PATON WELDING INSTITUTE

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WE ARE PATON

E.O. Paton Electric Welding Institute of the National Academy of Sciences of Ukraine (PWI), founded by academician Evgeny Paton in 1934, is the largest R&D center in the field of welding and allied technologies in Ukraine. From 1953 to 2020 PWI was headed by his son, academician Borys Paton, an outstanding scientist and engineer. His brilliant ideas, which were practically implemented, have convincingly confirmed that basic and applied research in welding is highly demanded in different spheres of life and plays an important role in the global innovation process.

PWI offers a wide range of the latest knowledge of intensive technologies for welding different materials and structures, construction, metallurgical production, additive technologies etc. for various industries, such as transport, aerospace complex, mechanical engineering, energy, in particular nuclear one, medicine, defense and security.

PWI strategic research fields are as follows:

- advanced technologies of welding and joining of materials
- automation of welding and related processes
- strength, reliability and life of welded structures
- nano-structured systems, nano-technologies and nano-materials
- surfacing, coating deposition and surface treatment technologies
- special electrometallurgy processes
- materials, equipment and technologies for medicine
- mathematical modeling of welding and related processes
- technical diagnostics and non-destructive testing

PWI now is a powerful scientific and technical complex, which comprises a research institute, an experimental design and technological bureau, and pilot plants of welding equipment, welding consumables and special electrometallurgy. The leading role in this complex is assigned to the academic units, which are at the forefront of basic research and applied developments.

Around 1100 highly qualified researchers and engineers work at PWI, including 70 full professors and 180 PhDs in 39 academic units. Scientific, technological and production experience combined with up-to-date financial management and marketing allows PWI to effectively collaborate with leading enterprises in Ukraine and countries around the world.

Our partners include Boeing Company, Airbus SE, Holland L.P., Plasser & Theurer, Progress Rail Services Corporation, Zhuhai KIWAY Enterprise Ltd., JSC «TURBOATOM», ANTONOV Company, Pivdenne State Design Office, Motor Sich Joint Stock Company, ArcelorMittal Kryvyi Rih PJSC, etc.

PWI is a member of international professional welding organizations:

- International Institute of Welding (IIW)
- European Welding Federation (EWF)

Director of PWI,
Prof. Igor Krivtsun

PWI website is: https://paton.kiev.ua

PATON PUBLISHING HOUSE

«Paton Publishing House» publishes scientific-and-technical journals «The Paton Welding Journal», «Avtomatychne Zvaryuvannya», «Suchasna Elektrometalurhiya», «Tekhnichna Diahnostyka ta Neruinivnyi Kontrol» and as well as books, monographs, subject collections of papers, conference proceedings, catalogues, atlases, booklets and other products related to welding and allied technologies. Priorities of the «Paton Publishing House» include assistance to the readers in finding solutions to practical problems, acquiring important and valuable knowledge as well as in opening the new possibilities for their professional development.

> International scientific-technical and production journal **«The Paton Welding Journal»** has been published monthly in PWI since 2000 in English, ISSN 0957-798X, doi.org/10.37434/tpwj. The content of the journal includes articles received from authors from around the world in the field of welding, metallurgy, material science, NDT and selectively includes translations into English of articles from the following journals, published by PWI: Automatic Welding, Electrometallurgy Today, Technical Diagnostics & Nondestructive Testing.

> International scientific-technical and production journal **«Avtomatychne Zvaryuvannya»** (Automatic Welding) has been published monthly since 1948 in Ukrainian and English, ISSN 005-111X, doi.org/10.37434/as. It includes articles covering all aspects of welding and related technologies (cladding, surfacing, soldering, brazing, coating, 3D prototyping, materials science and new materials).

> International scientific-theoretical and production journal **«Suchasna Elektrometalurhiya»** (Electrometallurgy Today) has been published quarterly since 1985 in Ukrainian and English, ISSN 0233-7681, doi.org/10.37434/sem. It includes articles covering all aspects of electron beam processes, electroslag technologies, plasma arc technologies, vacuum-induction melting, material science, and new materials.

> International scientific-technical journal **«Tekhnichna Diahnostyka ta Neruinivnyi Kontrol»** (Technical Diagnostic & Non-Destructive Testing) has been published quarterly since 1989 in Ukrainian and English, ISSN 0235-3474, doi.org/10.37434/tdnk. It includes articles covering all aspects of technical diagnostics and all methods of non-destructive testing of equipment, structures and mechanisms.

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TECHNOLOGY AND EQUIPMENT FOR
FLASH BUTT WELDING
OF HIGH WEAR-RESISTANT RAILS

> Technology of flash butt welding (FBW) of high wear-resistant rails was developed at the Paton Welding Institute (PWI) to provide properties of welded joints that meet requirements of Ukrainian and the EU standards.

A new generation of mobile rail welding machines was designed at PWI and manufactured at the Kakhovka Plant and the PWI Pressure Welding Center.

All the machines are equipped with modern computerized systems of multifactor control of welding parameters, fast-response hydraulic drives, and cutting device, which removes flash reinforcement in a hot state without unclamping the rail section.

The use of new machines allows performing FBW with tension of the welded rail sections for stabilization of the temperature-stressed state of continuous welded tracks.


K930


K950


K960

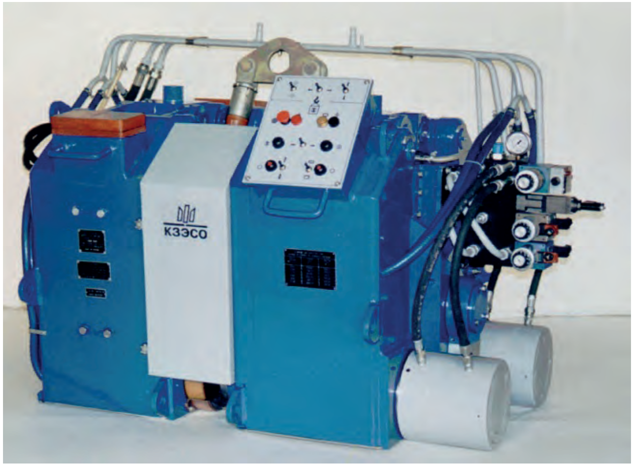
Specification of mobile rail welding machines

Parameter	Machine model		
	K930	K950	K960
Consumed power, kVA	210	210	210
Upsetting force, кN	1200	1200	2000
Clamping force, кN	2900	2900	4650
Hydraulic cylinders stroke, mm	200	250	280
Weight, kg	3600	3650	5670

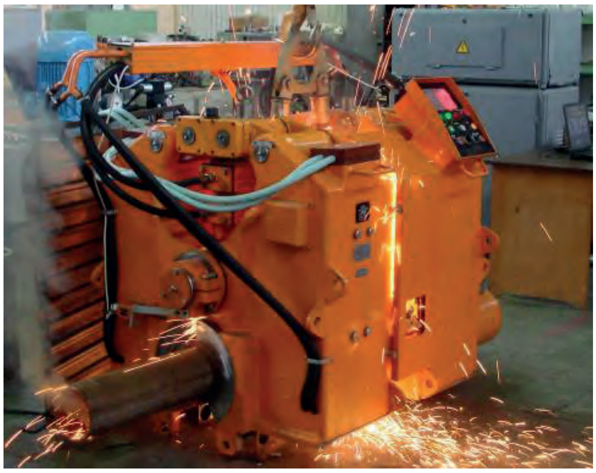
TECHNOLOGY AND EQUIPMENT FOR FLASH-BUTT WELDING OF PIPES

> PWI developed technologies for flash-butt welding (FBW) of pipelines of 114 to 1420 mm diameter

K813, K584, K805, K700 pipe-welding complexes successfully welded tens of thousands of kilometers of pipelines, in particular, in the harsh climatic conditions.



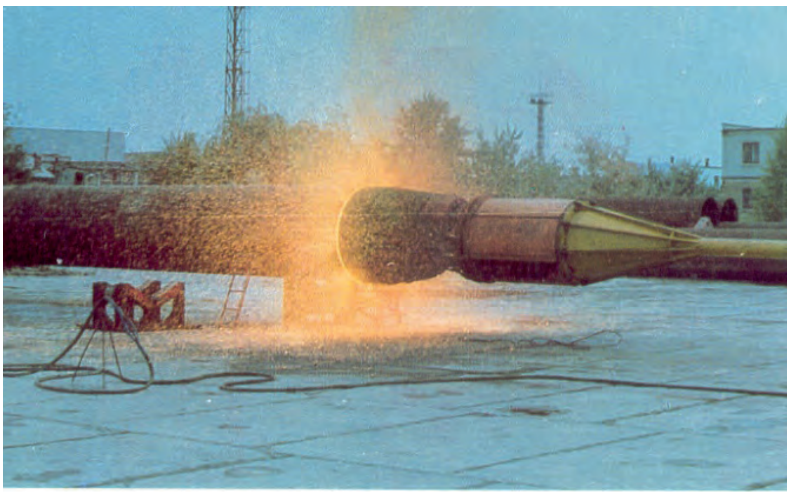
K813

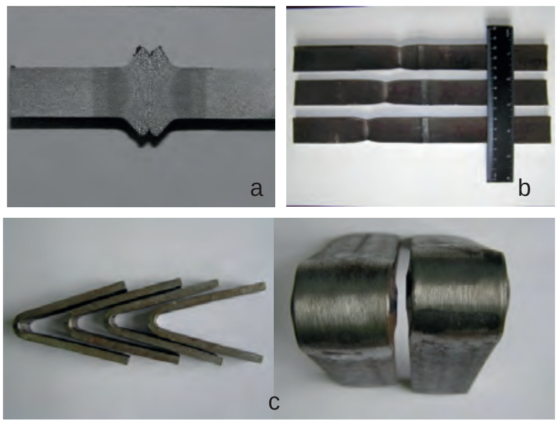


K584

Specification of machines for FBW of pipes of 114…530 mm diameter

Machine model	Pipe diameter,mm	Pipe wall thickness, mm	Upsetting force, tons	Consumed power, kVA	Productivity, butt/h	Dimensions, mm	Weight, kg
K813	114-57	10	12	70	12	1622x920x880	1300
K584M	325-114	14	40	150	10-12	1846x1100x1520	3500
K805	530-377	16	100	300	8-10	2575x1850x2600	12000





Macrosection of a welded joint (a), samples after tensile (b) and bending (c) mechanical tests

Specifications of machines for FBW of pipes of 720…1420 mm diameter

Machine model	Pipe diameter,mm	Pipe wall thickness, mm	Upsetting force, tons	Consumed power, kVA	Productivity, butt/h	Dimensions, mm	Weight, kg
K700-1	1420	20	400	1000	6-8	11605x1400	25000
K810	1420	26	500	1600	5	13700x1400	36000
K800	1220-1020	16	240	800	6-8	12000x1220	18000
K830	820-720	10	100	600	6-8	11500x780	10000

TECHNOLOGIES OF

FLASH-BUTT WELDING

OF HIGH-STRENGTH ALUMINUM ALLOYS

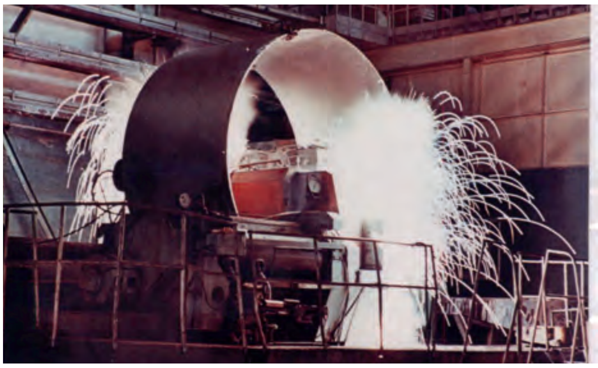
The method of flash-butt welding (FBW) is applied for joining all series of Al-alloys used in aircraft and rocket engineering

