



EDITORIAL BOARD

Editor-in-Chief

B.E. Paton

Scientists of PWI, Kyiv

S.I. Kuchuk-Yatsenko (*vice-chief ed.*),

V.N. Lipodaev (*vice-chief ed.*),

Yu.S. Borisov, G.M. Grigorenko,

A.T. Zelnichenko, V.V. Knysh,

I.V. Krivtsun, Yu.N. Lankin,

L.M. Lobanov, V.D. Poznyakov,

I.A. Ryabtsev, K.A. Yushchenko

Scientists of Ukrainian Universities

V.V. Dmitrik, NTU «KhPI», Kharkov

V.V. Kvasnitsky, NTUU «KPI», Kyiv

E.P. Chvertko, NTUU «KPI», Kyiv

Foreign Scientists

N.P. Alyoshin

N.E. Bauman MSTU, Moscow, Russia

Guan Qiao

Beijing Aeronautical Institute, China

M. Zinigrad

Ariel University, Israel

V.I. Lysak

Volgograd STU, Russia

Ya. Pilarczyk

Welding Institute, Gliwice, Poland

U. Reisgen

Welding and Joining Institute, Aachen, Germany

G.A. Turichin

St. Petersburg SPU, Russia

Founders

E.O. Paton Electric Welding Institute, NASU

International Association «Welding»

Publisher

International Association «Welding»

Translators

A.A. Fomin, O.S. Kurochko, I.N. Kutianova

Editor

N.G. Khomenko

Electron galley

D.I. Sereda, T.Yu. Snegiryova

Address

E.O. Paton Electric Welding Institute,

International Association «Welding»

11 Kazimir Malevich Str. (former Bozhenko Str.),

03150, Kyiv, Ukraine

Tel.: (38044) 200 60 16, 200 82 77

Fax: (38044) 200 82 77, 200 81 45

E-mail: journal@paton.kiev.ua

www.patonpublishinghouse.com

State Registration Certificate

KV 4790 of 09.01.2001

ISSN 0957-798X

DOI: <http://dx.doi.org/10.15407/tpwj>

Subscriptions

\$348, 12 issues per year,

air postage and packaging included.

Back issues available.

All rights reserved.

This publication and each of the articles contained

herein are protected by copyright.

Permission to reproduce material contained in this journal must be obtained in writing from the Publisher.

CONTENTS

SCIENTIFIC AND TECHNICAL

Ryabtsev I.A., Pereplyotchikov E.F., Bartenev I.A., Gordan G.N., Bogajchuk I.L. and Kapitanchuk L.M. Effect of amplitude and frequency of plasmatron oscillations on chemical and structural inhomogeneity of metal deposited by plasma-powder method 2

Dmitrik V.V., Glushko A.V., Syrenko T.A. and Grigorenko S.G. Peculiarities of welded joints weakening in operating steam pipelines 7

Serebryanik I.P., Atroshenko M.G. Poleshchuk, M.A., Puzrin A.L. and Shevtsov A.V. Properties of steel-copper bimetal produced by brazing in autonomous vacuum 12

Kuskov Yu.M., Biktagirov F.K., Grishchenko T.I. and Evdokimov A.I. Electroslag surfacing of high-chromium cast iron with 110G13I steel 17

INDUSTRIAL

Barvinko A.Yu., Barvinko Yu.P., Yashnik A.N. and Miryanin V.N. Application of leak before break criterion for prevention of avalanche fracture of the wall of vertical welded tanks 20

Kuskov Yu.M. Influence of electric parameters of surfacing with discrete filler in current-supplying mould on speed of slag pool rotation 27

Lobanov L.M., Makhlin N.M., Korotynsky A.E., Vodolazsky V.E. and Buryak V.Yu. Modern hardware-software complexes for training of welders 31

INFORMATION

On the occasion of the 175th birthday anniversary of N.N. Benardos, the inventor of electric arc welding 37

Unique complex for automatic arc welding at large depth 40

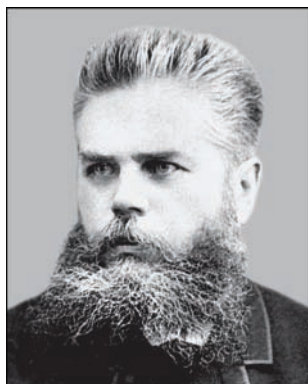
Equipment for electron beam welding 41

Electron beam welding for aircraft industry 42

Electron beam welding for engine repair 43

Laser technology and equipment for manufacture of multilayer bellows 44

ON THE OCCASION OF THE 175th BIRTHDAY ANNIVERSARY OF N.N. BENARDOS, THE INVENTOR OF ELECTRIC ARC WELDING



The life of N.N. Benardos began in village Mostovoye of Kherson province (now Nikolaevsky region), which was called Benardosovka by the name of the inventor grandfather, the general Pantelejmon Benardos.

