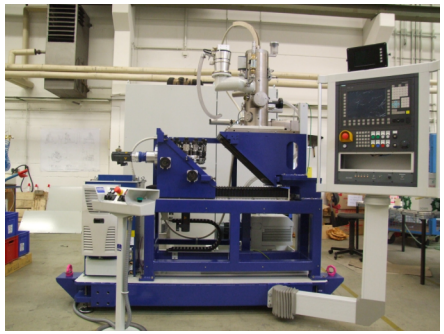
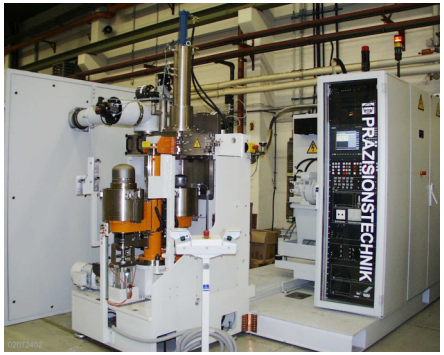
Customised PTR Machines (examples)

Chamber Type



Index-Table Type





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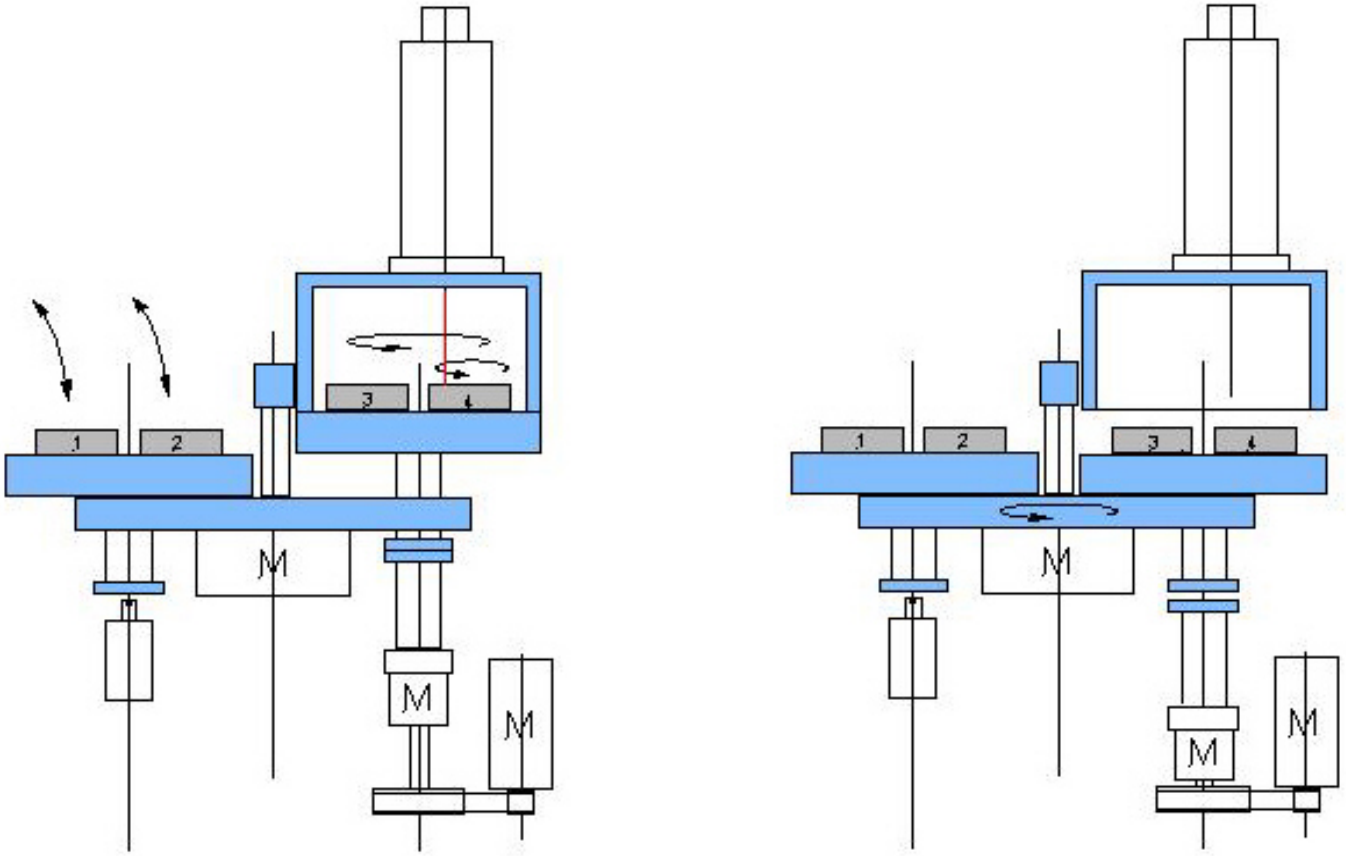
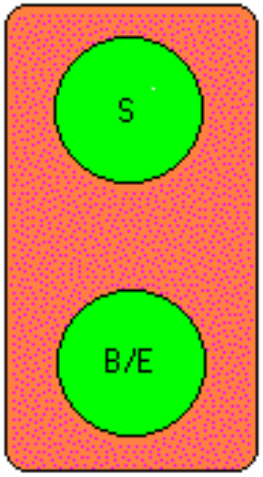
Scheme of P-Type Machine

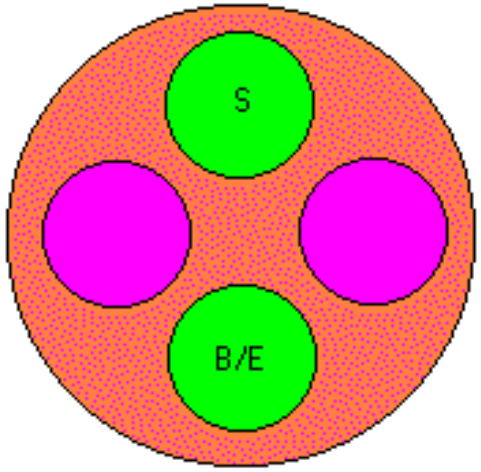


Different layouts are possible – e. g. number of parts per cycle; orientation of beam generator.

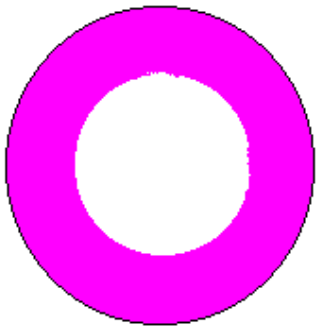
Tooling Tables of P- and S-Type Machines, resp.



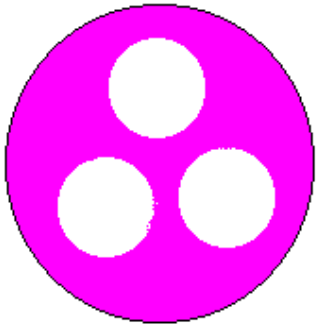
Type P 2
or S 2



Type P 4
or S 4



1 Spindle



3 Spindles

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Cycle-Type Machine: Type P4





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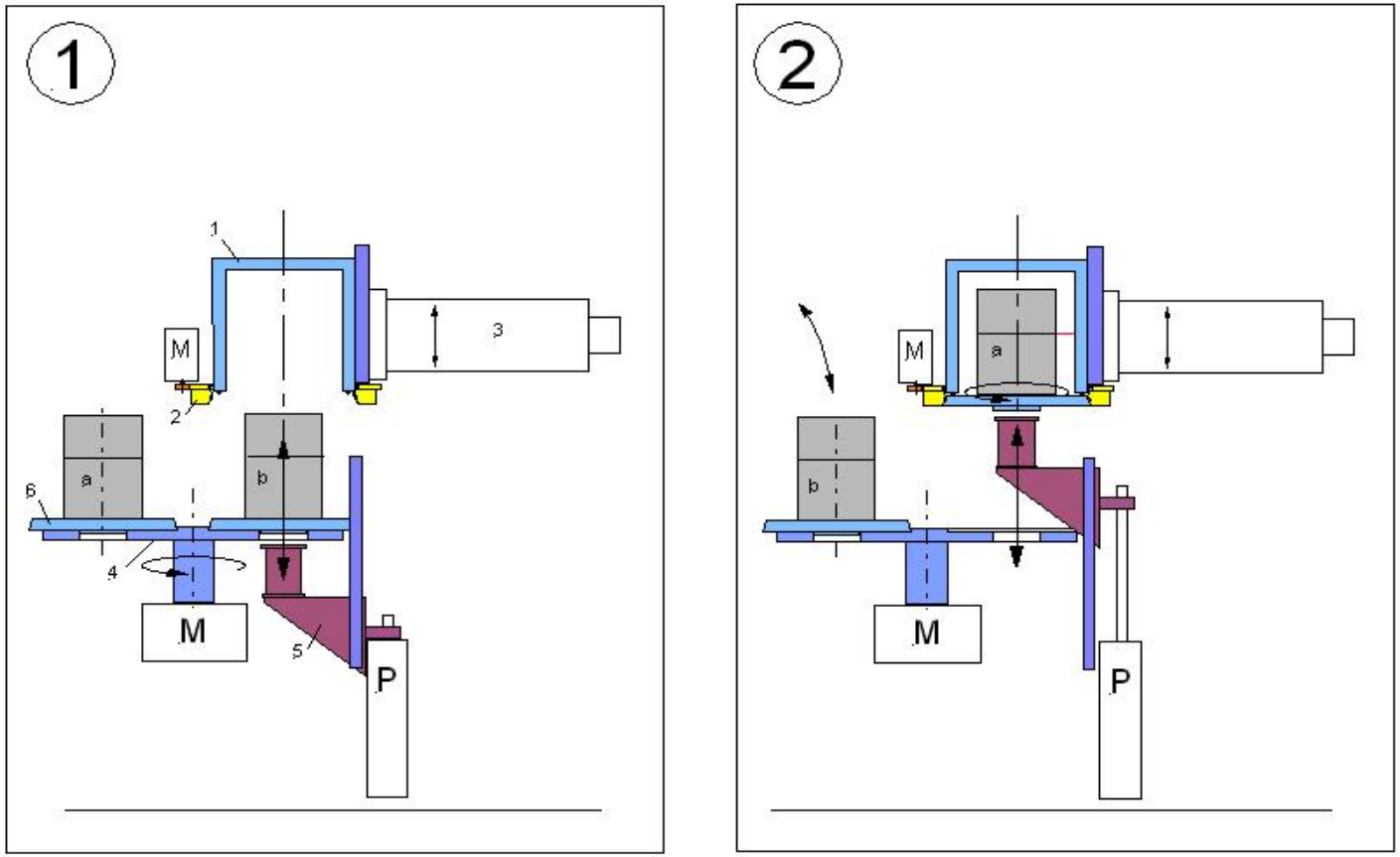
Scheme of K-Type Machine



Different layouts are possible – e. g. number of parts per cycle; orientation of beam generator.

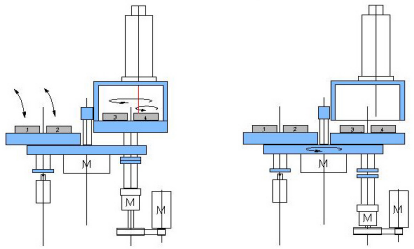
Cycle-Type Machine: EBOMAT K 25



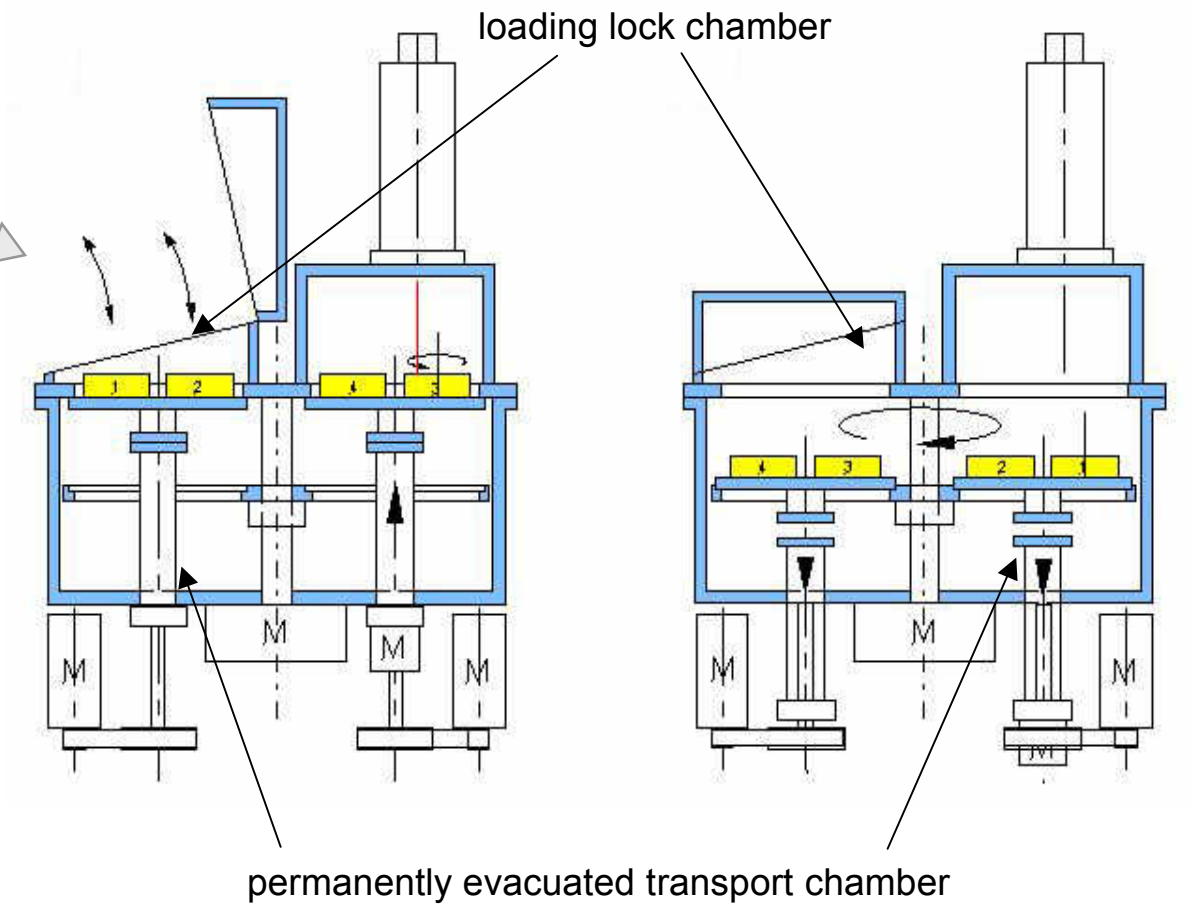




Index-Table Machine S-Type (schematic)