FBW provides:

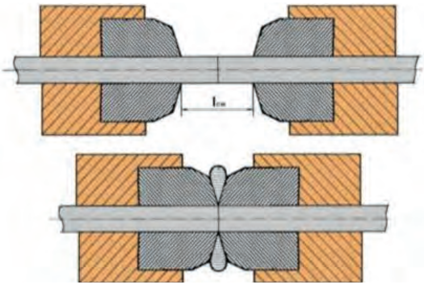
- strength of welded joints of more than 0.9 of base metal values;
- precision of geometrical dimensions for large-sized workpieces: ±1 mm (measured around the perimeter), no residual distortions;
- high productivity (welding time – 1…3 min);
- no need for welding consumables and shielding gas

Machines for FBW of shells, frame rings, and stringers

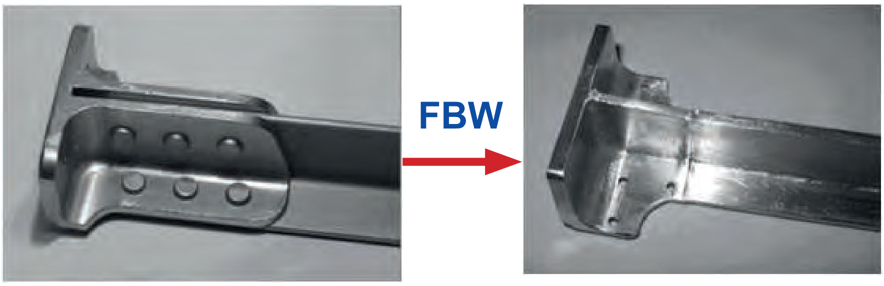
K393



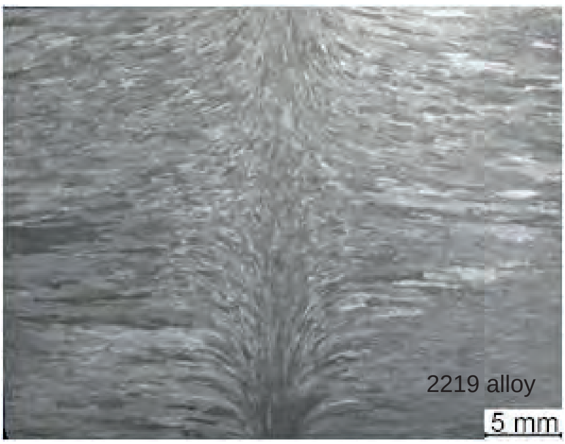
K767



Scheme of FBW with metal extrusion during the upsetting process



Welded stringers instead of riveted joints



Macrostructure of 2219 alloy FBW joint

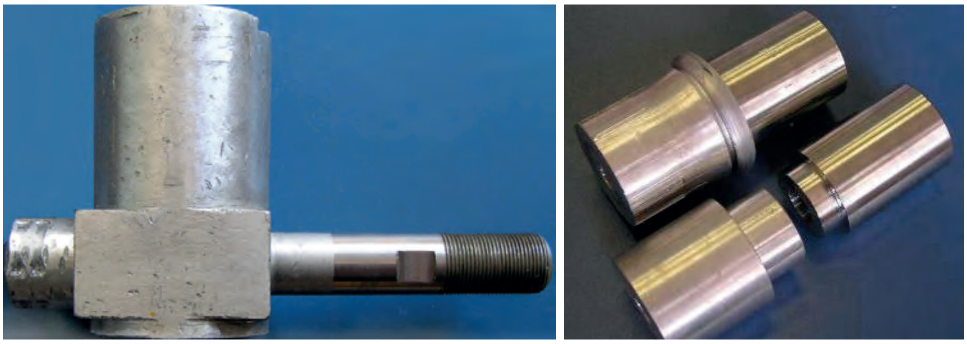
Samples of welded joint after tensile tests

Tensile strength of heat-treated welded joints (WJ) of Al-alloys, and corresponding base metal (BM) values

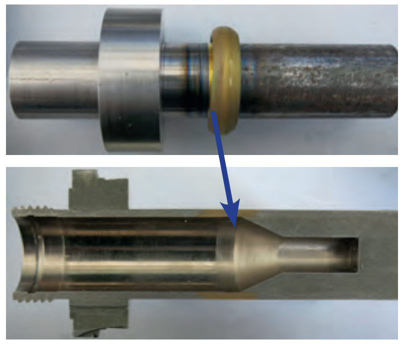
Alloy	σ_t, MPa		$\sigma_{0.2}$, MPa		δ,%		$K = \sigma_{tWJ}/\sigma_{tBM}$
	BM	WJ	BM	WJ	BM	WJ	
AMg6	330	312	163	157	20	19	0.97
2219	441	432	325	345	25,3	8.4	0.98
7075	487	479	419	406	12	9	0.98
6061	281	301	276	297	19	15	1

> Industrial technologies of friction welding (FW) of different alloys in similar and dissimilar combinations were developed at the PWI

Bimetal products for fuel systems of gas turbine engines for aircraft and rockets



AD1 aluminium alloy / AISI304 stainless steel

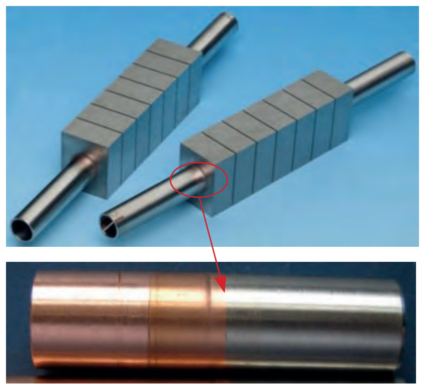


Steel /brass /steel product

Turbochargers (Cast nickel superalloy / / high-strength steel)

AMg6 alloy / AISI304 steel

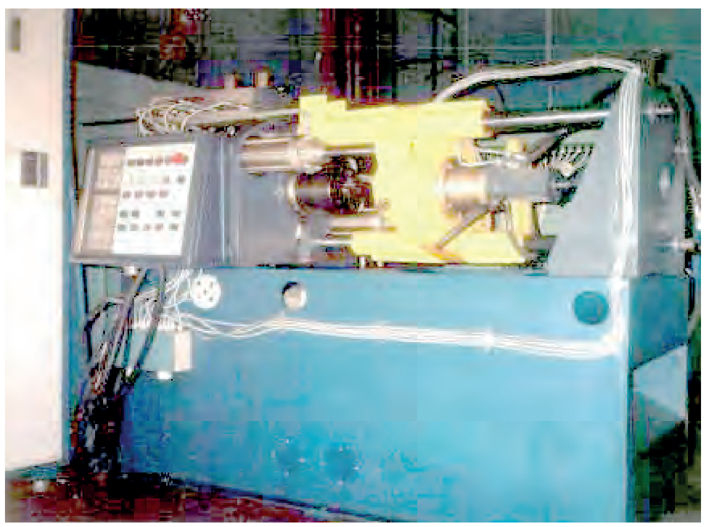
Bimetal valve (γ-TiAl aluminide / titanium)



Bimetal transition piece for «ITER» Project (Cu-Cr-Zr Alloy to 316l steel)

FW machines are characterized by simplicity of design, reliability and durability, a high degree of automation of the welding process and productivity.

ST109A



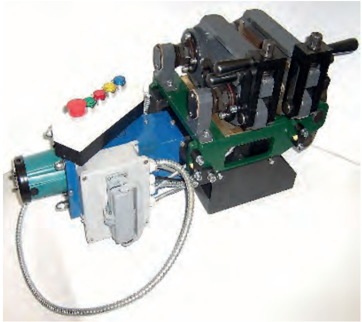
ST-120

MAGNETICALLY IMPELLED ARC BUTT (MIAB) WELDING

MIAB welding of carbon, low alloy, heat resistant, high-strength steel tubes, pipelines, hollow automotive parts is performed in the air without the use of welding consumables and shielding gas.

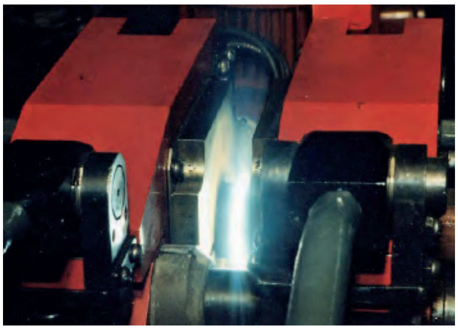
Practical advantages:

- short time of welding, pipe of Ø 120 x 5 mm – 22 s
- tightness of welded joints
- strength properties of the welded joint at the level of strength of the base metal
- no pores, inclusions, etc.
- control and registration of the main parameters in the welding process
- automation of the welding process
- high efficiency for industrial mass production.



Mobile machine MD1

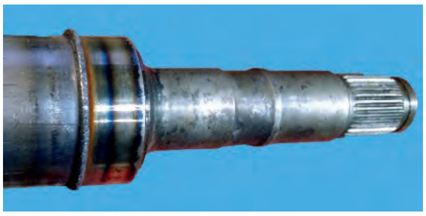
Machine MD205



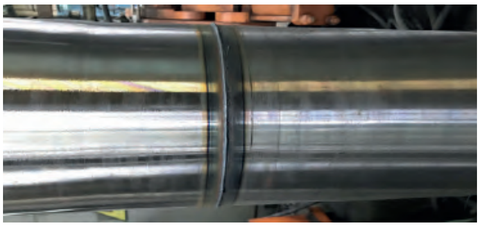
MIAB welding process

Welded steel sleeve, Ø 42 x 3.5 mm

Welded hydraulic pipes with fittings,
Ø 27.2 x 2.5 mm and Ø 42.7 x 4.2 mm



Welded shaft, Ø 51 x 2.2 mm of
the automotive Land Rover



Welded pipe, Ø 212 x 3.5 mm

Technical data of welding machines

Type	Pipe diameter, mm	Wall thickness, mm	Productivity, joints/hour	Time of welding, s	Power consumption, кVA	Weight, kg
MD-1	20 … 57	1 … 4	up to120	4-20	70	150
MD-215	30 … 150	3 … 10	up to 60	10-50	120	900
MD-205	40 … 220	3 … 10	up to 60	10-70	150	1500

EQUIPMENT FOR
ELECTRON BEAM WELDING

PWI has been engaged in EBW since 1958. The first commercial units were put into operation at the beginning of the 60th. Need for EBW has expanded with time to nuclear power engineering, instrument making, aircraft-, ship and space machine building.