In the workshops, where Benardos was working in the young years, there were no large heating furnaces. Therefore the inventor tied to heat metal edges by an electric arc before their forging. In this case the metal was fused partially and joined by small areas.

By creating the electric circuit between two electrodes the workmen waited for the appearance of arc, by which the necessary workpiece was heated. One day Benardos during his experiments guessed to transform the workpiece itself into one of electrodes by its including into the closed electric circuit. As a result, the arc began independently to melt the part surface and, thus, the scientist made his the most famous discovery, namely a method of electric welding. N.N. Benardos named his invention as «electrohefest», derived from the name of Hephaestus, the Greek God of war, fire, the patron of blacksmith's handcraft.

The first welds by using a carbon electrode were welded by Benardos in Paris in 1881 and presented at the Paris International Electrical Fair, where the «electrohefest» was recognized as the main exhibit and received a gold medal.

After the thorough testing and improving his method up to the feasibility of industrial application the ten-year Privilege No.11982 was issued to N.N. Benardos by the Department of Trade and Manufacturing of the tsarist Russia on December 31, 1886.

The method, invented by N.N. Benardos, was rather simple. Its principle in the description to the Privilege was presented in the following way: «The subject of invention is pertained to the method of joining and separation of metals by the action of electric current... based on direct formation of an electric arc between the metal treatment place, being one electrode, and another electrode, fed by the handle to this place and connected with a proper pole of electric arc. Using this method the following works can be carried out: joining of parts between each other, separation or cutting the metals into parts, drilling and making holes and cavities and deposition by layers».

In 1885 in Petersburg the first in the world welding company was organized: the Association «Electrohefest» on service and implementation of Benardos's invention. It soon acquired the world recognition. The manufacturers of many countries, who were producing locomotives, boilers, metal structures and other products, came to Petersburg to become familiar with the new technological process. Before the very eyes of specially coming famous German Prof. R.Ruhlman Benardos performed the repair of the factory boiler during 1 hour, which was planned to be repaired during three weeks.

In the middle of the 1890s the new technological process was implemented at the more than 100 factories of West Europe and USA. For example, the French locomotives of Schneider had weak frames, which could not be subjected to the traditional methods of treatment. Only the application of N.N. Benardos's electric welding could solve the problem and allowed the locomotives to pass the record 174000 versts without traces of any damages. Nevertheless, the opponents appeared, pointing out, for example, to a bright and dangerous electric arc light for eyes and skin.

Due to this, the Society «Electrohefest» began at once to apply the various means for protection against the radiation. It should be noted that the model of welder's suit of Shaturskaya sewing workshop was called «Benardos».



Gold medal of all-Russian Electrical Exhibition

N.N. Benardos worked continuously for the «electrofest» improving. At the IV All-Russian Electrical Exhibition, held in Saint-Petersburg in 1892, 30 different inventions of Benardos, formed into a separate exposition, was demonstrated. N.N. Benardos was awarded the highest award of the Exhibition: a gold medal.

On May 1 of the same year N.N. Benardos was awarded the highest award of the Emperor Russian Technical Society: a gold medal «For the successful application of electric arc for brazing of metals and deposition of one metal on another one», and in May, 1893 he was elected its full member.

N.N. Benardos paid a special attention to the improving the quality of welded joints. For this purpose he applied the shielding gases. He attained the weld improved quality by rolling the fused edges by rollers. The inventor offered and tested a great number of electrodes. His drawings of hollow electrodes, filled with a charge of mixture of metallic powders and fluxes, unique designs of disc-type and spiral electrodes are preserved, and the welding with a carbon electrode was named «The Benardos's method».

He developed the methods of arc cutting, underwater welding and cutting, welding in vertical surface. The inventor expressed the idea of welding in a gas jet and under flux. He invented the unique methods of spot and seam resistance welding. The list of his discoveries includes 196 inventions. He received patents in France, Belgium, Great Britain, Austro-Hungary, Sweden, Italy, Germany, USA, Norway, Denmark, Spain, Switzerland, tsarist Russia.