„open“ P-Type





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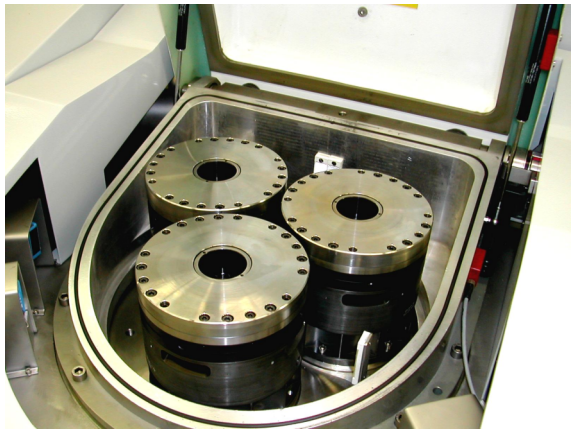
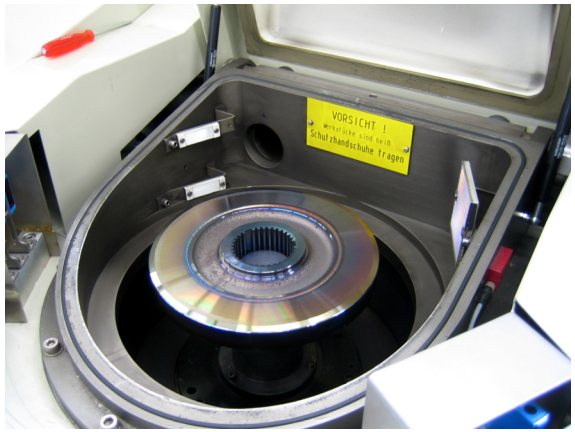
Cycle-Type Air-Lock Machine EBW S







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EB Welders and Automated Production Lines

- automated EB welder
- automated loading and unloading
- interlinking with stations before and after EB welding:
  - individualising and feeding of parts
  - cleaning and drying
  - assembling (pressing when required)
  - preheating (when required)
  - demagnetising
  - brushing
  - quality check (ultrasonic, optical, mechanical)
  - palletising
- all-inclusive safety features and equipment

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Gantry-automated Line with EBW P4-1/6-60



Automated Cell for EB Welding of Gear Parts

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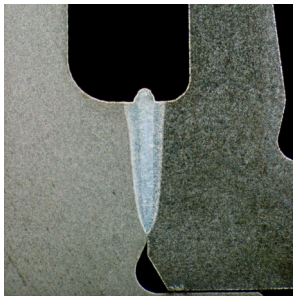

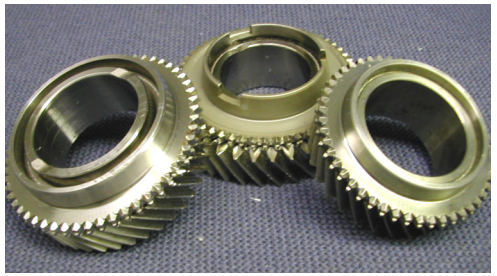

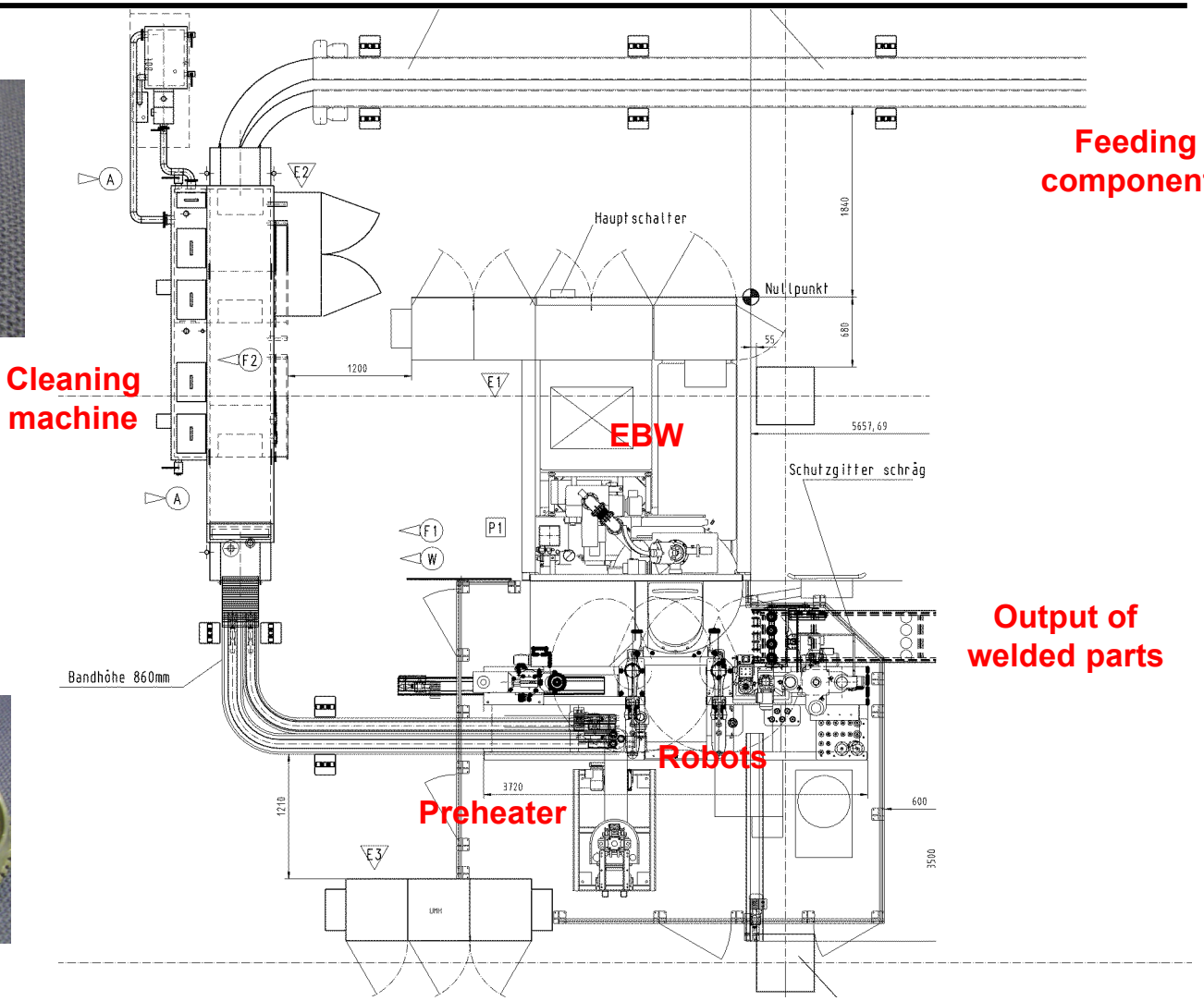

Feeding components

Cleaning machine

EBW

Output of welded parts

Robots

Preheater

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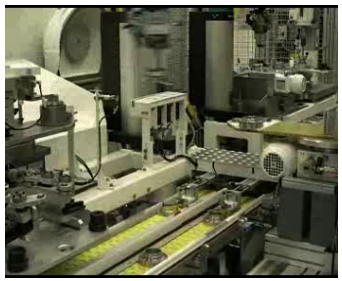
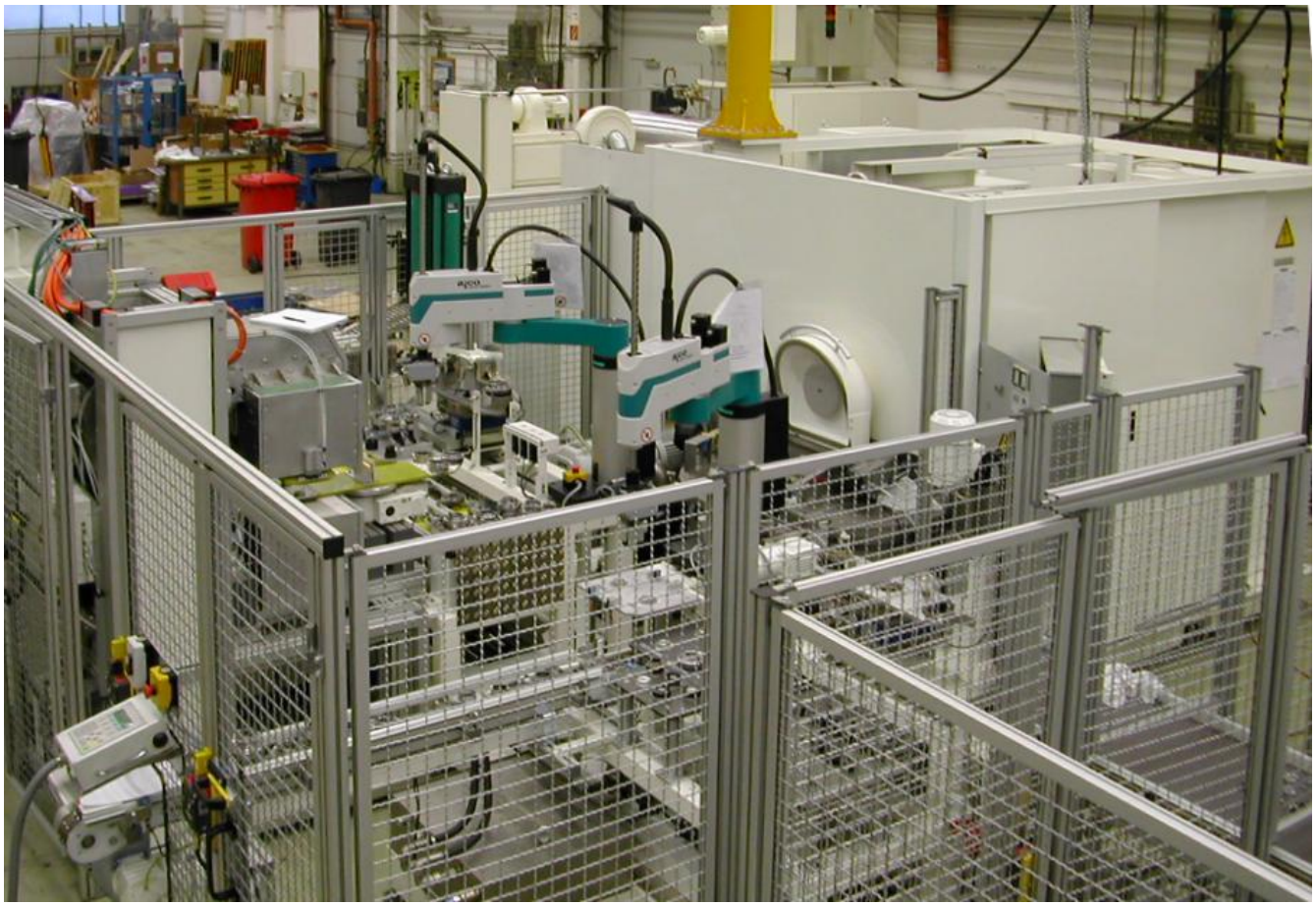
Automated Cell with EBW S2 and Robots







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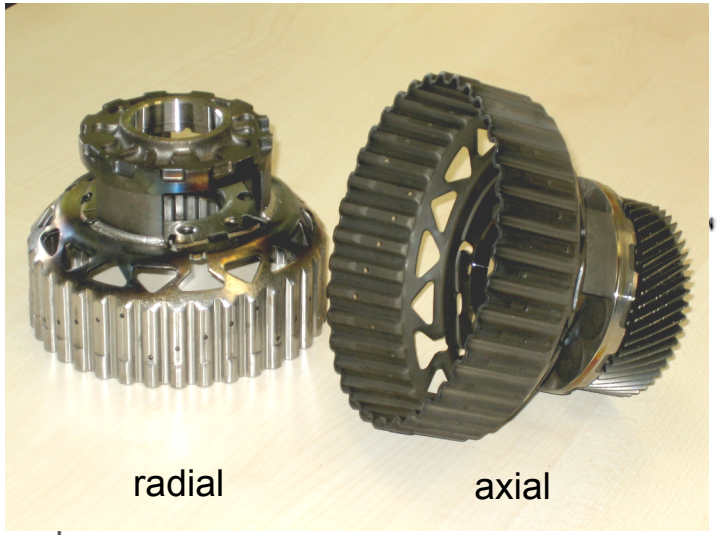
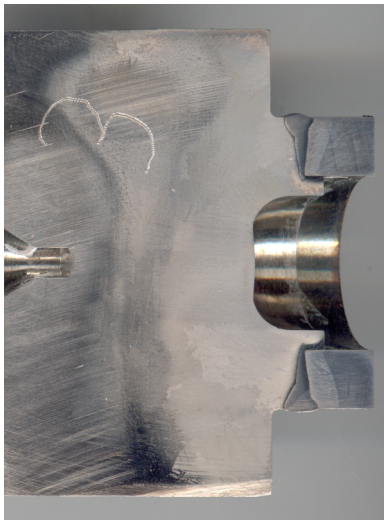
Automated Cell for EB Welding of Gear Parts