Covered tasks include:

- designing of mechanical and electrical sections of machines
- development of electron guns, power sources and control systems
- assembly and testing of complete machines and power units
- putting the produced machines into commercial operation;

Small-size unit of SB 112 type

Chamber volume	0.3 m^3
Accelerating voltage	60 kV
Capacity of power unit up to	15 kW

Mid-size unit of KL 138 type

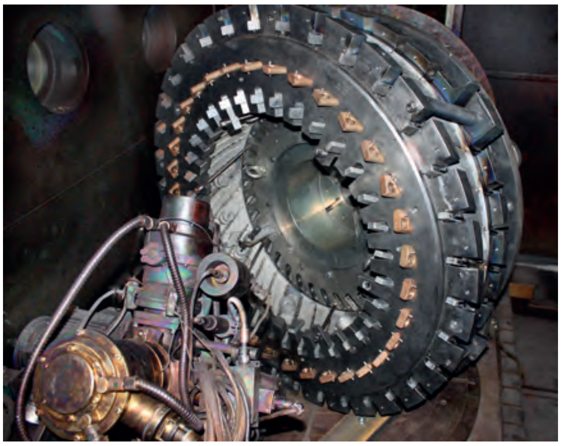
Chamber volume	40 m^3
Accelerating voltage	60 kV
Capacity of power unit up to	60 kW

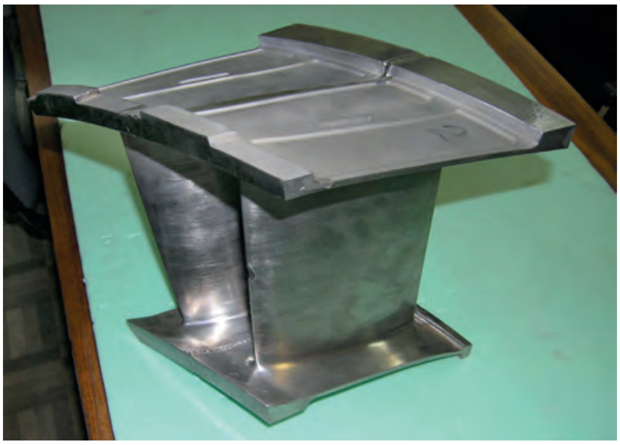
Large-size unit of KL 118 type

Chamber volume	66 m^3
Accelerating voltage	60 kV
Capacity of power unit up to	60 kW

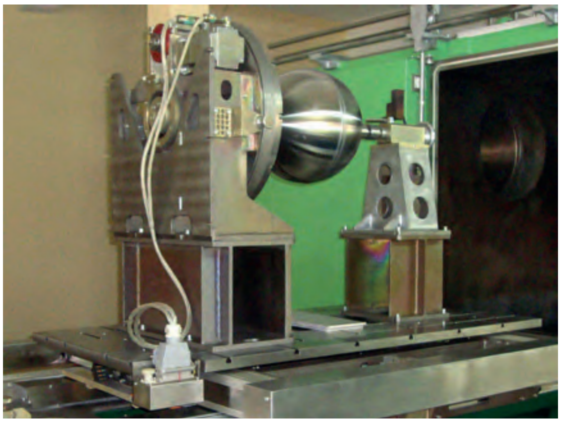
About 100 sets of different EBW equipment, including the units with vacuum chamber volume up to 100 m^3, have been put into operation for the last 10 years.

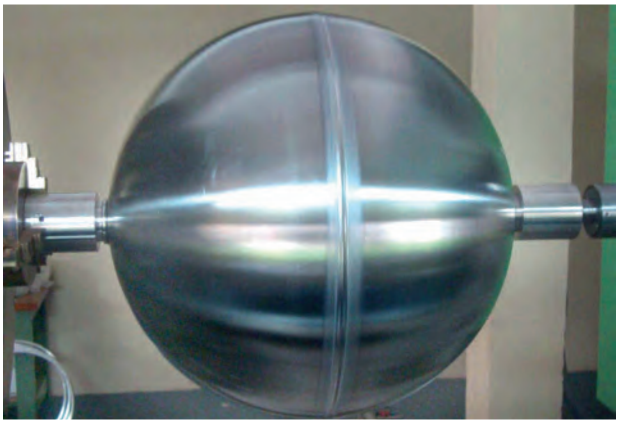
Gas turbine engines components



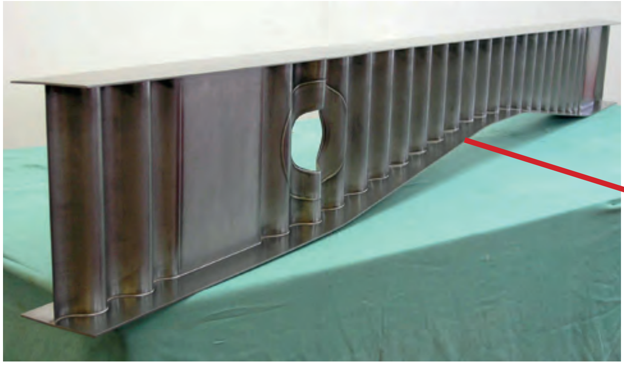


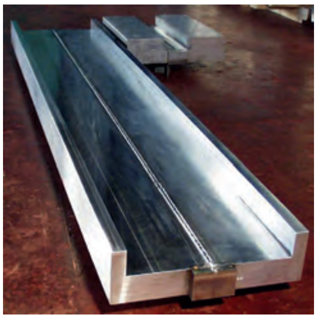
Spherical tank

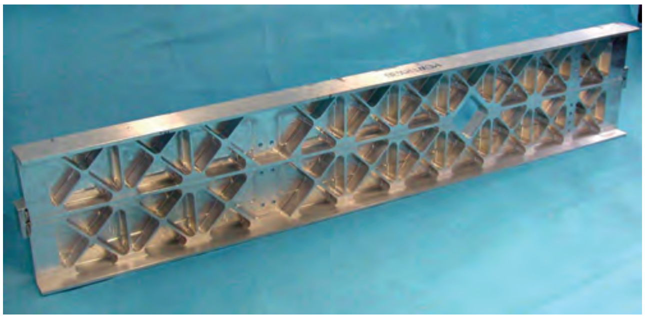




Ti-profiles



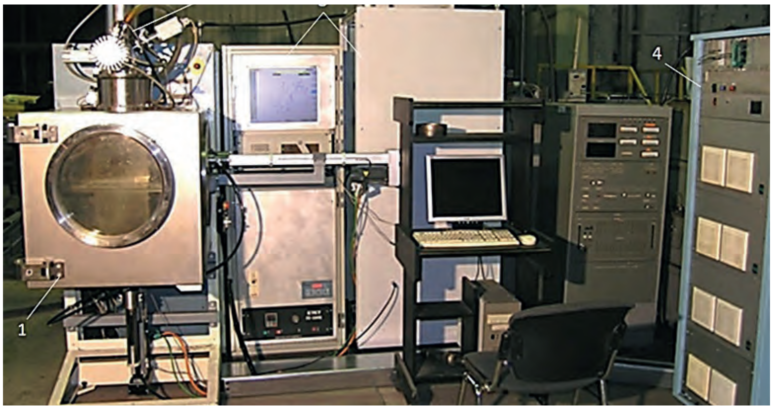




Al-beams of airplane wing

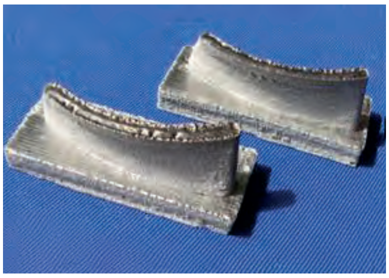
ELECTRON BEAM 3D TECHNOLOGIES

EB 3D prototyping of metal products from powder materials



- Productivity of up to 80 cm^3/h
- Powders of titanium alloys of spherical and arbitrary shape

Implant for brainpan



GTE stator blade

EB 3D prototyping of products using filler wire

- Productivity: from 3.0 up to 12 kg/h
- Wires from titanium and aluminium alloys, tungsten, tantalum, niobium

Surfaced cylinder

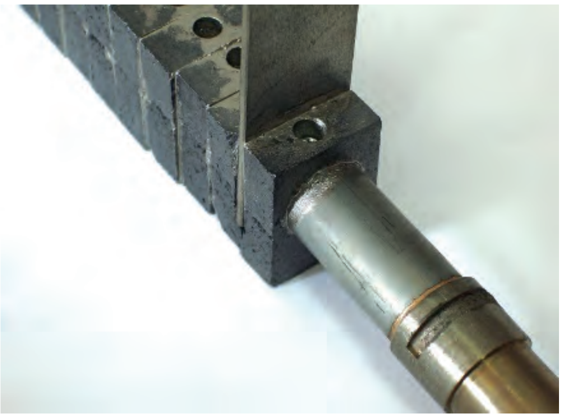
Restored shaft

BRAZING OF STRUCTURAL
and HARD-to-WELD MATERIALS

> PWI has developed technological processes and filler metals for brazing, including promising materials of new generation intermetallic, dispersion-strengthened alloys, carbon materials, titanium-based alloys, dissimilar copper-tungsten joints, molybdenum-graphite (stainless steel) and hard-to-weld materials to produce brazed joints in various industries.

For thermonuclear fusion divertor elements


Mo – C


C – Mo - SS

For instrumentation, nuclear power industries


Ti – Kovar


SS+SS

For the energy and aerospace industries

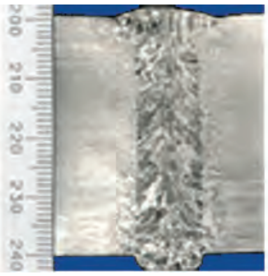
Al

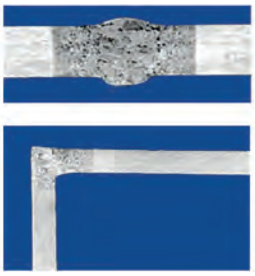

High temperature nickel superalloys

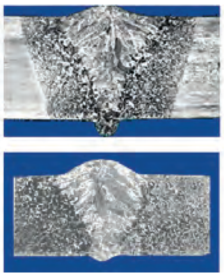
WELDING OF TITANIUM
AND ITS ALLOYS

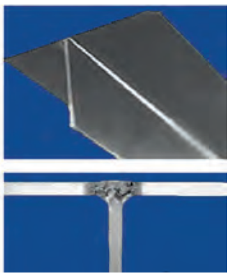
A team of experts in the field of welding of titanium and alloys on its basis has been working at PWI for more that 30 years. For the first time in the world the unique technologies of non-consumable argon-arc welding of titanium with halogenide fluxes; narrow-gap argon-arc tungsten electrode welding with controlling magnetic field; press welding of titanium with copper and aluminum with steel were developed in course of these years.

The technologies for welding titanium and its alloys developed at the PWI have found wide application in aircraft- and rocket construction as well as at enterprises of chemical machine building of CIS countries. Currently, PWI fulfills contract-based complex works on development of technology and equipment for titanium welding and engineering maintenance at manufacture of specific products.



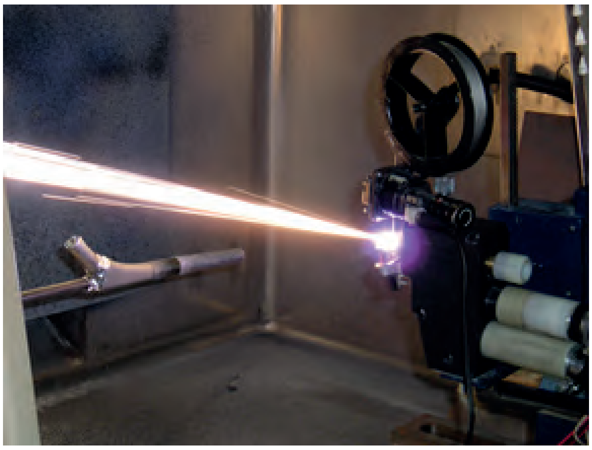




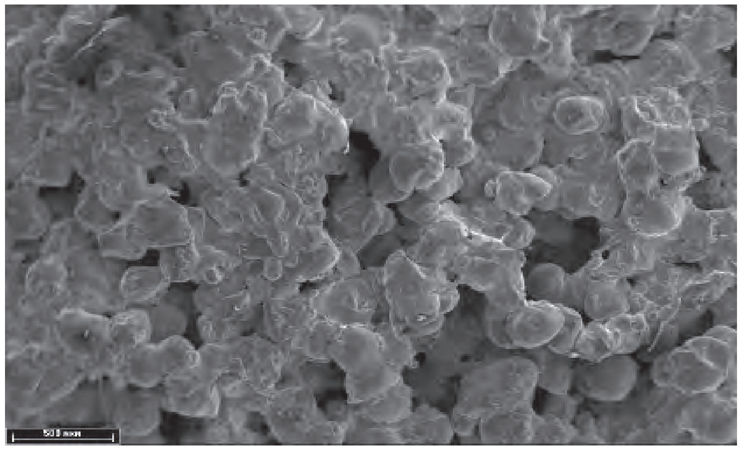


MICROPLASMA SPRAYING
OF BIOCOMPATIBLE COATINGS

> PWI developed a method and equipment for microplasma spraying (MPS) of biocompatible coatings, both pure titanium and composite coatings, consisting of a titanium sublayer and an upper layer based on hydroxyapatite.