Benardos developed many designs of welding automatic machines, he suggested and realized ideas of mechanization of welding process by the products rotation. His electric arc welding machines amazed by their service life. One of them operated at the Goujon factory above 30 years and was dismantled only in 1931.



Bust of N.N. Benardos, author G.G. Dochkin

The last years of N.N. Benardos's life were rather difficult. In 1898 Benardos moved to Fastov town of Kiev province, because the life in Petersburg was almost beyond his pocket. Nevertheless he patented by the last money the method of preparation of spongy lead for the accumulator plates, and in 1890 he received the privilege for the method of harrows manufacture by the method of stamping from a sheet. In 1899 the Electro-technical University in Petersburg awarded him with a title of the honorary electrical engineer, bringing his invention to the same level with outstanding invention of radio by A.S. Popov.

In spite of the public recognition, he was poor as usual. After the long years of hesitations Benardos dared to ask the Council of Russian Technical Society to grant him a life-time pension. After three years, in September 21, 1905 Benardos died. None of the journals informed officially about his death.

But the electric welding, invented by N.N. Benardos, is undoubtedly the best monument to its inventor. The genius invention of Benardos found its unexpected application in the art. As an example, a sculptural bust of the inventor, created by Grigoriy G. Dochkin, the talented Ukrainian welder, can be presented. It is manufactured by using the titanium argon arc welding without post mechanical treatment.



Academician B.E. Paton presents «Dove of peace» work of G.G. Dochkin to Richard Nixon (PWI, 1994)

The passion of G.G. Dochkin for an art welding began since the time when the young specialist had to weld the separate titanium parts for the space «Lunokhod». By selecting the different welding conditions, he noted such a material property as the change in color depending on temperature and heating duration. These peculiarities astonished Grigoriy and since that moment the small pieces of metal in hands of Dochkin began to transform into various sculptural masterpieces in the form of tiny insects, animals and flowers. By giving these compositions different color and exquisiteness of forms, the specialist with a high level of skill could transform his personal passion into a professional work by developing an own technique of art welding. Among the Dochkin's works, there is a titanium ring-basement with inscriptions «USA» and «USSR». On this basement a woman's hand is arranged, from which a dove of peace is flying up. This masterpiece was given as a gift to Mr. Richard Nixon, the American President, during his visit to the E.O. Paton Electric Welding Institute of the NAS of Ukraine.

Hundreds of millions of tons of the metal structures, from piles and beams up to nuclear reactors and space-ships, are manufactured at the present time by different methods of arc welding. The better achievements of the modern science are put into service of the welding engineering. It is created and developed by the new generations of scientists and inventors, whose memory of gratitude to N.N. Benardos, the inventor of arc welding, will be preserved for ever.

A huge amount of inventions and newest technologies created a sophisticated world, accelerated its progress and allowed the science and technology of many countries to have a thriving development. The inventors quite often become popular. Such names as Nicola Tesla and Tomas Edison, Dmitry Mendeleev and Igor Sikorsky are known to each pupil in any civilized country. However, the another situation is also possible, when the invention of genius is used in the whole world, but his name is little known not only during his lifetime, but undeservedly moved aside to the second plan in history. Moreover, some inventions became so ordinary, that people do not simply pay attention to them, but in spite of this their importance became not less significant.