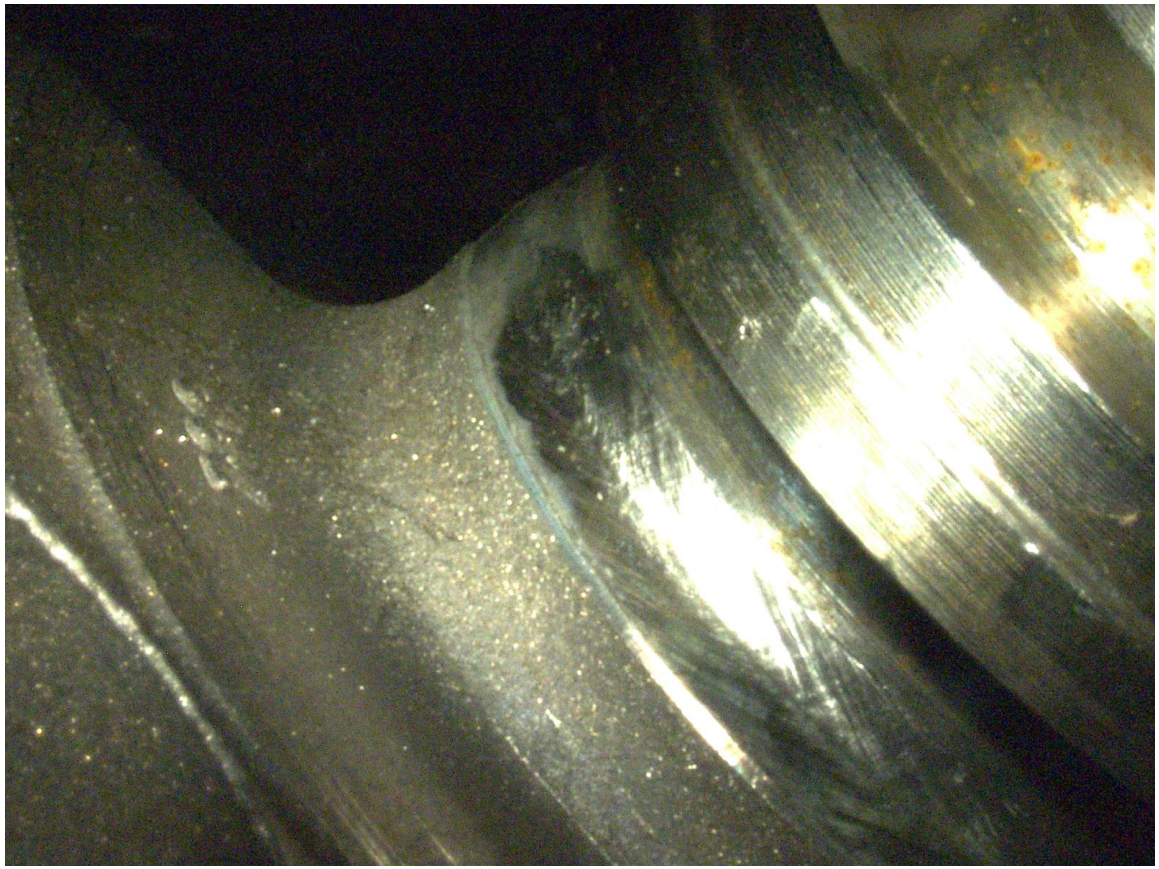
Example: EB welded Rotor for Turbocharger

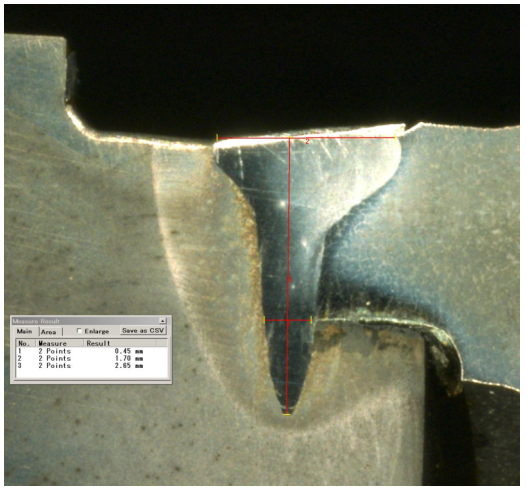


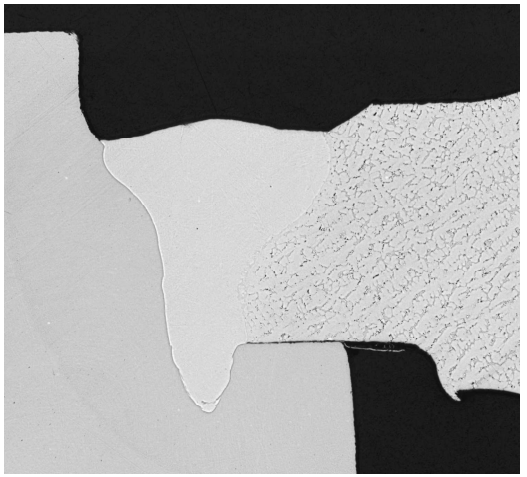




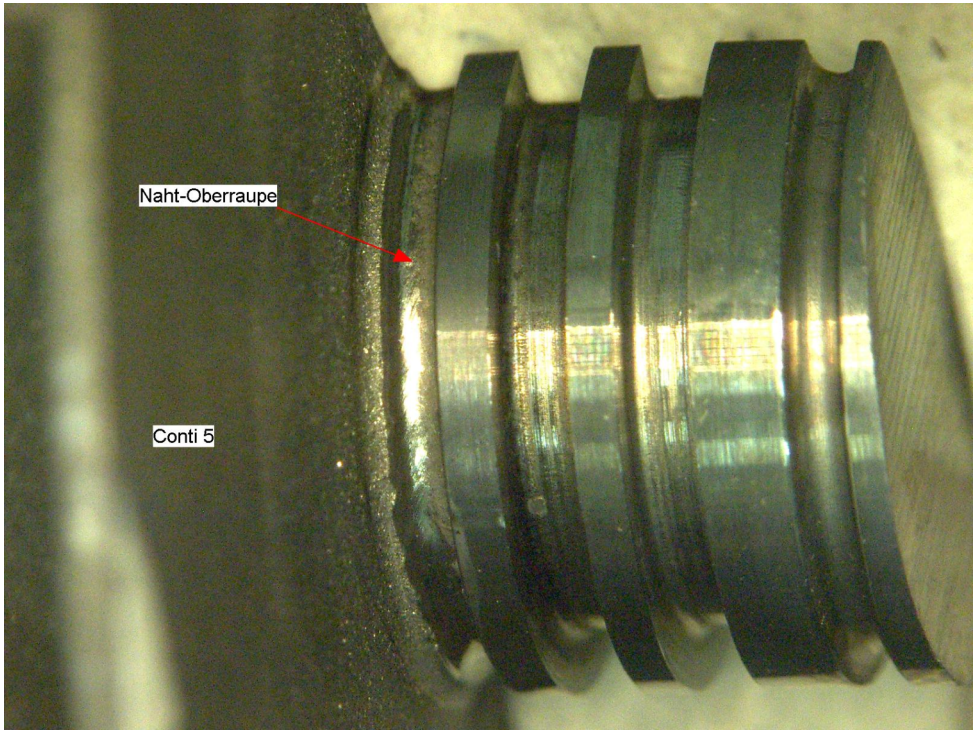
NN1: Welded Rotor (42CrMo4 + Inconel 713 LC)

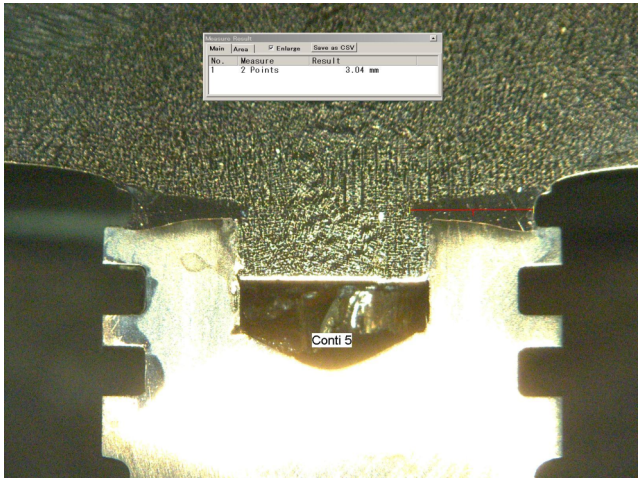


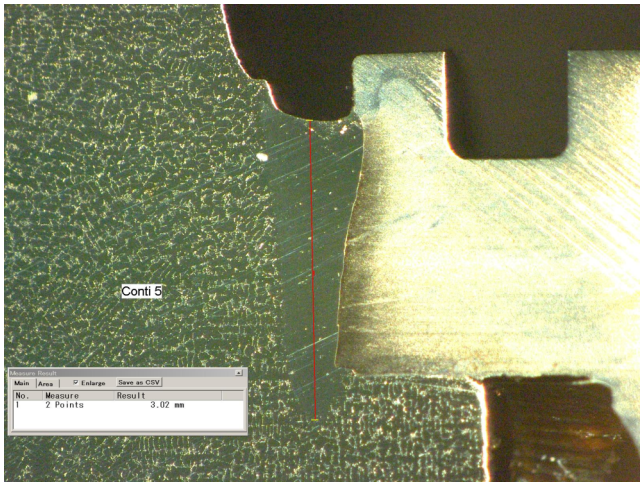




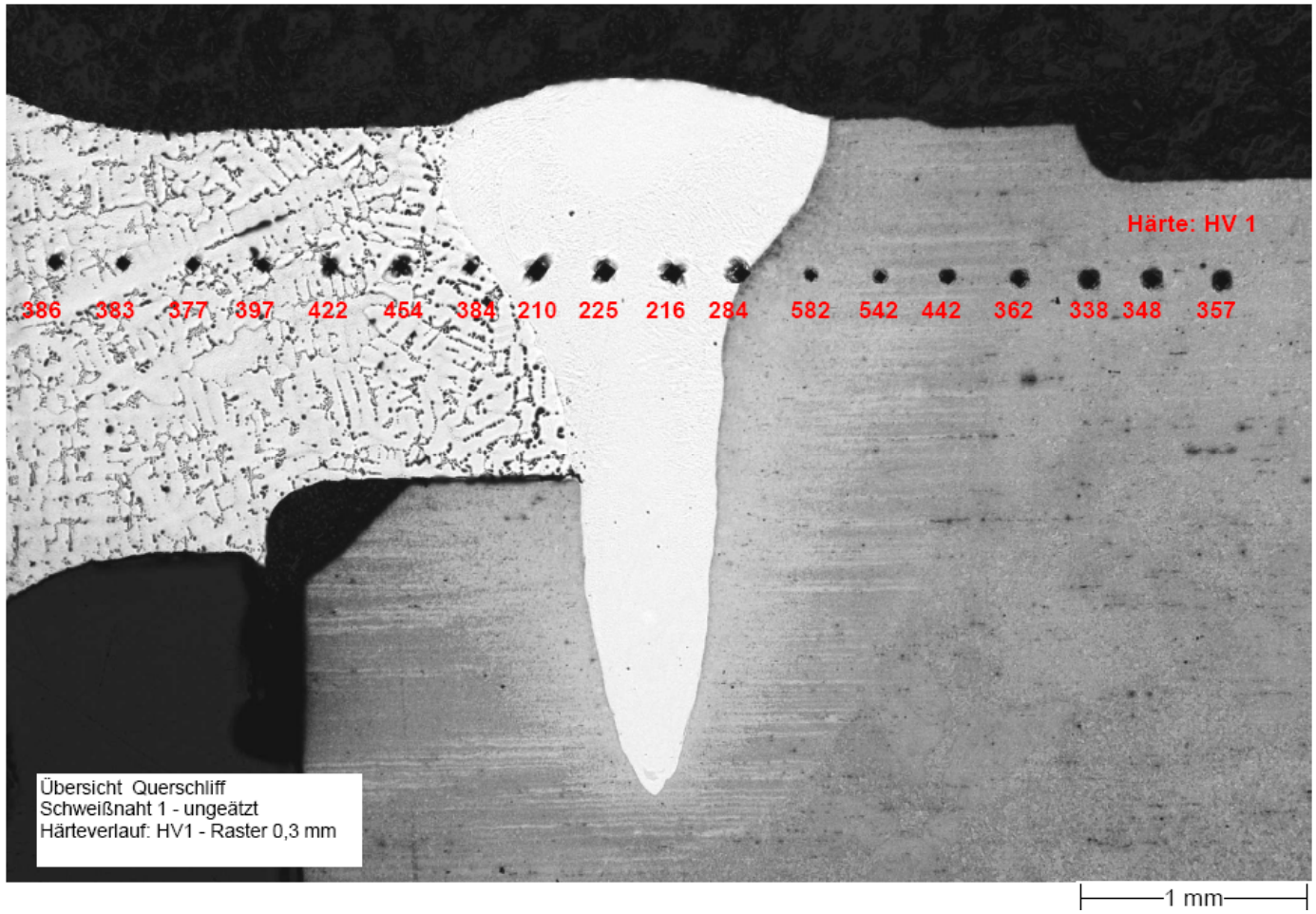
NN2: Welded Rotor (X22CrMoV12-1 + MAR-M246)