Deposition of coatings from titanium wire by microplasma spraying



Morphology of microplasma biocompatible coating

Parts of hip endoprothesis with a titanium coating deposited by microplasma spraying method

The developed MPS technology allows controlling the phase composition of hydroxyapatite coating during its formation (ratio of the crystalline and amorphous phase from 70/30 to 98/2, lowering of the degree of hydroxyapatite decomposition and CaO content and controlling the degree of the texture);

The method of microplasma wire spraying allows deposition of biocompatible Ti-coatings with a developed surface morphology and up to 31.0% porosity and pore size of up to 150–250 μm, that will ensure secondary fixation of the endoprothesis in the bone.

Measurement of adhesion strength of the produced microplasma biocompatible coatings showed that at tear testing it is 24.2 ± 3.5 MPa (at 300-500 μm thickness), and at shear testing it is 25.6 ± 4.6 MPa that satisfies the requirements of ISO 13179-1 to coatings for endoprotheses.

Proceeding from the results of the conducted studies a technology of deposition of microplasma, biocompatible and porous coatings was developed, which became applied in manufacture of the components of hip endoprothesis of «ITZ-MOTOR SICH» system.

EQUIPMENT FOR LASER WELDING

WITH INCREASED DEPTH OF PENETRATION IN VACUUM

The equipment is designed to produce welded joints of alloyed steels, titanium, nickel and copper and other alloys, as well as from aluminium, magnesium and beryllium alloys in vacuum to 10^{-1} Pa. The power of laser radiation is 0.2-5 kW (it can be increased if necessary). The dimensions of the vacuum chamber, the number of degrees of freedom and the working stroke of the manipulator drives in the vacuum chamber are made in relation to the dimensions and surface shape of the parts to be welded. Vacuum Laser Welding (LWV) produces welds with aspect ratios of 1 or less (key-hole penetration) and produces results comparable to Electron Beam Welding (EBW) at the same beam power.

A distinctive feature of the equipment is the possibility of welding with the feed of one or two heated filler wires, which makes it possible to increase the productivity of the laser welding process in vacuum (by 30-50%) and control the chemical composition and mechanical characteristics of the weld by using filler wires of different chemical composition.

Advantages of laser welding in vacuum

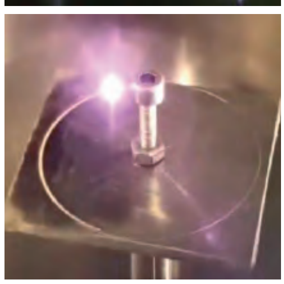
Compared to conventional laser gas shielded welding

- increasing the penetration depth up to 1.5-2.5 times and reducing the weld width by 30-50%
- increase in welding speed up to 2 times

improving the quality of the formation of the upper part of the welds through the use of filler wires

Compared to electron beam welding

- 100-1000 times less vacuum required
- smaller welding heads, simpler vacuum equipment and shorter vacuum times
- lower prime cost of 1 m of weld and equipment maintenance costs



1 – set of laser equipment; 2 – vacuum chamber; 3 – mobile control system; 4 – vacuum station

Macrosections of welds from aluminium alloy 5083 (Al-Mg-Mn) obtained by laser welding in dynamic vacuum and in air with gas protection (laser power of the fiber laser 800 W, welding speed V = 32 mm/s (192 cm/min). Depth of penetration: a – 3.76 mm; b – 1.4 mm.

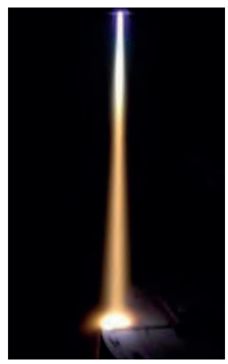
EQUIPMENT FOR HIGH-PERFORMANCE SUPERSONIC PLASMA SPRAYING

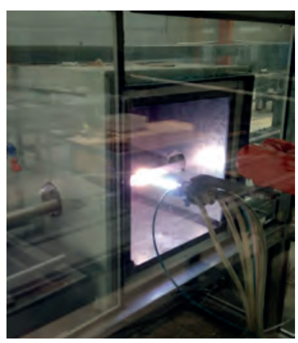
OF WEAR-RESISTANT, HEAT-RESISTANT AND HEAT-PROTECTIVE COATINGS

The equipment is designed for applying wear-resistant, corrosion-resistant, heat-shielding and special coatings by spraying powders from metals, alloys, carbides, borides, oxides and metal-ceramic materials. The thickness of applied coatings is from 20-50 microns to 1-2 mm and more. As a plasma gas, air is used with small (about 5%) additions of combustible gas (methane or propane-butane). This equipment ensures the implementation of a supersonic plasma process without the use of expensive and scarce gases (air + 5% methane or propane-butane) and at the same time provides the ability to apply high-quality coatings from various refractory metals (W, Nb, Ta) and alloys based on them, oxide ceramics and oxygen-free ceramics (ZrO_2-Y_2O_3, Cr_2O_3, WC, TaB_2, $TaSi_2$, $MoSi_2$), and multilayer cermet coatings with a combination of properties characteristic of both metals and ceramics.

The supersonic speed of the plasma jet leads to an increase in the speed of particles of the sprayed material at the moment of meeting with the base by 3-4 times, to an increase in their kinetic energy by 9-16 times, which leads to a qualitative jump in all service properties of the sprayed coatings (adhesion and cohesive strength, wear resistance) and also provides a minimum porosity (less than 0.5-1%). The process is also distinguished by increased productivity of the spraying - up to 25-50 kg/h and more of the sprayed material for metal coatings and up to 10-18 kg/h for oxide coatings.

Parameters	Values
Plasma forming gas	air + methane, propane-butane (up to 5–10%)
Plasma temperature, K	3500–7000
Plasma jet speed, m/sec	1500–3000
Spray particle speed, m/sec	400–800
Maximum spraying capacity, kg/h	15–50
Electric power, kW	40–180
Spray material utilization rate	up 0.8





Microstructure of powder coatings deposited using supersonic plasma spraying (x 2000): a – metal ceramic mechanical mixture 29%NiCr-Cr_3C_2; b – chromium oxide Cr_2O_3; c – ZrO_2+Y_2O_3

EQUIPMENT FOR ROBOTIC SPOT PLASMA WELDING

ON ASYMMETRIC ALTERNATING CURRENT AND DIRECT CURRENT STRAIGHT POLARITY

Spot welding is performed by a plasma arc on alternating asymmetric current to join materials with a refractory oxide film on the surface (aluminium, magnesium and beryllium alloys) or on direct current of direct polarity to join materials without a refractory oxide film on the surface (low-alloy steels, stainless and high-strength steels, titanium, copper alloys). Spot joints are formed both without and with the use of filler wire feed.

The equipment provides:

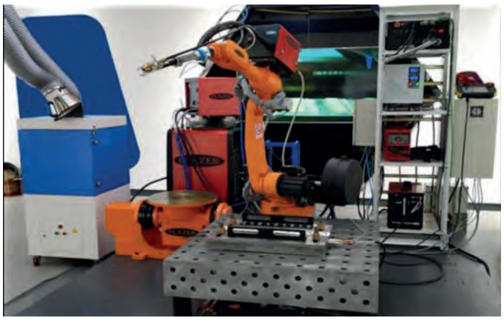
- modulation of the welding current to improve the mixing of the liquid metal of the weld pool from different areas of the parts to be joined
- regulation of the plasma gas supply rate at different stages of the formation of a spot welded joint according to a given algorithm
- application of a special algorithm for feeding the filler wire from the middle of the stage of formation of the weld pool along the thickness of the product.

Advantages of plasma spot welding over traditional resistance spot welding:

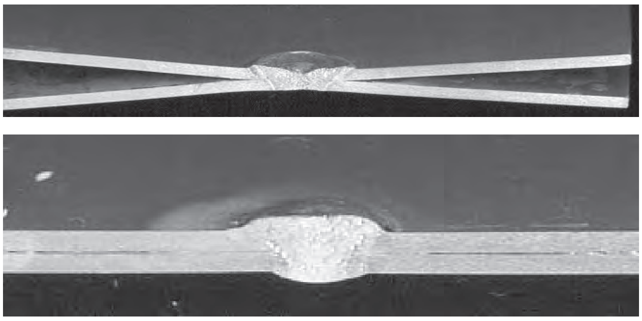
- effective destruction of the oxide film when welding aluminium and other light alloys (higher quality), the quality of welding does not depend on the electrical resistance in the contact between the parts to be joined;
- minimizing the risk of burns-through and damage, improving the structure of the seam when welding thin parts (thickness up to 1.0 mm) from light alloys (alloys of aluminium, magnesium, etc.);
- the possibility of obtaining a point connection in the presence of a gap between the connected parts
- significantly less weight of the welding tool and its greater mobility;
- higher rates of static and cyclic strength of a spot welded joint;
- the possibility of welding in hard-to-reach places (welding is performed only on one side of the product to be welded), including the possibility of welding both internal and external corner surfaces.

The use of this equipment allows:

- to produce lightweight hollow structures (density is lower by 30-60% compared to solid alloys), which consist of several sheets of high-strength aluminium and magnesium alloys with alternating sheets and truss (embossed) intermediate layers;
- welding sheets in a multilayer honeycomb panel with a thickness of 0.5 to 3.0 mm, welding sheets to a thinner corrugated filler, obtaining a honeycomb multilayer panel up to 4 m wide and up to 12 m long;
- to produce lightweight curvilinear panels by bending the first sheet of the panel according to a template, to obtain the required surface shape while ensuring high structural rigidity.



Robotic complex (left) and plasma torch (right) with a pneumatic clamping mechanism for spot plasma welding with direct and alternating asymmetric current of increased frequency



Cross-section of a welded joint of aluminium alloy 5083 (AlMg4.5Mn) 1.0 + 1.0 mm thick, made by spot plasma welding with alternating asymmetric current of increased frequency without (above) and with feeding (below) filler wire

HIGH-SPEED HYBRID LASER-PLASMA WELDING

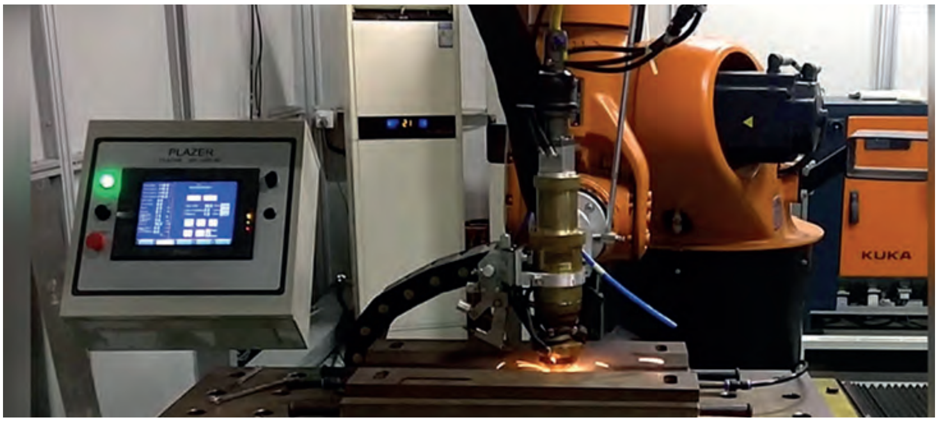
Hybrid laser-plasma welding implements the process of joint action of two heat sources (laser beam and plasma arc) into one weld pool, which increases the efficiency of absorption of laser beam energy by the welded metal. The equipment is designed to produce welded joints from aluminium and magnesium alloys, titanium, nickel and copper and other alloys, as well as low-alloy and alloy steels without and with filler wire feed.