Information was prepared by «Steel Work» Company

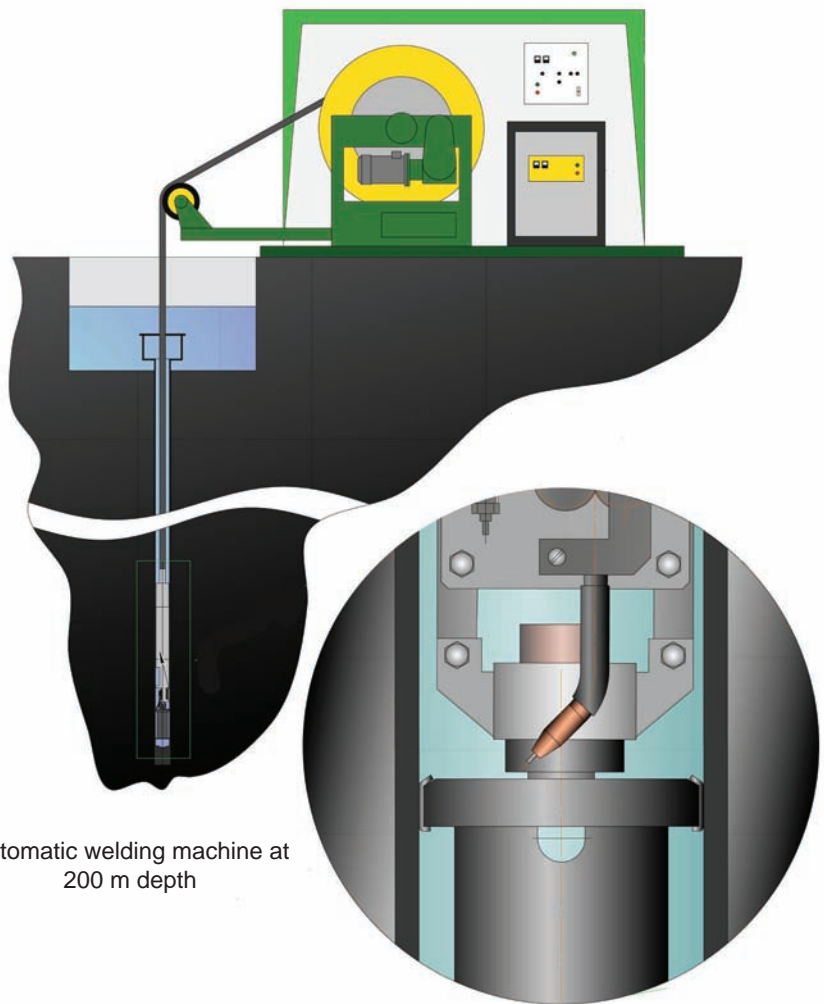
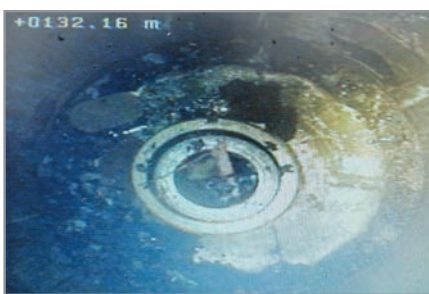
UNIQUE COMPLEX FOR AUTOMATIC ARC WELDING AT LARGE DEPTH

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 on GDE company object, 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

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. Necessity in EBW has expanded with time on nuclear power engineering, instrument making, aircraft-, ship and space machine building.

Covered tasks include:

- > designing 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 SV 112 type

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

Mid-size unit of KL 138 type

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



Large-size unit of KL 118 type

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

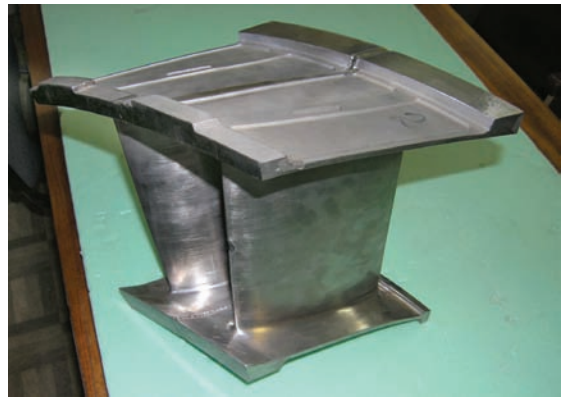
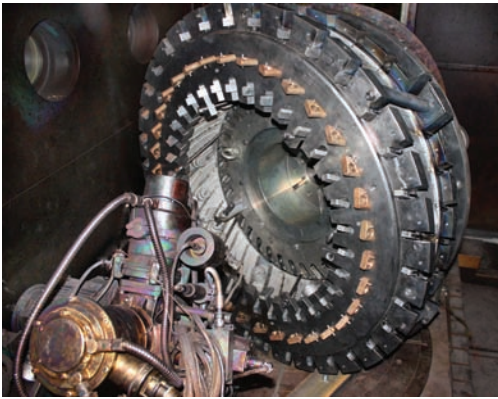
About 100 sets of different EBW equipment, including the units with vacuum chamber volume to 100 m³, have been put into operation for the last 10 years.