NN3: Hardness 40NiCrMo2-3 + MAR-M246



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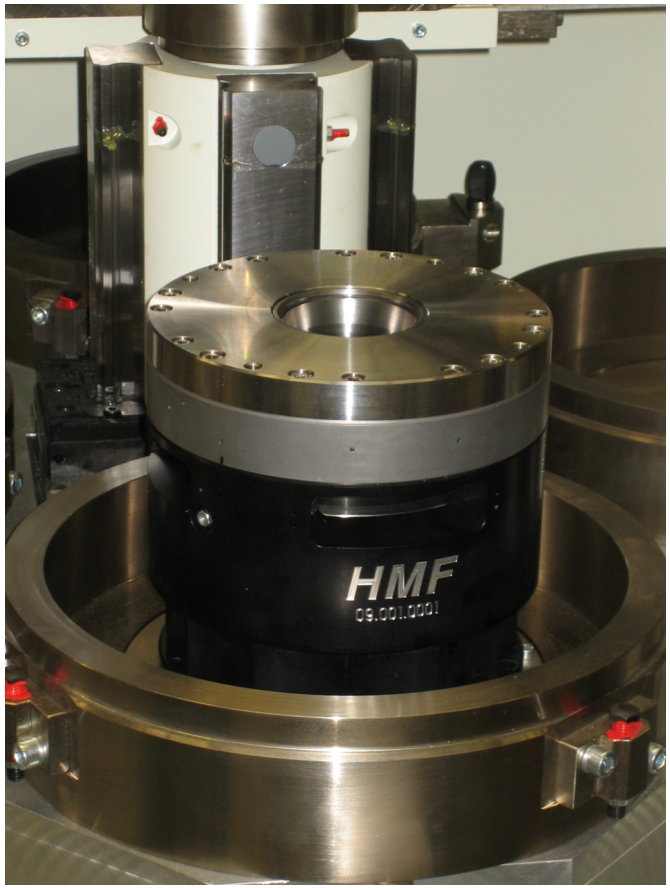
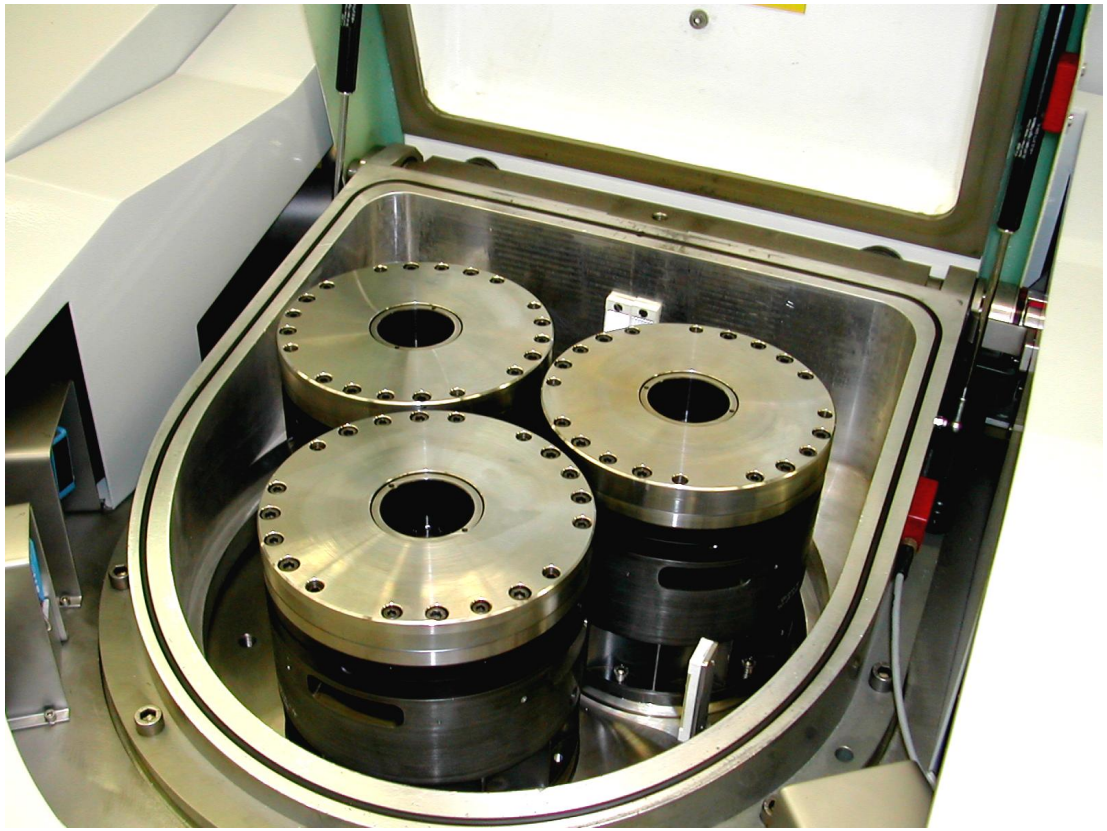
Turbo-Rotor Tooling

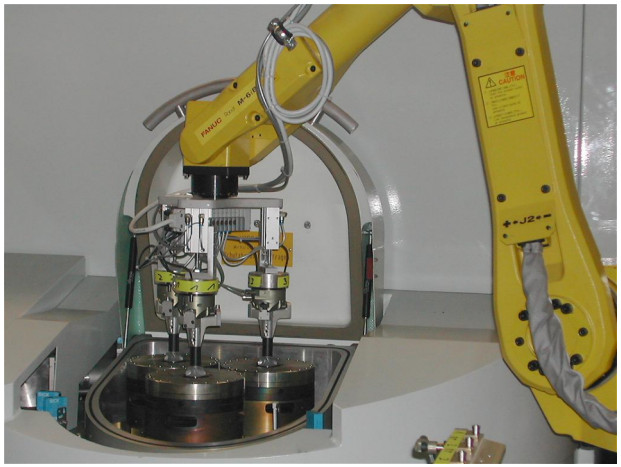




Robot Handling for Turbocharger Rotors



Precision tools for clamping
of final machined parts





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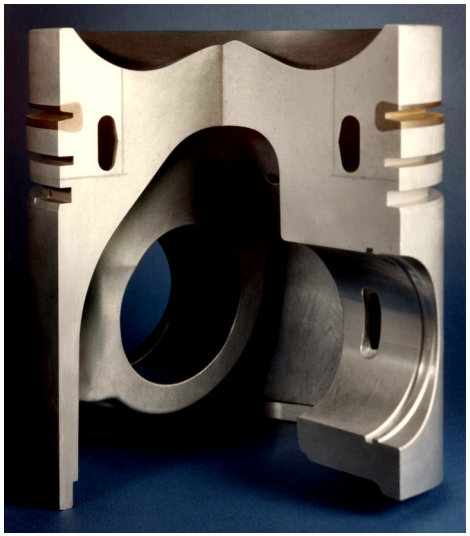
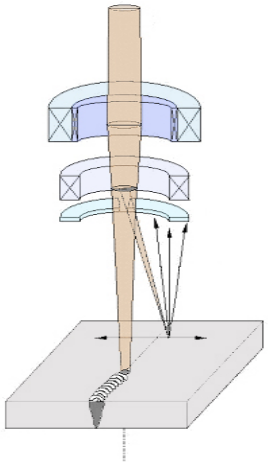
Piston Welding (radial + axial simultaneously)