An additional option for welding joints with grooves is the use of one or two heated filler wires. There are two modes of plasma arc generation:

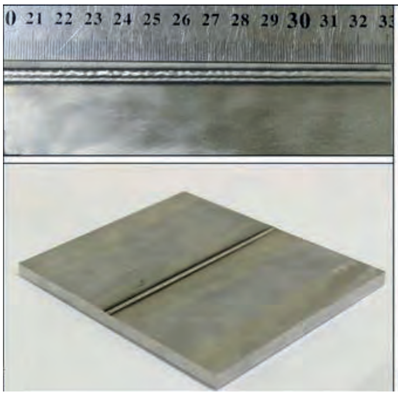
- on direct current with the imposition of high-frequency modulation;
- on alternating asymmetric current of increased frequency (effective destruction of the oxide film is ensured when welding aluminium and magnesium alloys, improving the quality and mechanical properties of welded joints).

The speed of hybrid laser-plasma welding is 30-60% higher compared to laser welding and 2-3 times higher than plasma welding for the same thickness of the parts to be welded. The width of the weld in hybrid laser-plasma welding is 30-50% of the width of the weld obtained by plasma welding, and the penetration depth is 50-70% higher than in laser and plasma welding at the same electrical power consumption. The process of laser-plasma welding, in comparison with the process of laser welding, is less sensitive to gaps in the joint when assembling joints for welding (the presence of a gap of up to 1.0 does not cause defects in the formation of the seam).

Equipment completeness (head for hybrid laser-plasma welding with laser radiation input system; cable-hose package to head; plasma module for operation on direct and alternating asymmetric current; general cabinet of power supply, gas treatment and control systems; mobile control system console with touch panel and PLC controller; feeding and heating system for filler wires; forced autonomous cooling unit).



Technical specifications	
Power, kW: laser radiation / plasma arc	0.2-5.0 / 0.2-10.0
Operating current of the plasma arc, A: direct polarity /alternating asymmetric current	10-320 / 10-320
Plasma arc operating voltage, V: direct polarity / reverse polarity	12-28 / 24-36
Gas flow rates, l/min: plasma-forming (Ar) / protective (Ar; Ar + CO_2)	1.0-10 / 0.4-40
Pressure of working gases at the inlet to the gas treatment system, bar	2 – 4
Filler wire (0.8-1.6 mm diameters) feed rate, m/h	0…420



UNDERWATER WELDING AND CUTTING

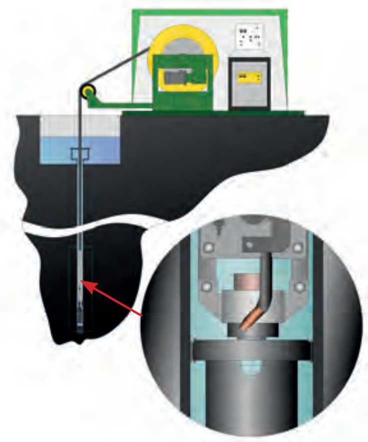
Unique complex for automatic arc welding at great depth

The technology and equipment allows automatic welding of structural elements, which seal from the inside the lower part of heat exchanger column, using a method of wet arc welding with flux-cored wire.

Work originality lies in development of automatic welding machine, which can operate when it is immersed in 119 mm diameter pipe at 200 m depth in liquid heat-carrying agent medium.

> The complex was successfully tested in GDE Company facility, London.

Welding complex can be used in welding, surfacing and cutting of vertical steel product pipelines operating in water medium.

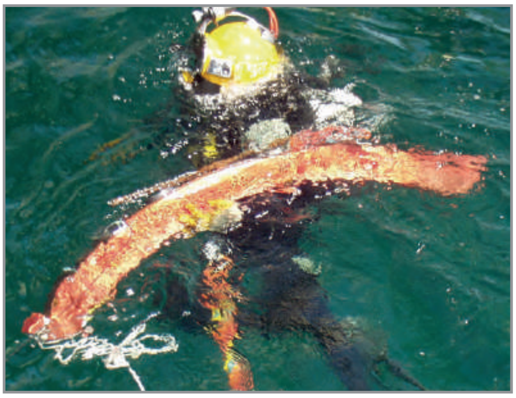


Automatic welding machine at 200 m depth

Explosion cutting under the water at off-shore platform construction

The base platform MSP-7 with welded pontoons

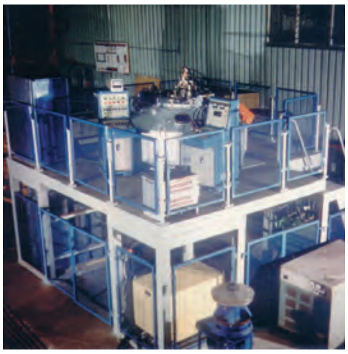
Segmental charge



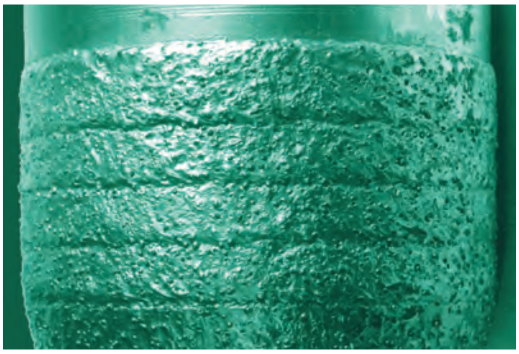
Transportation of segment charge by the diver to the place of its installation

Cutting off the pontoon after rising to the surface

SUPERHARD FUSED
SPHERICAL TUNGSTEN CARBIDES


«Sfera-2500» machine for thermal centrifugal spraying


Appearance of spherical tungsten carbides


Drill pipe tool joint coated with spherical tungsten carbide

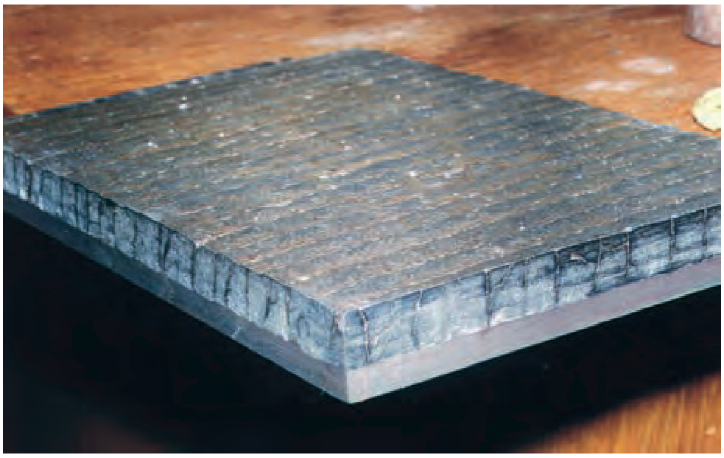
- particle size, mm – 0.15 – 1.10
- hardness, HV_{-01} – > 3000


Characteristic wear of drill bit teeth clad using tungsten carbide

WEAR-RESISTANT
BIMETAL PLATES

- For lining fast-wearing parts of mining, power generation, metallurgical and other equipment.

Chromium carbide-based wear-resistant cladding of plate structures provides 1.5 to 2.5 times increase in their service life for a wide range of parts and hardware.



Base plate 2600×1400 mm – St.37-2
Deposited layer 2500×1250 mm

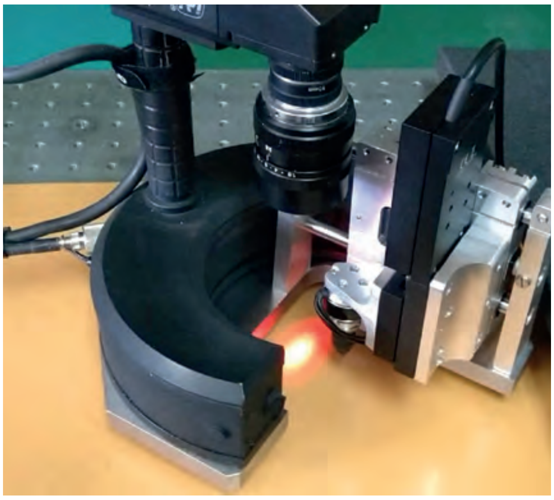
Plate thickness:

- base metal + deposited layer
  5+3, 5+5, 8+5, 10+10, 12+12, 12+17 mm

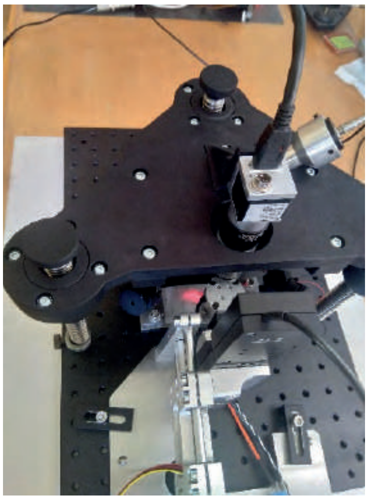
Hoppers, conveyers, chutes, cyclones, smoke exhausters, pipelines, screens, dump truck bodies and other parts and structures subjected to abrasive wear are manufactured from wear-resistant bimetal plates.

ESPI-HD SYSTEM

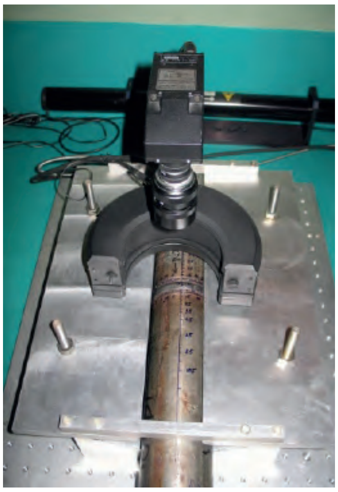
The ESPI-HD method for residual stresses measurement is based on the hole-drilling method (standard ASTM E837). The application of optical whole-field interferometry method (electronic speckle-interferometry – ESPI) for determining residual stresses allows to gather more information about the stress state of an object compared to the data from resistance strain gauges. Such advantage is achieved by calculating a significantly larger amount of displacement values induced by the hole-drilling. The ESPI-HD method additionally enables automated data analysis and selection of predefined areas with displacements in the vicinity of the drilled hole.