Developed by the E.O. Paton Electric Welding Institute of the NAS of Ukraine. E-mail: office@paton.kiev.ua

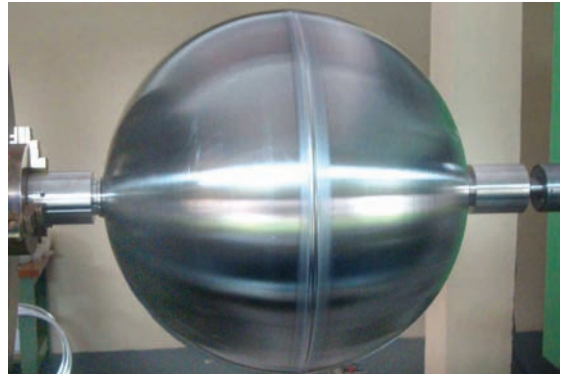
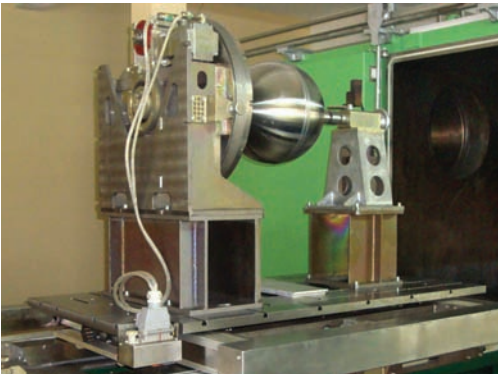
ELECTRON BEAM WELDING

FOR AIRCRAFT INDUSTRY

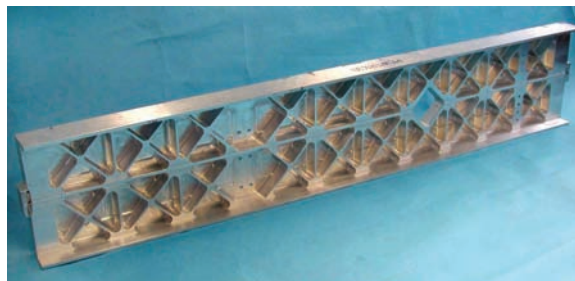
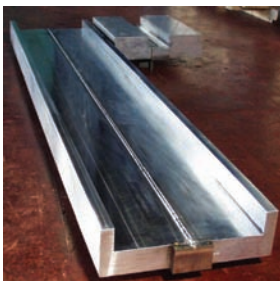
Engines



Hemispheroid Tank



Ti-profiles

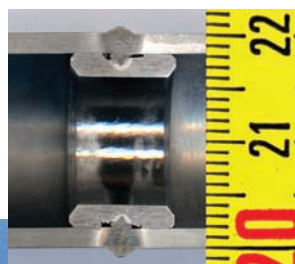
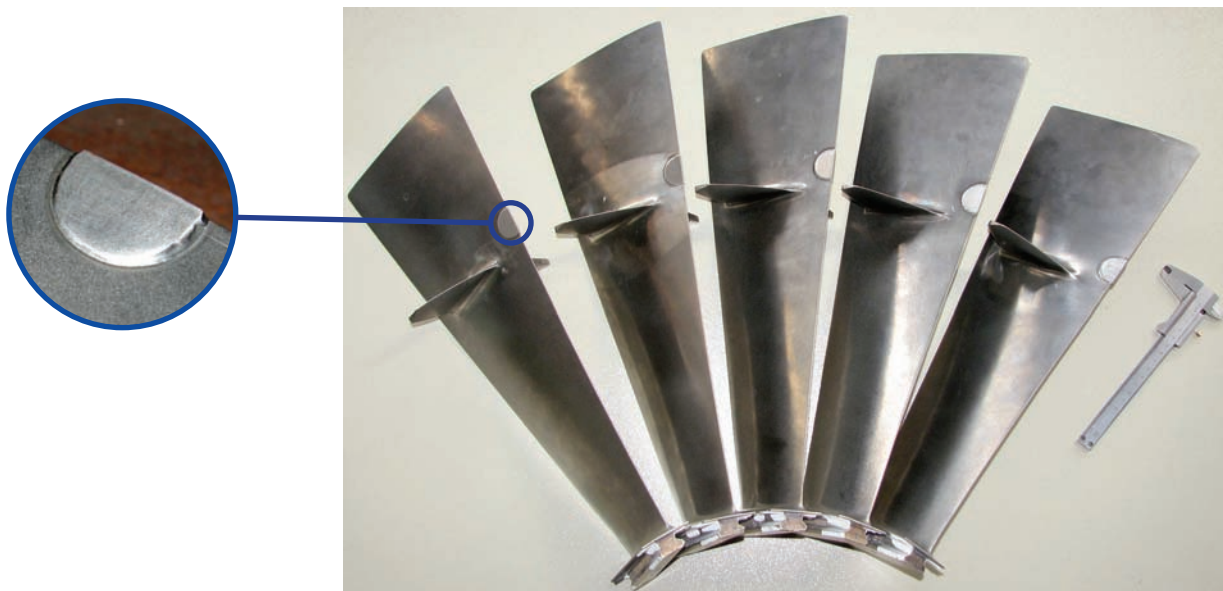