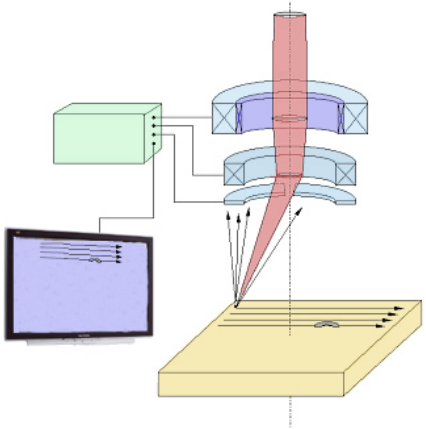




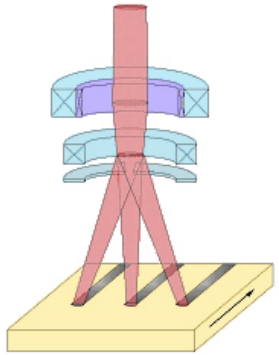
Beam Deflection Scopes by EBO JUMP



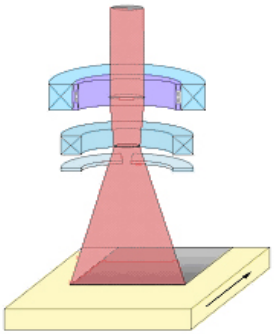
joint detection



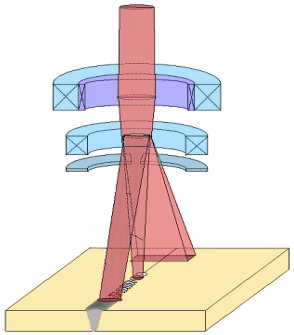
imaging



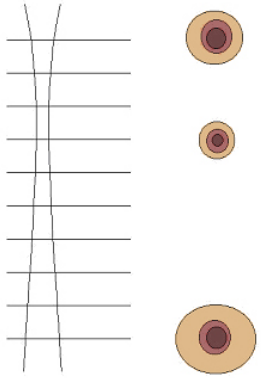
multi pool working



surface modification

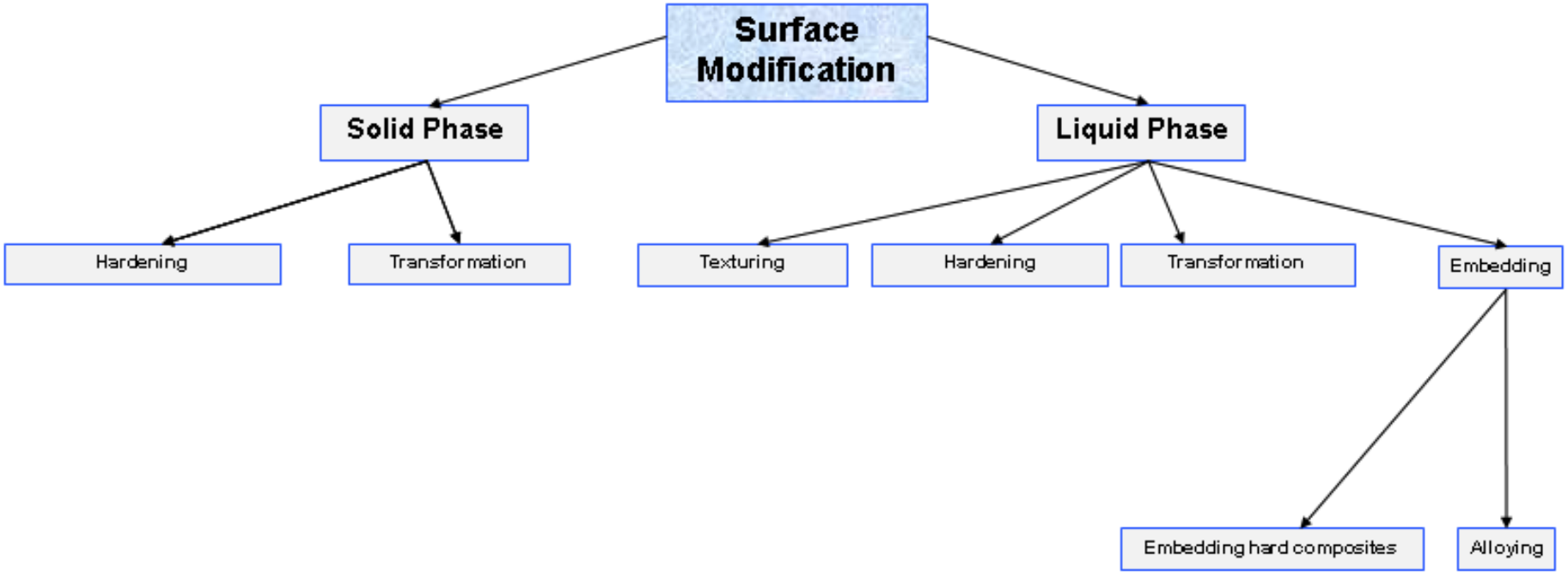


multi processing

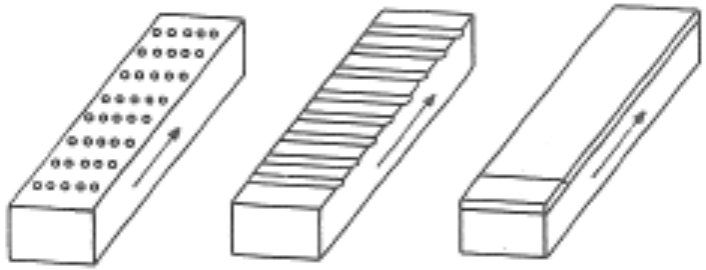


beam analysis

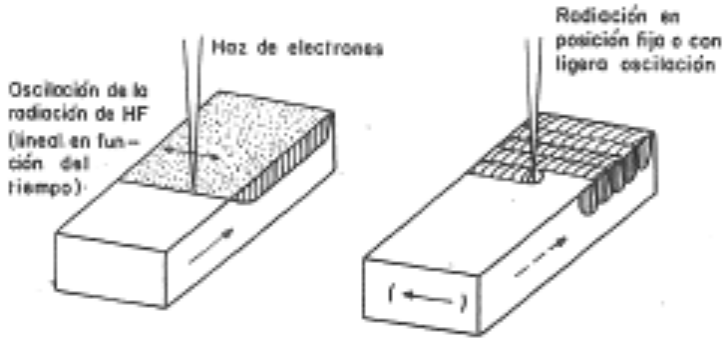
Variants of EB Surface Modification



Methods for EB Surface Modification



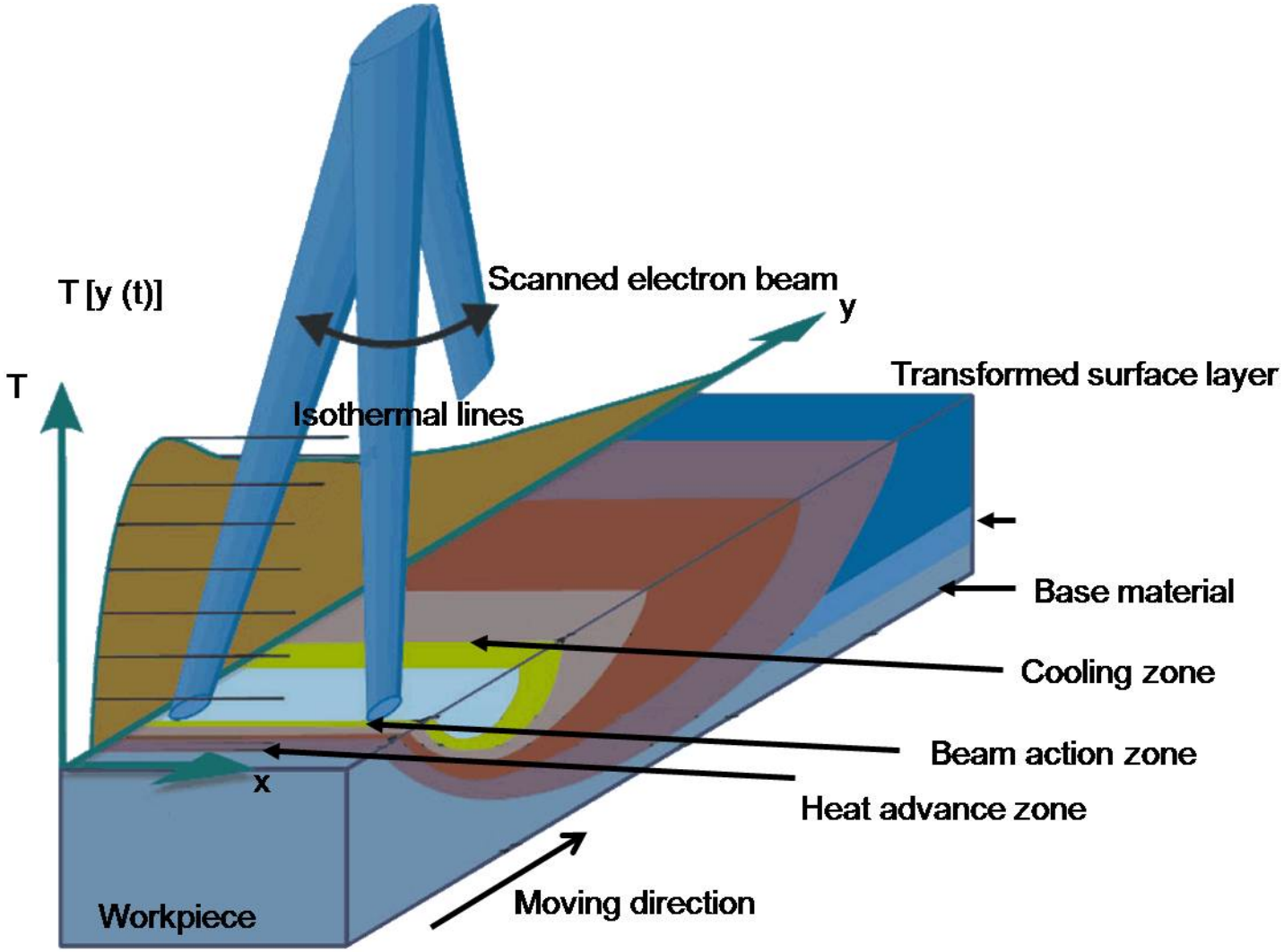
Various patterns of
surface structuring



Solid phase

Liquid phase

Principle of EB Surface Modification



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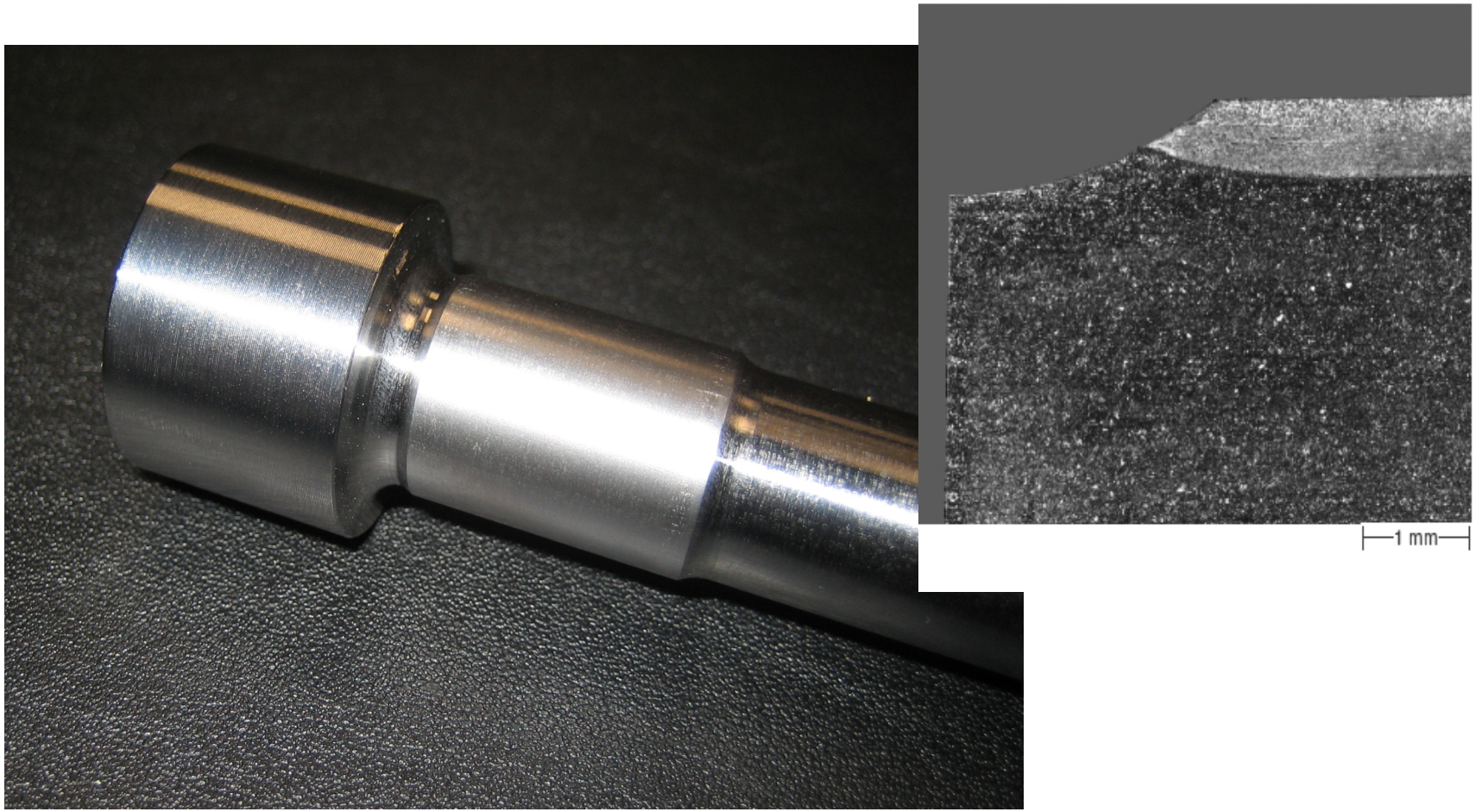
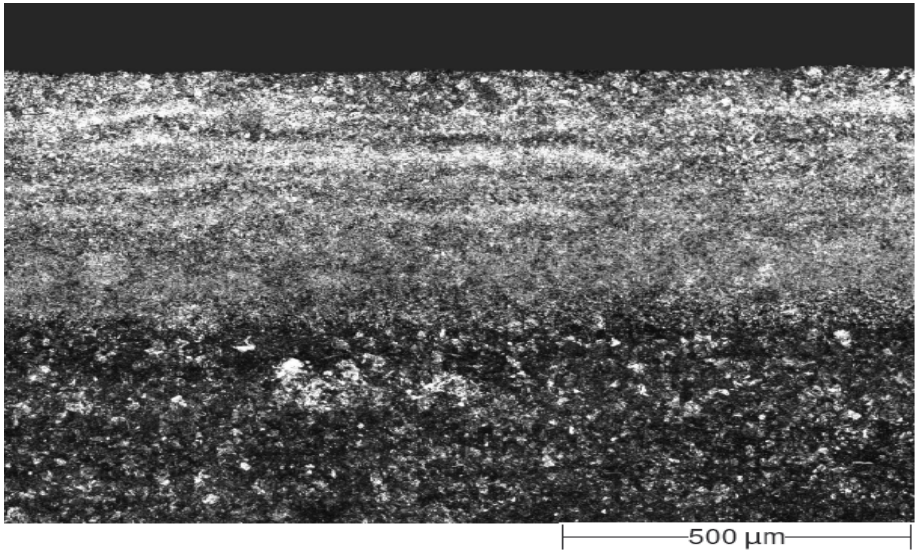
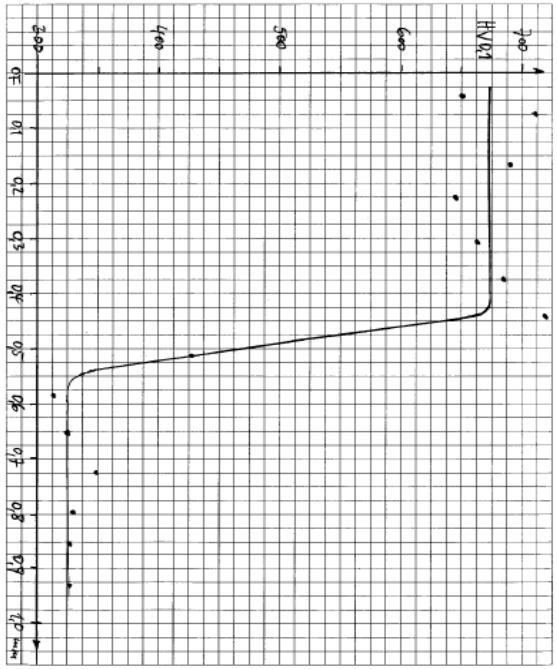
EB hardened bearing surface of 42CrMo4



EB hardened bearing Surface of 42CrMo4





EB Hardening (Solid Phase)

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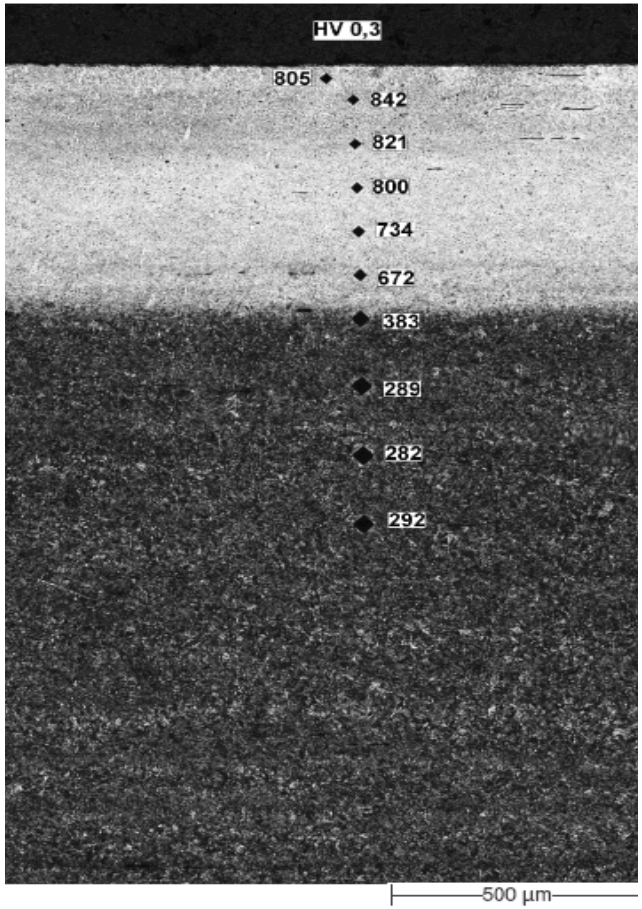
51CrV

4 oval cam tracks

hardening depth > 0,4 mm



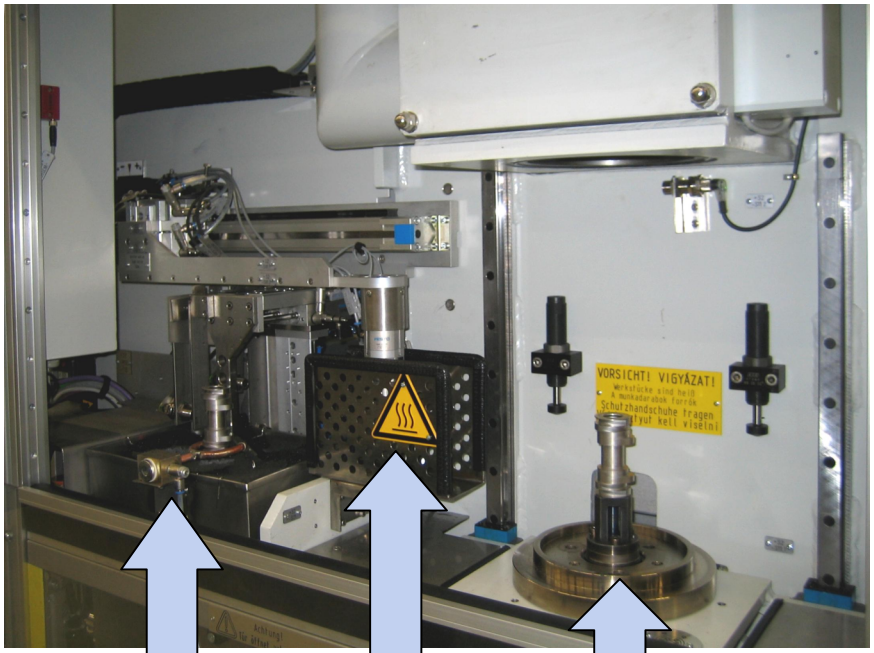
NC axles
in process:

- rotation
- focus
- deflection



EB Hardening Machine for Cam Shafts





AUDI: EB Hardening Machine



EB Machine (1,6 m x 5,0 m) for Chaku-Chaku Line

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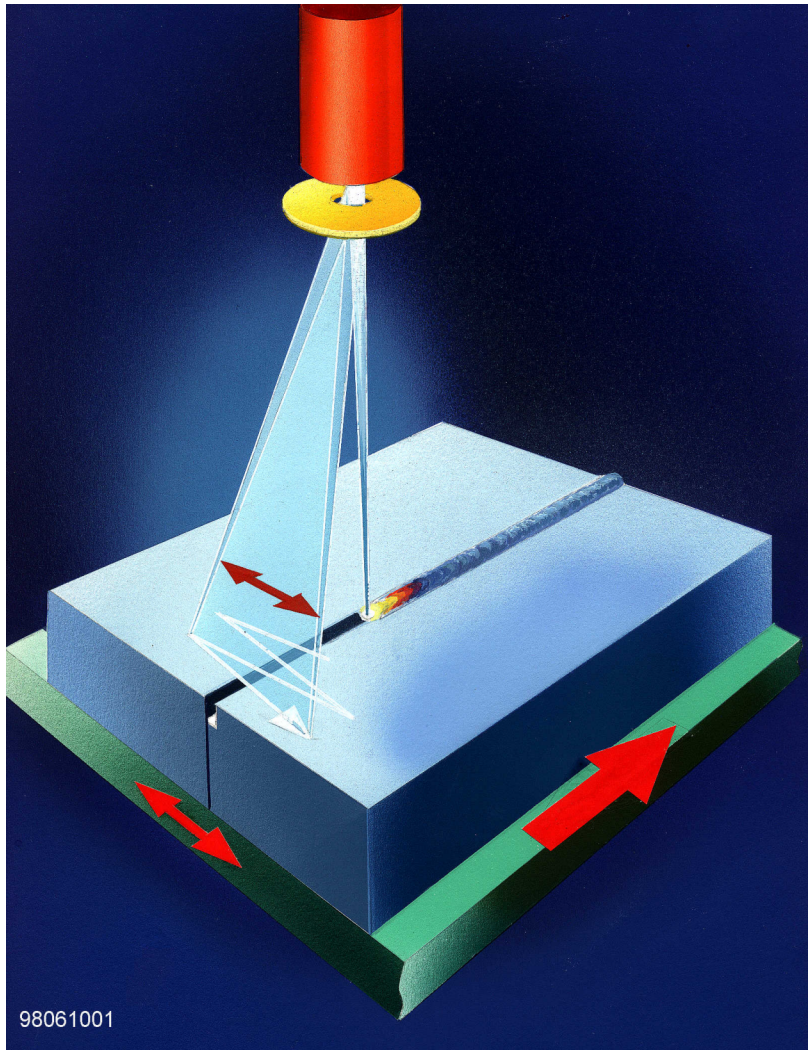
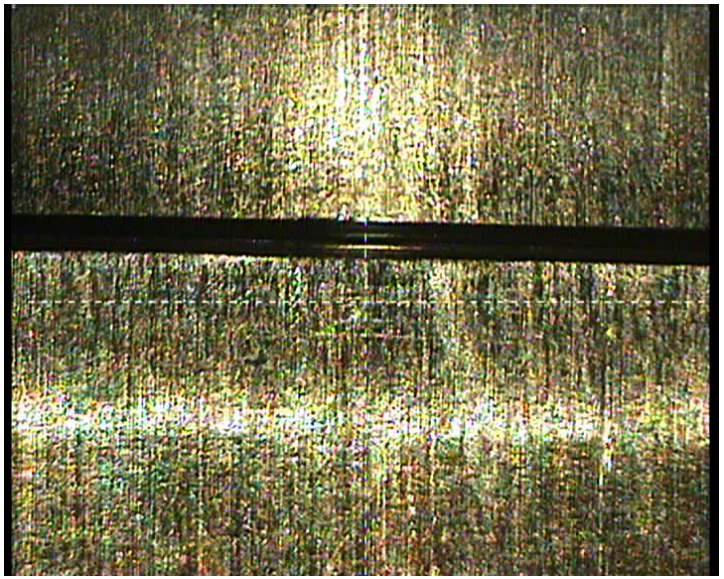
„Joint Detection“ using the Electron Beam



Video optic: Seam tracking



Pressure Accumulator



Joint in Video Optics

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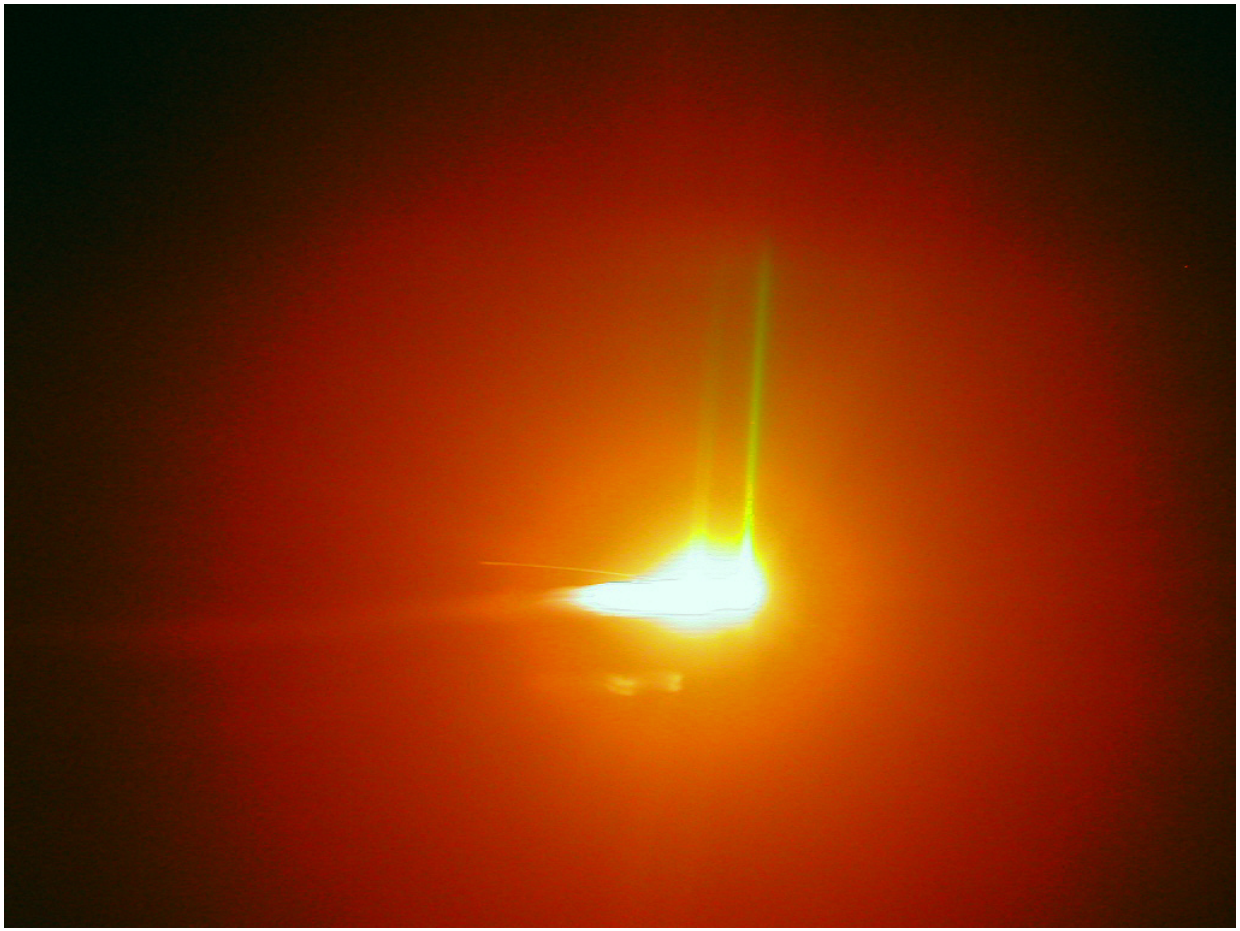
2-Beam Technology: Welding + Smoothing



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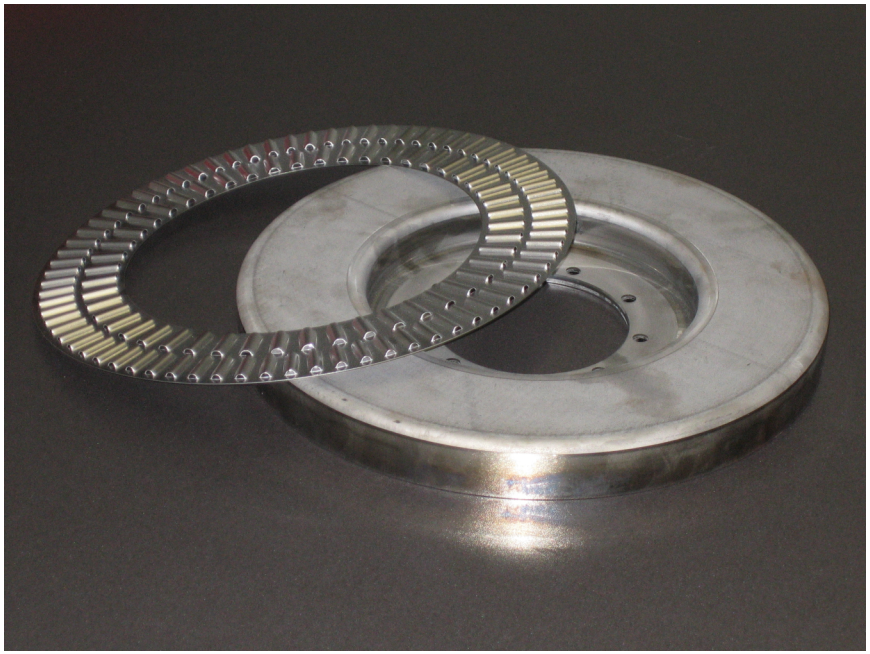
Use of Beam „Splitting“ (example)

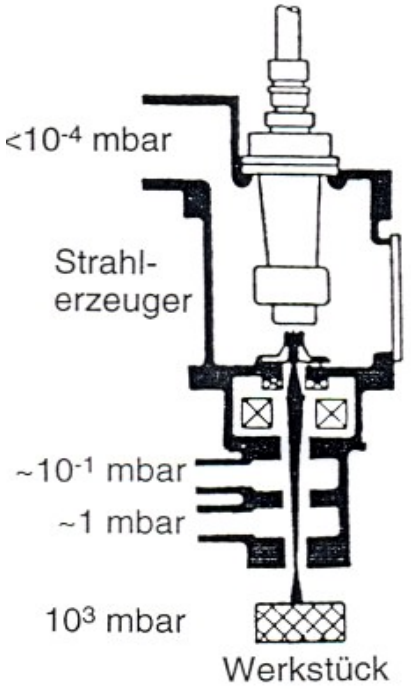


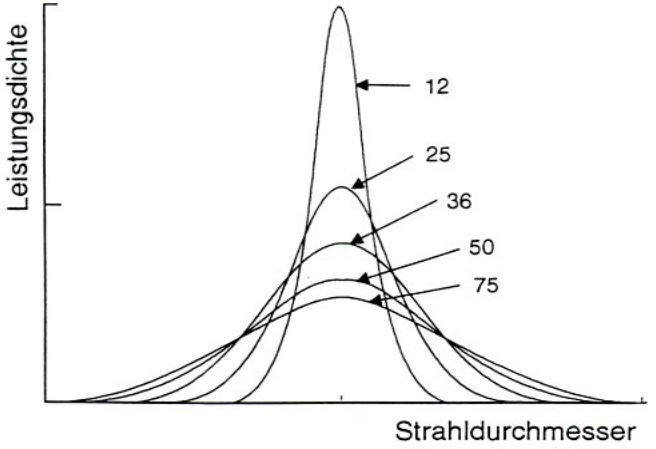
Beam „Splitting“: 2 Axial Welds in 1 Run





EB welding on atmosphere

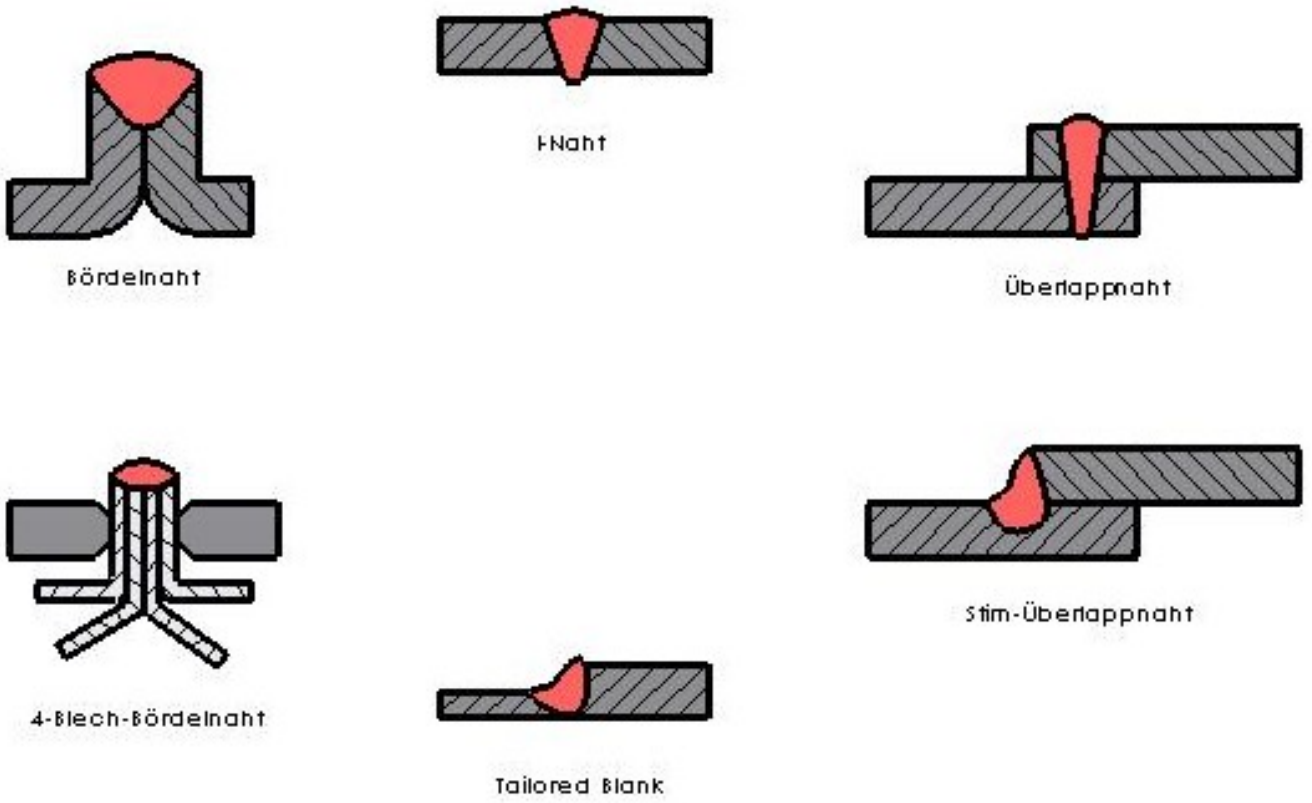






Atmosphäre

Joint Geometries in Nonvac EB Welding



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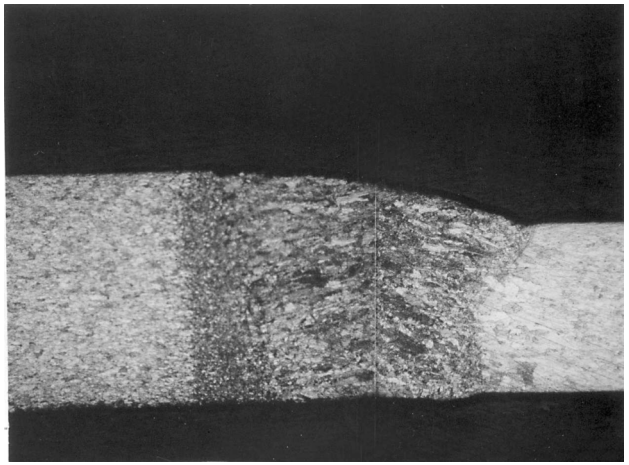
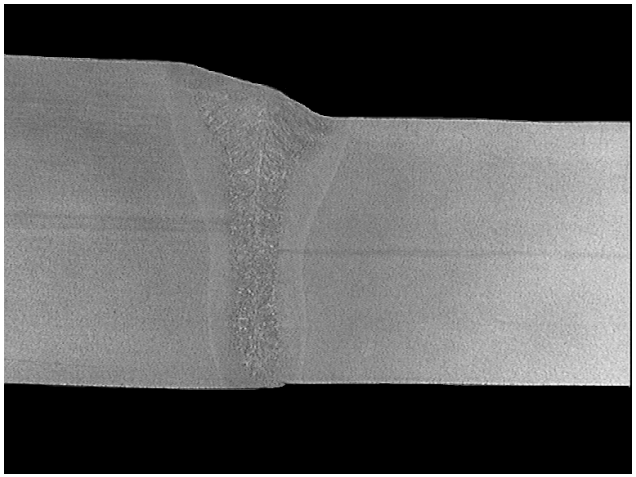
Weld examples: in vacuum and on atmosphere