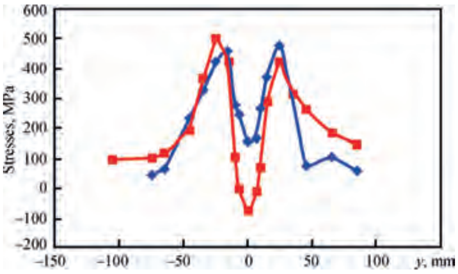


Speckle-interferometers with a precision automatic hole-drilling device

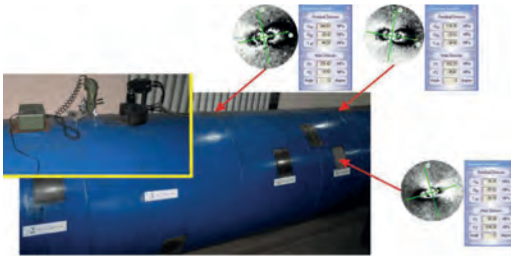


Examples of application of the ESPI-HD system



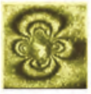


Welded tube (76 mm diameter) and residual stresses versus distance from the weld center line

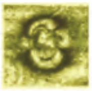


Determination of residual stresses in welded joints of gas and oil pipeline

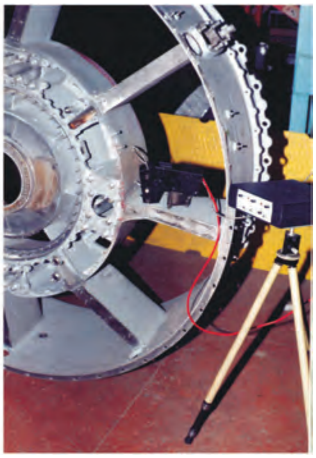
σ_{max}= 120 MPa



σ_{max}= 100 MPa



σ_{max}= 45 MPa

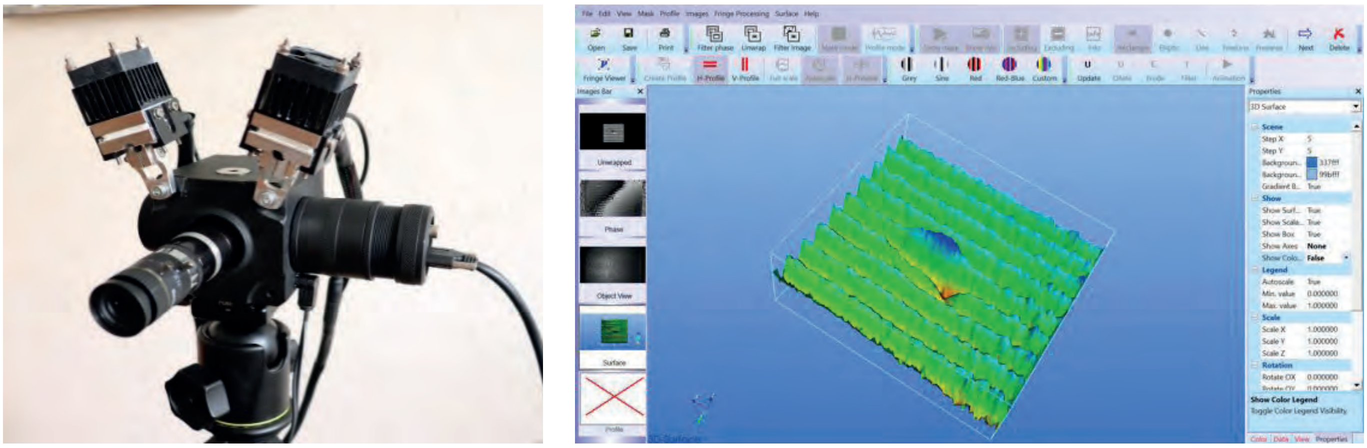


Determination of residual stresses in an aircraft engine framework after repair welding

ELECTRON SHEAROGRAPHY

METHOD FOR NON-DESTRUCTIVE TESTING

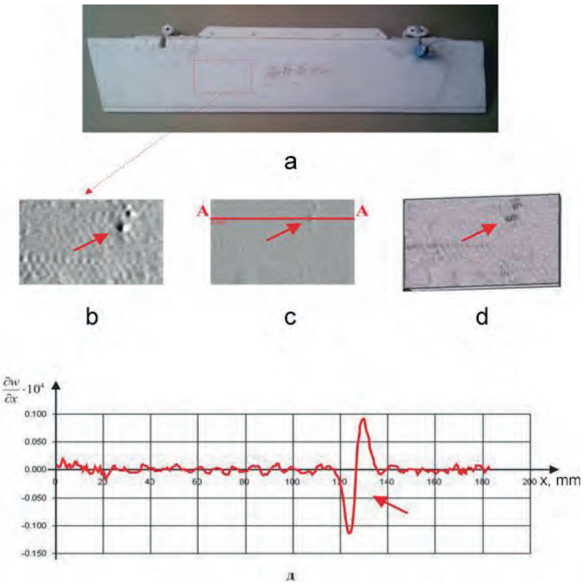
Portable low-weight shearography interferometers and software for nondestructive testing of composite and metallic structures have been designed at PWI.



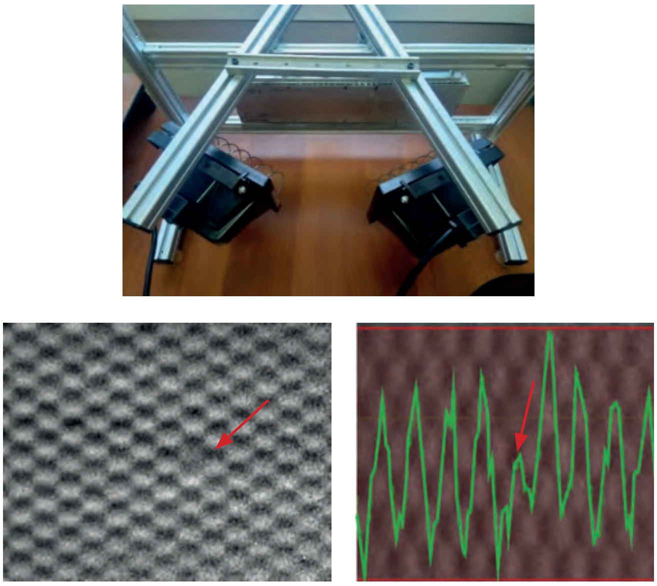
Shearographic interferometer with two laser modules and Fringe Editor for shearography software

Full-field and non-contact shearography measurements of surface deformation allow revealing different types of defects (lack of penetration, cracks, lack of adhesion, and other imperfections of materials). Due to optical differentiation, the shearographic system can be used in real time mode not only in the laboratory, but also in industrial conditions.

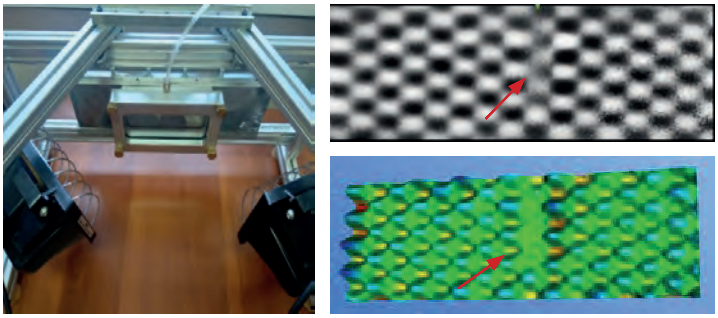
Examples of NDT using the shearography method



NDT of aircraft element under thermal loading



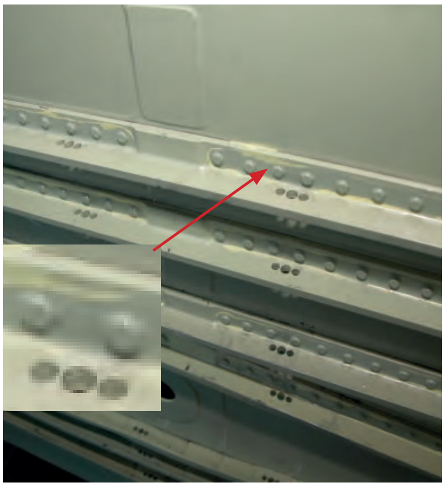
NDT of Al honeycomb panel under thermal loading



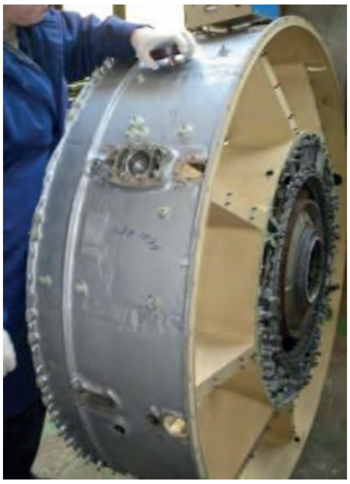
NDT of Ti honeycomb panel under vacuum loading

METHOD OF ELECTRODYNAMIC TREATMENT (EDT) TO
CONTROL THE STRESS-STRAIN STATES OF WELDED JOINTS

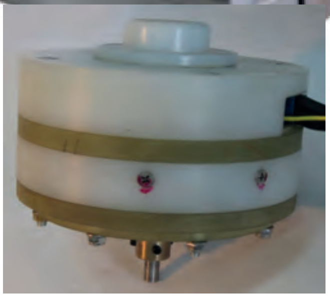
Pulsed current sources



EDT of aircraft wing panel

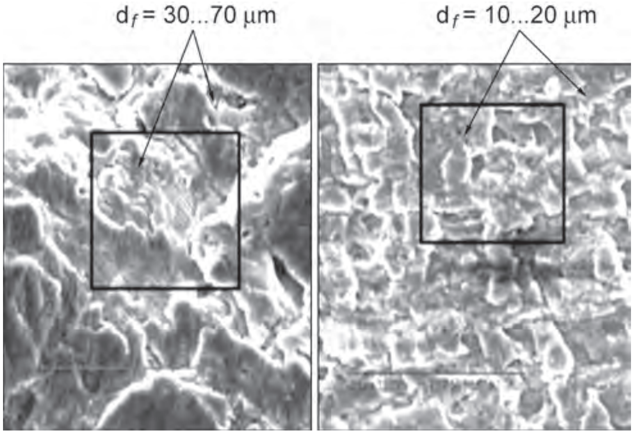


EDT of aircraft engine case from ML10 magnesium alloy



Electrode assembly

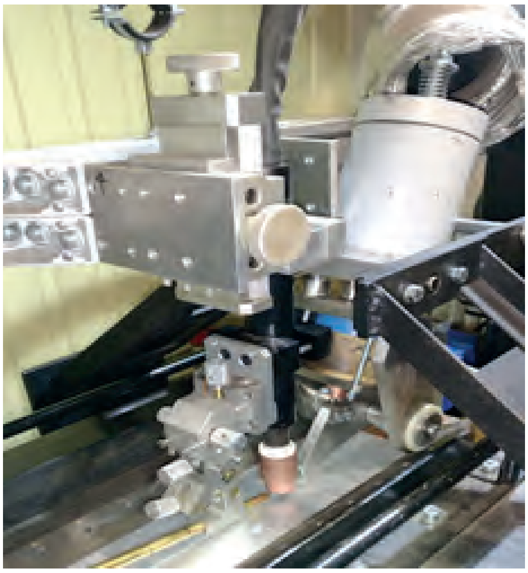
Fracture surfaces of AMg6 alloy after low-cycle loading, where d_f is the facet size



without EDT

after EDT

EDT during welding



EDT of shipbuilding structures from AMg6 and 1561 aluminium alloys

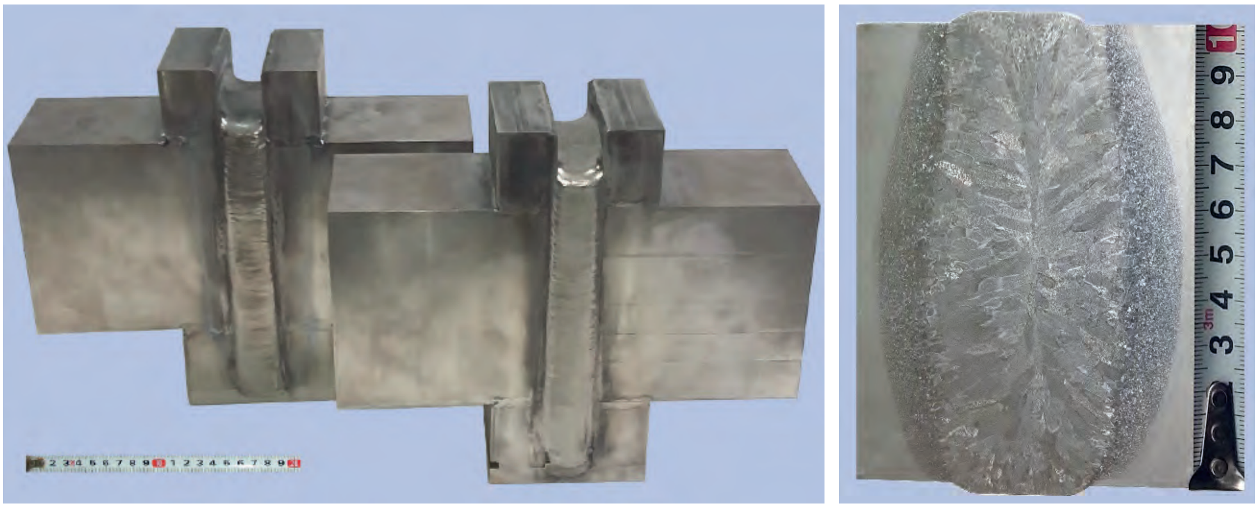
Hand tool

ELECTROSLAG WELDING
OF ULTRA-THICK TITANIUM PARTS

PWI has developed technology for electroslag welding (ESW) of ultra-thick parts made from titanium alloys. ESW makes it possible to joint parts with a wall thickness from 40 to 400 mm when performing butt, corner and T-joints.