Al-beams of airplane wing

Developed by the E.O. Paton Electric Welding Institute of the NAS of Ukraine. E-mail: office@paton.kiev.ua

ELECTRON BEAM WELDING FOR ENGINE REPAIR

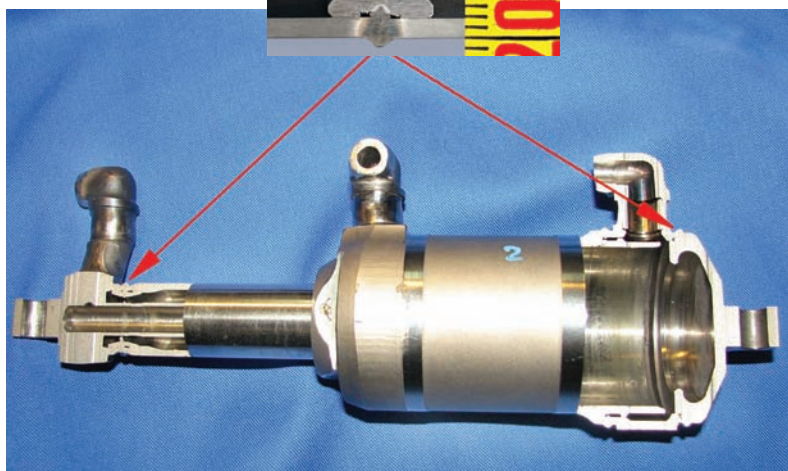
Blades and Vanes Repair



Hydraulic Cylinders Repair



Welded joints



Developed by the E.O. Paton Electric Welding Institute of the NAS of Ukraine. E-mail: office@paton.kiev.ua

LASER TECHNOLOGY AND EQUIPMENT FOR

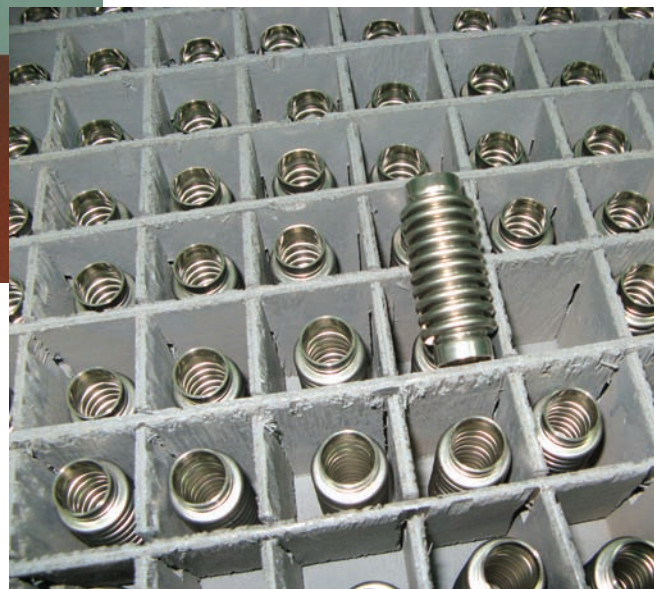
MANUFACTURE OF MULTILAYER BELLOWS

PWI has developed the technology and equipment for laser welding of thin-wall pipes of stainless steel for manufacture of multilayer bellows, which carry and divide liquid and gaseous media, including aggressive ones.

Following the developed technology the bellow consists of several laser-welded thin-wall pipes (from 3 to 10 layers) of 0.15–0.20 mm thickness each. The bellow will keep working capacity in such a multi-layer bellow structure, even if one welded joint breaks in process of operation.

Development advantages:

- > reduced amount of rejects from 50% in argon-arc welding to 0.5 % in laser welding
- > 4 times rise of productivity
- > cyclic strength, corrosion resistance and other characteristics of laser-welded multilayer bellow 1.5–4 times exceed the characteristics of single layer bellow made by argon-arc welding (depending on number of layers and bellow sizes).



Developed by the E.O. Paton Electric Welding Institute of the NAS of Ukraine. E-mail: office@paton.kiev.ua