1.2 + 1.6 mm thick



12 + 15 mm thick

30 mm deep

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Properties of NVEBW

- **Key- hole effect** is possible
- Suitable for nearly **all joint geometries**
- **No protection gas** needed because of metal vapour plasma
- Very **high welding speeds** possible
- Only **3 main parameters** to be adjusted
  - Beam power
  - Working distance
  - Welding speed
- **Tolerable** against
  - Gap bridging
  - Edge mismatch
  - Beam impact angle
- Use of **additional material** (e. g. filler wire) possible
- **Low consumption costs**

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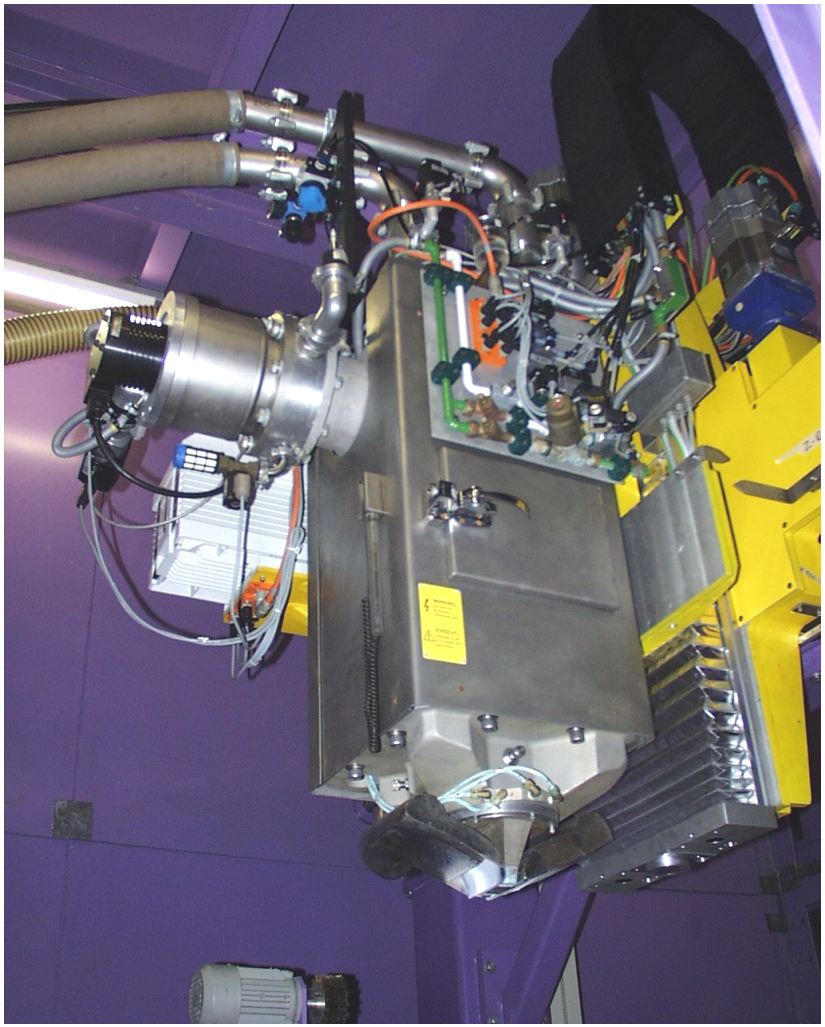
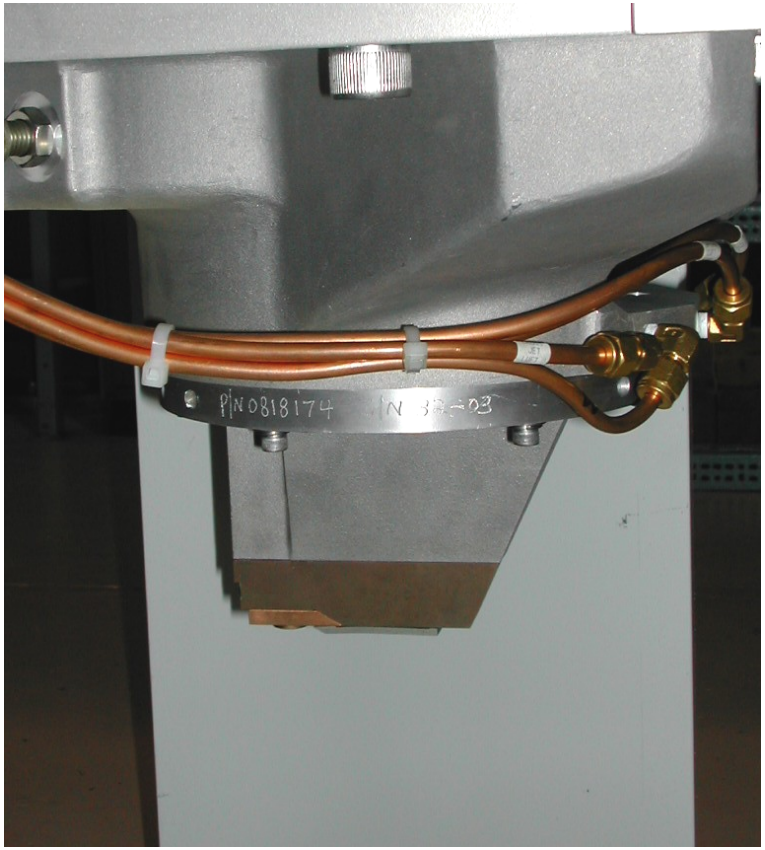
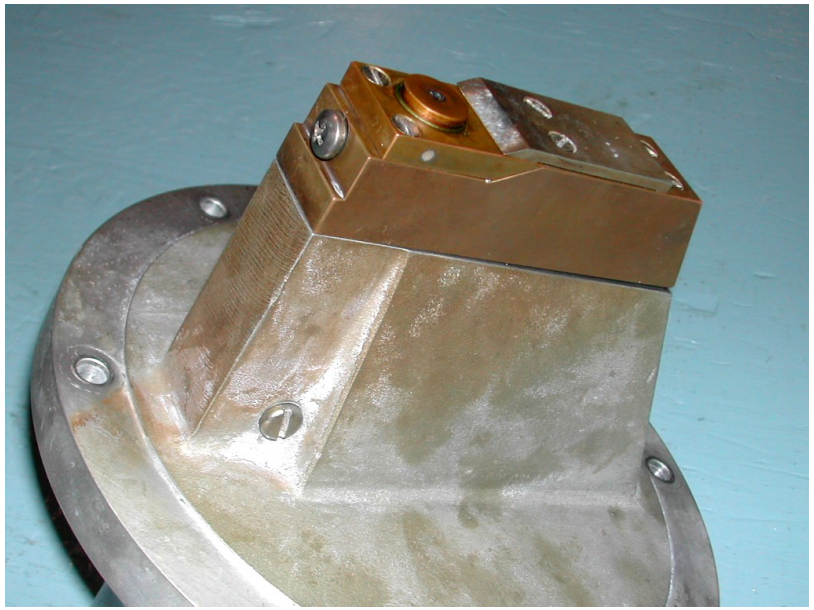
NVEBW Generator on a Gantry



NVEBW: Orifice System at Generator





robust and serviceable

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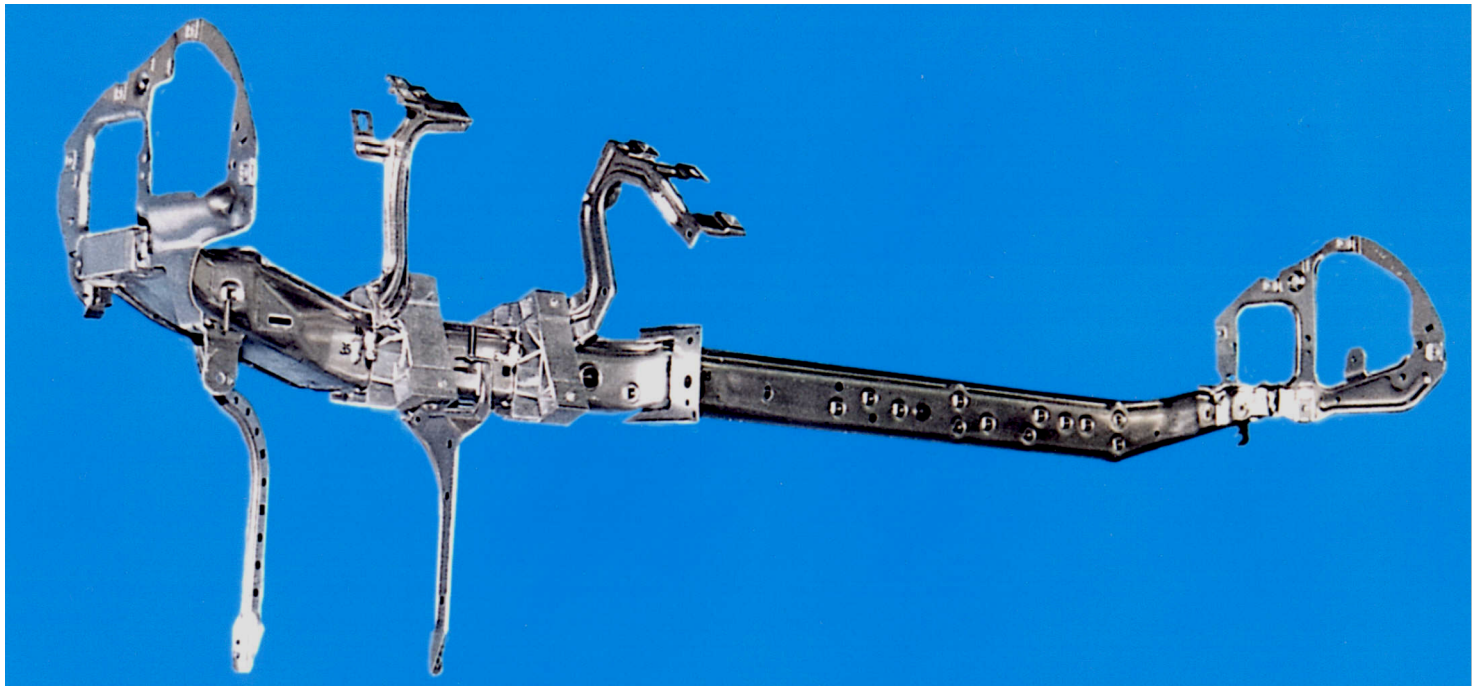
NVEB welded Cockpit Carrier Beams (completed)