The technology provides the following advantages: the ability to weld ultra-thick products by one pass without processing of edges; high welding productivity; dense structure of the weld metal without pores, inclusions, lacks of fusion and other defects; no evaporation of alloying components during welding; no angular deformations. The process does not require the use of bulky and expensive vacuum chambers.

ESW can be successfully applied for the enlargement of Ti ingots and slabs, for welding power titanium elements of marine and aviation equipment, tanks and pressure vessels for the chemical industry, reactor vessels, etc.



View and structure of Ti-6-4 alloy welded joint

SUPER LARGE PROFILED SINGLE CRYSTALS OF
TUNGSTEN AND MOLYBDENUM

PWI grows and delivers tungsten and molybdenum single crystals in the form of 20 x 160 x 170 mm size plates. Crystallographic orientation is determined by Customer. Size of crystals can be increased to 20 x 250 x 300 mm.

WELDING OF LIVE TISSUES

High-frequency live tissue welding (HF LTW) process developed at PWI in close cooperation with leading medical organizations of Ukraine demonstrated its effectiveness and has been successfully applied in surgical practice starting from 2002. During this time over 150 various surgical procedures have been mastered and more than two hundred thousand surgical operations have been successfully performed in such fields as general and abdominal surgery, traumatology, pulmonology, proctology, urology, mammalogy, otolaryngology, gynecology, ophthalmology, etc. This method is highly promising for the transplantation of various organs as well.

As it is confirmed by numerous reports of leading surgeons and noted several times at various seminars and conferences, HF LTW method ensures:

- bloodless, fast, convenient for surgeon and low-traumatic for patient performance of operative intervention, reliable hemostasis;
- reduction of blood loss by 50% and more;
- shortening of surgery duration by 20 – 50%;
- high ablasticity of surgery performance;
- absence of suppurations;
- fast and complete postoperative rehabilitation;
- possibility of surgical treatment of patients, who were regarded as inoperable.

Respective equipment and instruments are the practical basis for HF LTW process realization. Starting from the first apparatuses created as far back as in the middle of the 90ties of the previous century, PWI developed a whole range of apparatuses supporting this process. The area of distribution of apparatuses (over 200 pieces of apparatuses of various modifications) covers many regions of Ukraine as well as such countries as the, Bulgaria and China.

All-purpose apparatus EKVZ-300 PATONMED®
for live tissue welding

TECHNOLOGY AND EQUIPMENT FOR HEATED TOOL
BUTT WELDING OF THE POLYMER PIPES

> Innovative technology and equipment allow heated tool butt welding in the semi-automatic mode, without preliminary mechanical treatment of pipes edges, and forming joints without internal rag.

Welding of pipeline at industrial plant

Conventional technology

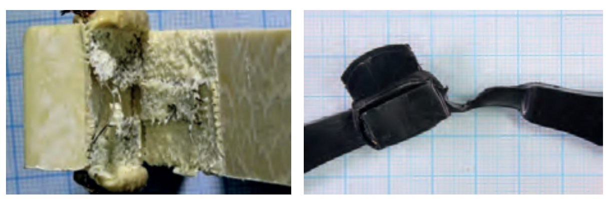
Innovative technology

Test result of the innovative welds

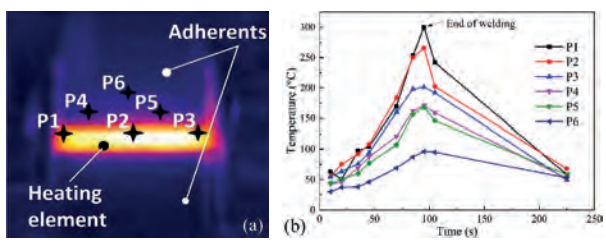
TECHNOLOGY AND MATERIALS FOR
RESISTANCE WELDING OF PLASTIC UNITS
WITH COMPLEX GEOMETRY

> The technology is devoted to increasing the operational strength of welded joints by using heating elements based on metal mesh with modified surface and electrically conductive polymer composite, as well as specific parameters of the welding mode. The embedded elements can be also used as lifetime sensors for real time monitoring of the welded joints.

Specimen of a T-welded joint with complex geometrical surface



High-quality welded joints made with metal mesh with modified surface and polymer composite as an embedded element



Resistance welding with embedded element based on polymer composite

MEDICAL IMMOBILIZING INFLATABLE PLASTIC SPLINTS (IIS)

> Application area for IIS – temporary immobilizing of damaged parts of human body for transportation of the wounded man from the place of accident to the medical facility.

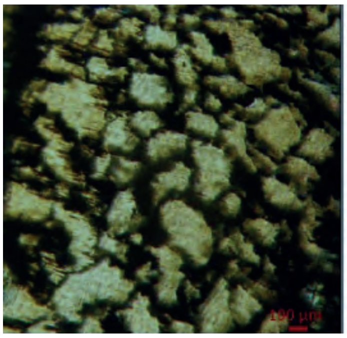
Laboratory tests have been performed on the Traumatology and Orthopedics Cathedra of the National Medical University named after A.A. Bohomolets. Field tests have been carried out in the Training Center of the Armed Forces of Ukraine.

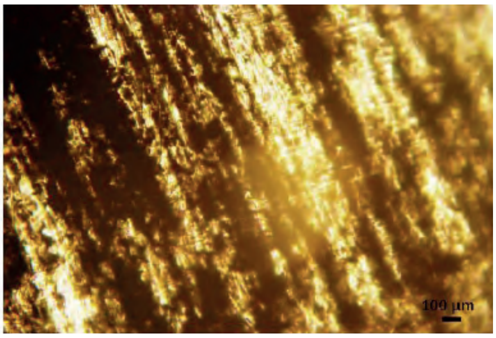
IIS approbation has been performed in accordance to the Special Program «Military Medicine» on the platform of VI International Medical Forum «Innovation in Medicine – Health of Nation» with the participation of prominent specialists in military medicine.

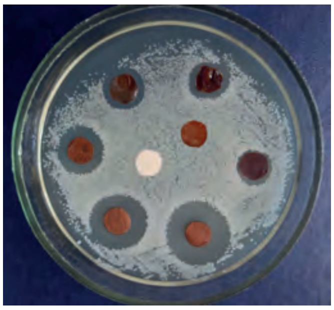
TECHNOLOGY AND MATERIALS FOR

ADDITIVE MANUFACTURING OF THE FUNCTIONAL PLASTIC PRODUCTS

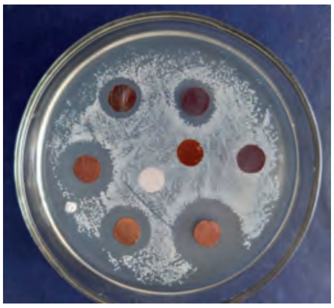
> The developed FDM 3D printing technological modes allow forming plastic products with predicted operational properties. Polymer composites developed for the FDM 3D printing allow forming plastic products with functional properties. Polymer composites with a structured electroconductive microphase and filaments on their base allow FDM 3D printing of electroconductive plastic products. Polymer composites with a statistically formed Ag+ nanophase and filaments on their base allow FDM 3D printing plastic products with antimicrobial properties.







Escherichia coli



Staphylococcus aureus

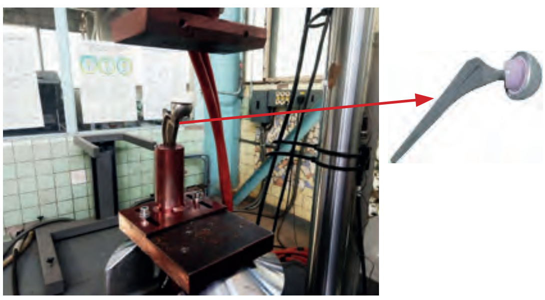
STRENGTH AND FATIGUE LIFE

TESTING LABORATORY (ISO/IEC 17025)

Testing Laboratory of the Institute is accredited according to ISO/IEC 17025 in the following areas: determination of chemical composition and corrosion resistance of metals and alloys; testing of metals, alloys, steels, cast irons, rolled steel, semi-finished products, welded joints, pressure vessels, steel pipes, parts of pipelines and fittings.

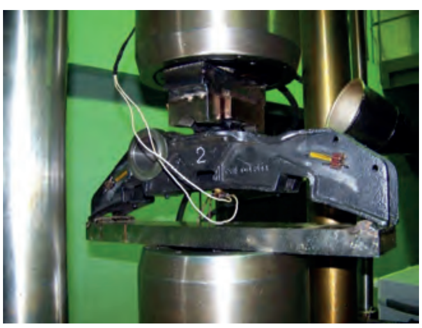
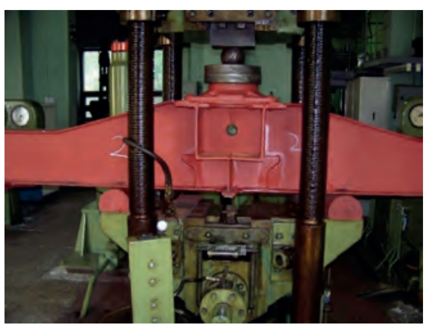


- microstructural and fracture surface analysis of materials and welds;
- chemical composition measurements (optical emission spectroscopy, EDS, etc.);
- low and high-temperature mechanical testing, including testing in corrosive environments;
- fatigue life of structures and welded joints at constant and variable amplitude loading;
- post weld treatment methods development to increase fatigue life;
- development of fracture mechanics criteria of welded joints;
- fracture toughness and fatigue crack growth evaluation of welded joints.




Laboratory conducts the following research work:

- quality evaluation of materials (welding consumables, steels and alloys, polymers) and products (rolled products, pipes, fittings, wire, screws, cast and welded structural elements), their compliance with certificates and standards;
- examination of cases of delivery of low-quality materials and products;
- investigation of accidents and predicting their probability during service life of welds, cast products and structures, caused by violation in the technology of their manufacture and abnormal operation.
- fatigue life assessment of structures and welded elements, and extension of their service life.

CENTER FOR
PHYSICO-CHEMICAL INVESTIGATIONS OF MATERIALS

> The Center is fitted with a unique complex of analytical and research equipment of leading Japanese, US, and West European companies, which includes: metallographic laboratory; electron microscopy laboratory; laboratory of X-ray spectral and X-ray structural analysis, and Auger spectroscopy; thermal analysis laboratory; spectral analysis laboratory; gas analysis laboratory; chemical laboratory.