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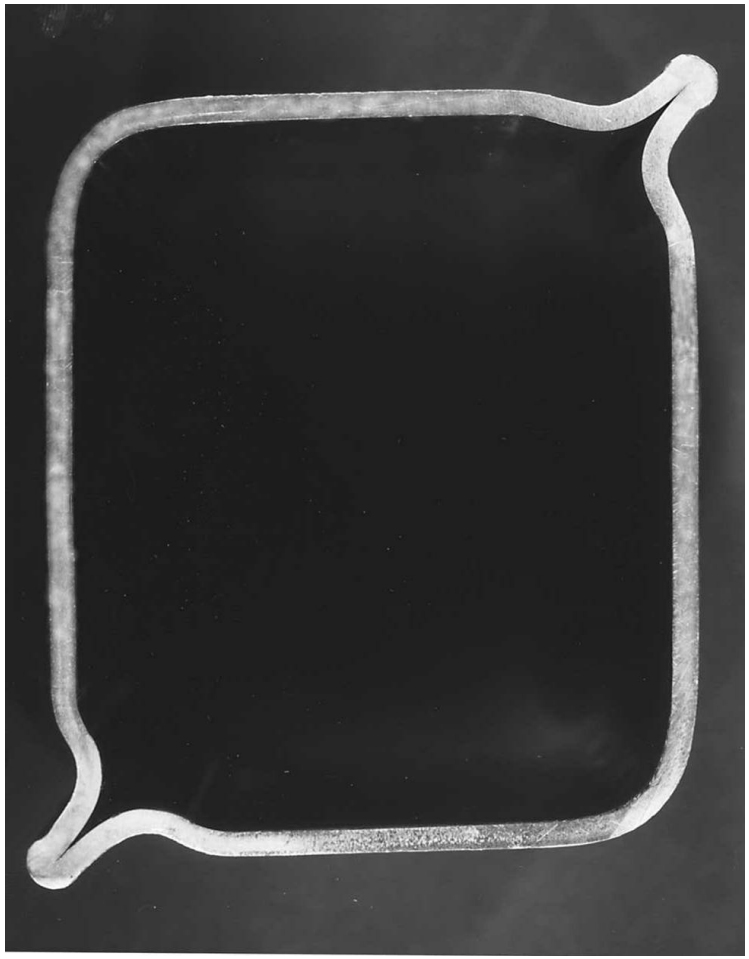
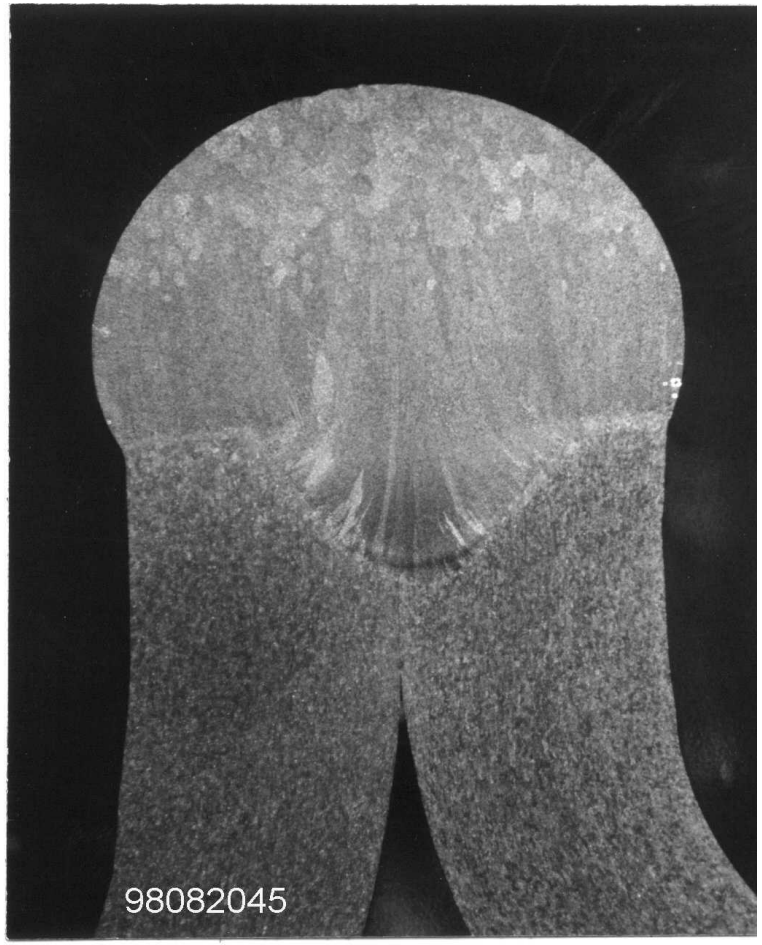
NVEBW Edge Weld (2 x 2,5 mm) on AlMg3 Cockpit Carrier Beam





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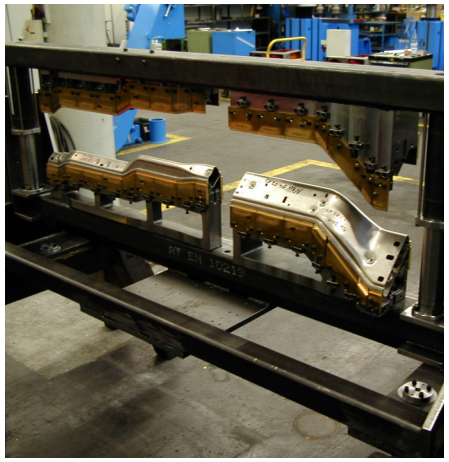
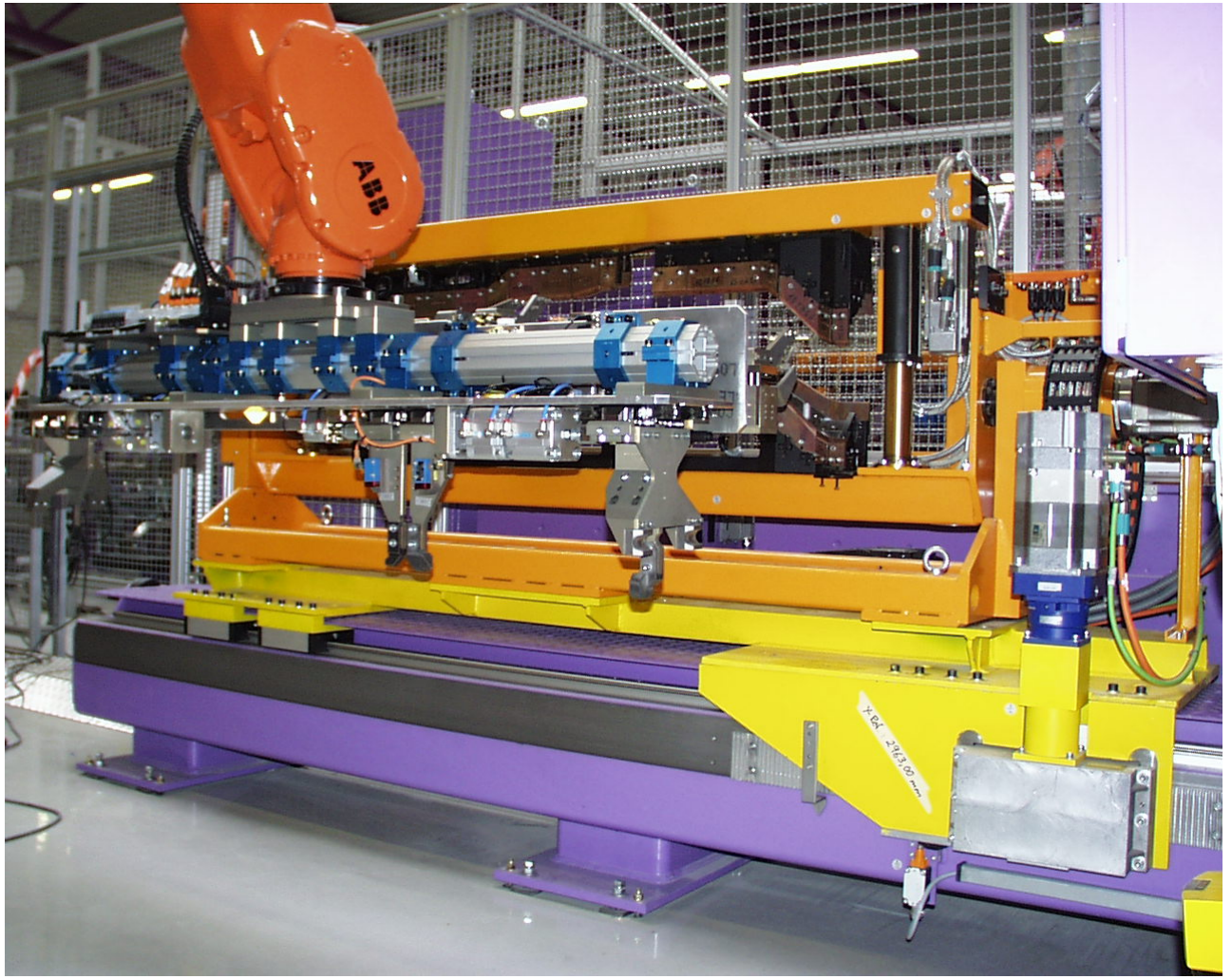
Loading of Beam Parts into Tooling







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NVEBW Twin Plant with 2 Generators



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NVEBW Production of Cockpit-Carrier Beams



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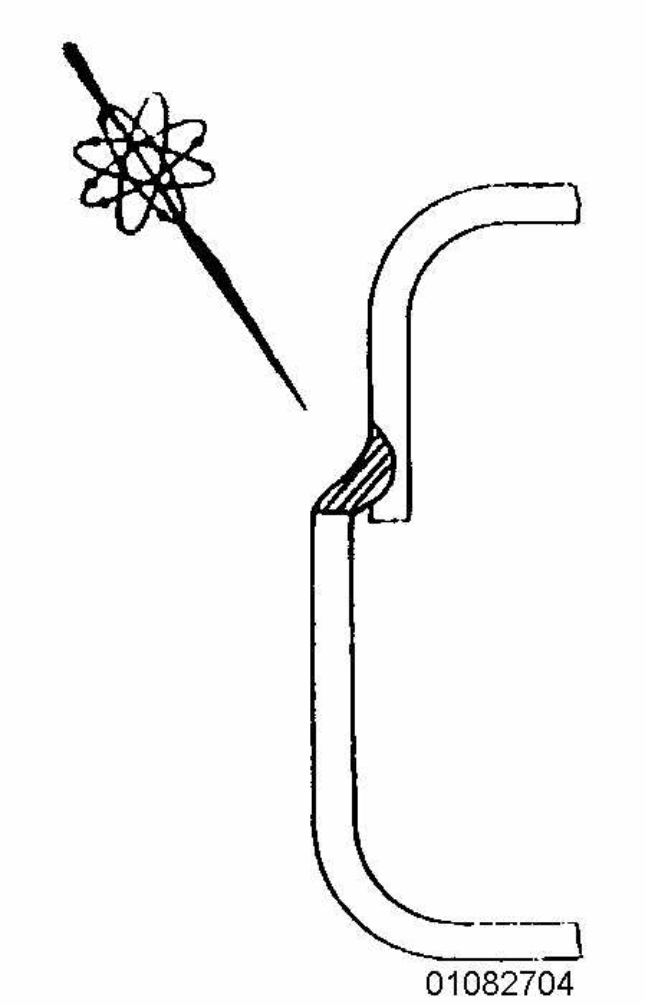
Nonvac EB welded Torque Converter



NVEBW on Torque Converter (schematic)



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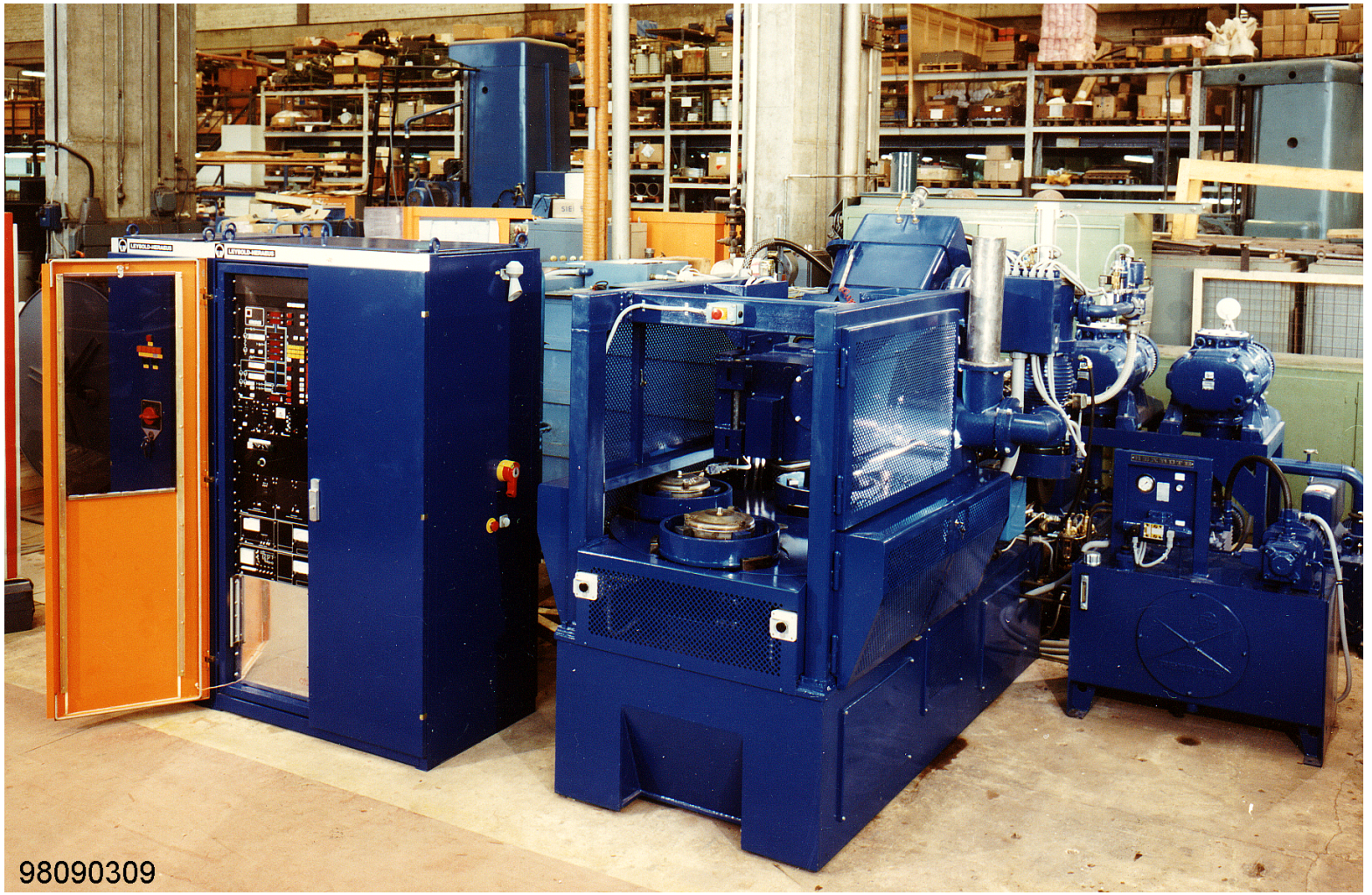
NVEB Welder for Torque Converters



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NVEBW of Die-Cast Part (with Gaps of 1 mm)



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Properties of the Electron Beam

- beam power of **30 W to 60 kW** (on work-piece) possible
- power densities > 10^7 W/cm^2 possible
- electromagnetic **beam forming** and deflection (static or dynamic)
- electromagnetic **beam splitting** (time-shared)
- absorption of beam energy **independent on material** and surface
- no limitation by plasma effects
- use of reflected electrons for **joint detection or imaging**
- welding in **vacuum** or under **atmospheric pressure**
- **electrical regulation** of all parameters
- **energy efficiency** of entire beam generation >> 50%
- low **consumption costs**

Customer Support from PTR Präzisionstechnik GmbH

- Draft of welding design and manufacturing technolgies
- Support in development of welding approach and parameters
- Welding of pilot and pre-series parts
- Draft of custom-tailored production plant
- Manufacturing and delivery of turn-key ready welding plants
- Education and training of customer‘s personnel
- All-including service over decads of years

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EB Welder on the Way to Customer…