The Center performs comprehensive investigations of the structure and properties of different materials produced by the current technologies of melting, welding, and brazing and by additive manufacturing technologies.

ICP – ICAP 6500 DUO spectrometer (Thermo Fisher Scientific, USA). Emission spectrometer for analytical studies of atomic composition of inorganic materials

SPECTROVAC-1000 DV-4 (BAIRD, the Netherlands). Optical emission spectrometer for analysis of chemical composition of alloys on iron, nickel, aluminium, copper and other element base

GLEEBLE-3800 (DSI, USA). System for modeling the thermodeformational state of metals

JAMP-9500F (JEOL, Japan). Auger microprobe for analysis of elements from beryllium to uranium

JSM-840 (JEOL, Japan). Scanning electron microscope for studying the structure and topography of the surface

Gas analyzer TC-436 (LECO, USA)

Equipment for crucibleless (levitation) melting

JEM-200CX (JEOL, Japan). Transmission electron microscope for fine structure and phase composition studies

SEM – 515 (Philips, the Netherlands). Scanning electron microscope for phase analysis of the surfaces

PATON INTERNATIONAL

Plant of welding equipment

PATON INTERNATIONAL, LLC is one of the leading Ukrainian manufacturers of welding equipment and materials, and it also occupies a leading position among manufacturers in this area in the different countries of the world.

Today the company produces more than 30 models of welding equipment, in such areas as:

- Inverter welding rectifiers (from 150 A to 630 A);
- Semiautomatic welding machines (from 160 A to 630 A);
- Argon arc inverters (from 200 A to 315 A);
- Air-plasma cutting devices (from 40 to 100 A);
- Multifunctional digital inverters (from 250 A to 350 A).

The company has its own design and technological base and production facilities, fitted with high-quality equipment for development and production of new samples of welding equipment and materials, which have no analogs in Ukraine.

Thanks to more than 60 years of experience in production, a wide range of welding equipment and materials of the highest quality, PATON™ products meet the needs of welding professionals, both in Ukraine and in more than 30 countries all over the world.

SCIENTIFIC & TECHNICAL COMPLEX
«E.O. PATON ELECTRIC WELDING INSTITUTE»

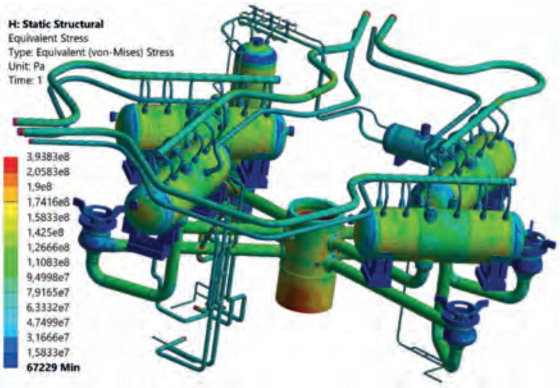
- STC «vb vbE.O. Paton Electric Welding Institute» works in various areas of industry (such as machinery/engineering, shipbuilding, trunk pipelines, nuclear power plants, etc.) with structures that are operating under difficult conditions (that includes variable amplitude loading, very high and low temperatures, different aggressive environments).

STC has comprehensive solutions to problems related to:

- design and modelling of various constructions;
- integrity and strength analysis;
- non-destructive testing, microstructure analysis, mechanical testing;
- risk analysis and incidents investigation;
- modeling of thermohydraulic processes;
- repair and coating of elements and structures;
- improving fatigue life of welded joints;
- extension of service life of current equipment.

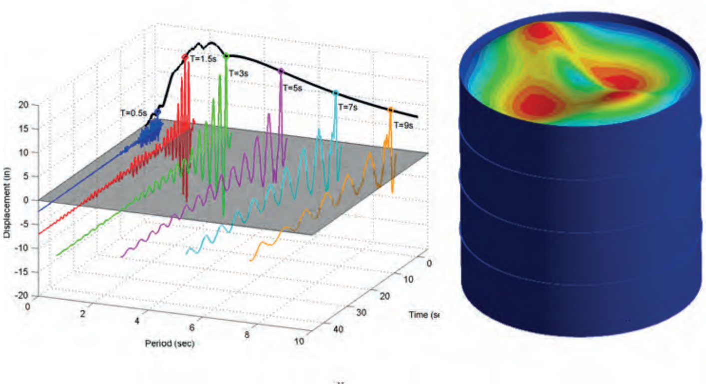
In the process of preventive repairs of heat and power equipment of power units of nuclear power plants, STC has extensive experience in:

- coordination of repair technologies of welded joints of pipelines, shut-off valves, heat and power equipment;
- choice and combination of welding and surfacing materials, welding methods;
- materials science questions of the properties of welded joints;
- possibility to replace welding materials;
- determination of volumes and methods of non-destructive testing of welded joints;
- preliminary and local or bulk final heat treatment of welded joints and structures.

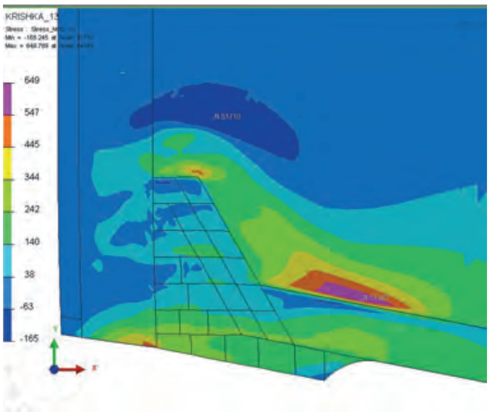


Stress-strain state of the equipment model of the primary circuit of the VP Rivne NPP


Ultrasonic testing of wind turbine hub



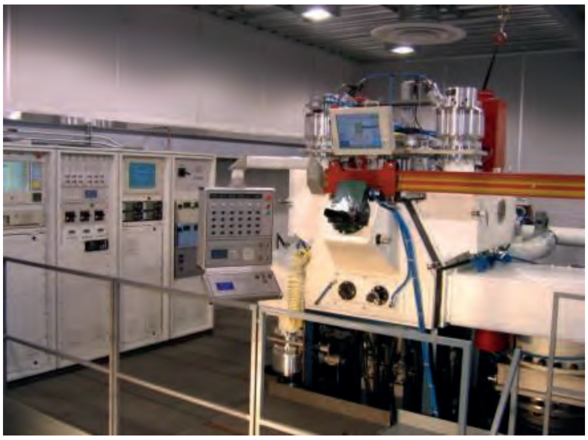
Variants of the seismic response of the liquid-filled tank


Finite element modeling of the stress-strain state during multi-pass welding of the PCS tube to the reactor vessel cover

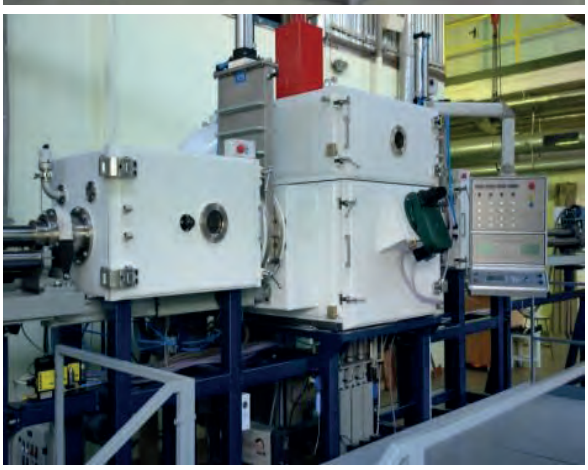
INTERNATIONAL CENTER FOR ELECTRON BEAM TECHNOLOGIES OF PWI

Electron Beam – Physical Vapor Deposition (EB-PVD) Technologies and Equipment

- technology for high-rate electron beam evaporation of metals and alloys, using an intermediate «hot» pool of refractory metals;
- technologies for deposition of functional multilayers and graded protective coatings (oxidation-resistant, corrosion-resistant, thermal barrier, erosion-resistant and damping) for GTE components;
- design, manufacture and «turn-key» delivery of EB-PVD units (UE-204, UE-207S, UE-210 and UE-211 types), in keeping with customer specification;
- training customer specialists to operate the EB-PVD units.








PRODUCTION OF TITANIUM ALLOY INGOTS

«TITAN» CENTRE

At present, industrial production of titanium alloy ingots by the method of electron beam cold-hearth melting (EBM) is organized in the facility of SE «SPC «Titan» of E.O. Paton Electric Welding Institute of the NAS of Ukraine» with equipment providing 3000 tons total annual capacity. Company specialists continue work on creation of new titanium-based alloys, develop and manufacture locally-produced equipment and technology of ingots melting based on titanium and other metals by EBM method.


Electron beam unit UE-5812

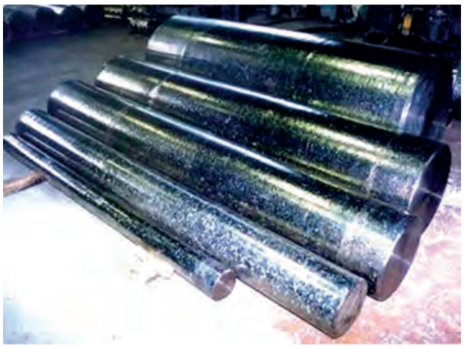

All-purpose electron beam unit UE-5810

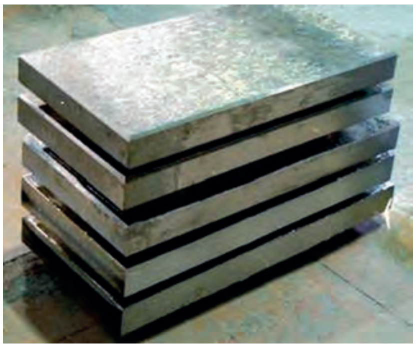
Range of products produced by «Titan» centre:

Size range
Diameter, mm: 110, 150, 200, 300, 400, 500, 600, 830, 1100; of up to 4000 mm length Width and thickness, mm: 165×950, 150×530; of up to 4000 mm length
Grades*
VT1-00, VT1-0, PT1M, 3M, ET3, VT5, PT7M, PT3V, VT6, VT8, VT9, VT3-1, VT14, VT20, VT22, VT23, T110, Grade 1, Grade 2, Grade 5, Grade 9, Grade 12
*Other alloy grades can be produced by agreement with the Customer.

Chemical composition of the ingots meets the requirements of the local and foreign standards DSTU, ASTM, AMS, etc. (ISO 9001 Quality System Certificate).


Titanium ingot of 1100 mm diameter


Titanium ingots of 100–600 mm diameter


Titanium slabs of 165×950×1500 mm

TRAINING AND QUALIFICATION CENTRE

The Training and Qualification Centre provides continuous multidiscipline vocational training of personnel in the field of welding and allied processes aimed at developing and deepening their professional competence. The Centre has accreditation in the national education system and accreditation of the International Institute of Welding for occupational training with awarding of International Welding Qualifications.

Special training, advanced training and certification of welding engineers and technicians in accordance with national and international standards:

- Engineers, technologists and foremen;
- Welding supervisors (coordinators);
- Chairmen and members of welder examination boards.

Advanced training and certification of welding instructors in accordance with national and international standards:

- Teachers of special welding disciplines;
- Fusion welding instructors.

Vocational training, retraining, advanced training and certification of the following personnel in accordance with national and international standards and rules:

- MMA welders;
- MIG/MAG welders;
- FCAW welders;
- TIG welders.

Modern training facilities, innovative training techniques, highly skilled lecturers and instructors ensure that each student receives a designated qualification level.