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MULTIPURPOSE ELECTRON BEAM UNIT UE-5810

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ABSTRACT

In order to implement the electron beam melting technologies the E.O.Paton Electric Welding Institute of NASU developed a multifunctional electron beam unit UE-5810 of megawatt class, designed for producing ingots of titanium and its alloys of up to 20 tons weight. Description of a multipurpose universal electron beam unit UE-5810 and its specification are given. Functional features of the components of the unit, technological fixtures and electron guns are described. Electron beam unit UE-5810 is a reliable highly efficient installation of industrial type for melting highly reactive metals and alloys, as well as treatment of the produced ingots by glazing.

KEYWORDS: electron beam unit, electron beam gun, technological fixtures, melting, glazing, ingot

INTRODUCTION

High requirements to metal product quality, as well as significant achievements in improvement of operational reliability of electron beam equipment and its automation, lead to ever wider application of the technology of electron beam melting (EBM) in metallurgical processing of titanium [1–3]. The predicted total annual industrial capacity of production of ingots of titanium and its alloys exactly by EBM method can exceed 50 thou t per year in the near future [4]. Such a tendency is first of all due to the fact that based on electron beam application as an independent powerful heat source the EBM technology has received a reliable technological implementation in the recent years in the form of modern highly productive and efficient electron beam units designed by such companies as TIMET (USA), TyssenKrupp (Germany), TOHO Titanium (Japan), Panzhihua Steel Titanium Industry Company (China), SC "SPC "Titan" of the E.O. Paton Electric Welding Institute of the NAS of Ukraine", which ensure production of high-quality titanium ingots and lowering of the cost of metallurgical processing of titanium [5, 6].

Therefore, the main tendency in development of equipment for EBM technology realization is creation of large multifunctional electron beam units of megawatt class, designed for melting ingots of more than 10 ton weight.

In Ukraine extensive experience of development of such units has been accumulated [5–8]. Electron beam units of the latest generation allow, due to a rather simple operation of technological fixture replacement, implementing practically all the EBM technological schemes. In 2004 PWI designed, built and put into operation a universal multipurpose industrial electron beam unit UE-5810 with the annual capacity of 1.5 thou t, which has no analogs in the world (Figure 1).

UE-5810 design differs from that of the units earlier developed and operating in the industry of Ukraine by a higher level of technical and economic characteristics [9]. In UE-5810 the mechanisms for raw materials feeding into the melting zone and ingot drawing are made as chain ones. It allows doubling the overall dimensions of the load and ingot chambers, compared to the rod design of the feed mechanisms,

Figure 1. Appearance of electron beam unit UE-5810

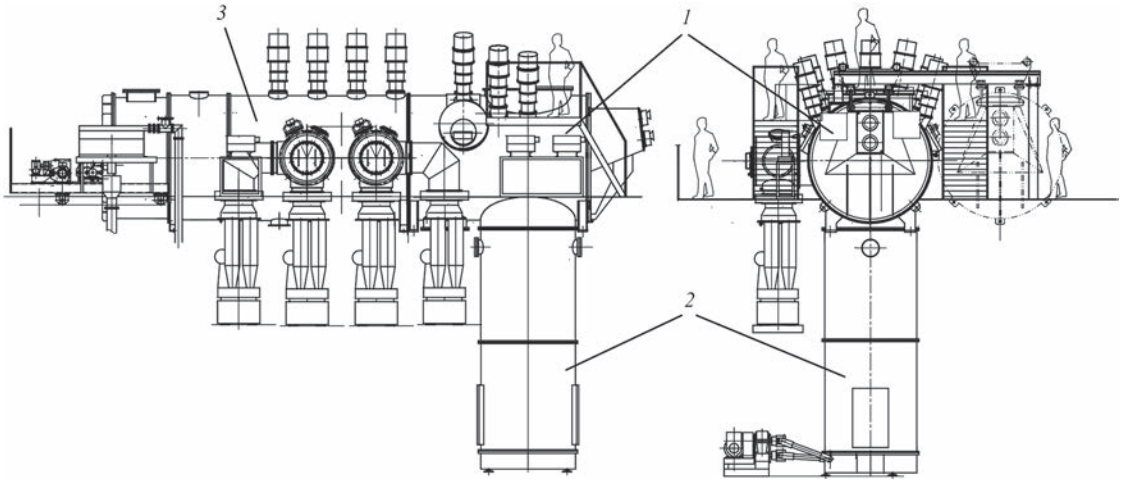

Figure 2. Design of electron beam unit UE-5810: *1* — melting chamber; *2* — drawing chamber; *3* — billet/glazing chamber

significantly reducing the mounting space, and increasing the length of the produced ingots. Moreover, the unit features a high adaptability-to-manufacture, when conducting some melting processes, which is achieved by a simple replacement of one fixture by another one. In particular, it allows melting ingots of a round cross-section from 400 to 1200 mm, rectangular cross-section of the dimensions from 155×950 to 410×1310 mm and up to 4 m length.

The unit traditionally consists of the chambers for melting, ingot drawing and its loading. The load chamber, if required, is transformed into the ingot glazing chamber (Figure 2). All the chambers have forced water cooling.

Main technical characteristics of electron beam unit UE-5810 are as follows:

Installed power, kV·A	5100
Technological power, kW	3700
Accelerating voltage, kV	30
Number of guns, pcs	11
Largest dimensions of the billet, m:	
length	6
cross-section	0.9
Largest dimensions of the ingots, m:	
length	4.0
diameter	1.2
For rectangular cross-section, m	1.3×0.4
Unit overall dimensions, m	27×10×6

Here, considering all the advantages of cold-hearth electron beam melting, in addition to regular titanium scrap, it is possible to use uncrushed titanium sponge blocks (as initial charge), which allows an essential cost reduction for production of titanium ingots of up to 1200 mm diameter. Moreover, UE-5810 design allows combining the processes of melting of the block side surface already at the stage of preheating and melting in one vacuum chamber. Melting of uncrushed sponge titanium blocks of 0.7–5.0 t weight in electron beam unit UE-5810 (Figure 3) allows eliminating from the technological cycle of ingot production not only the stage of consumable electrode compacting for further remelting, but also the operation of block crushing and sponge titanium sorting into lumps of up to 70 mm size; and using low-grade titanium sponge in remelting [10]. This, in its turn, ensures improvement of technical and economic indices by 20 %, compared with EBM of sponge titanium

Figure 3. EBM of sponge titanium blocks; *a* — 4 t sponge titanium block, compared to 0.7 ton block; *b* — EBM of 1100 mm dia. ingot from uncrushed sponge titanium blocks

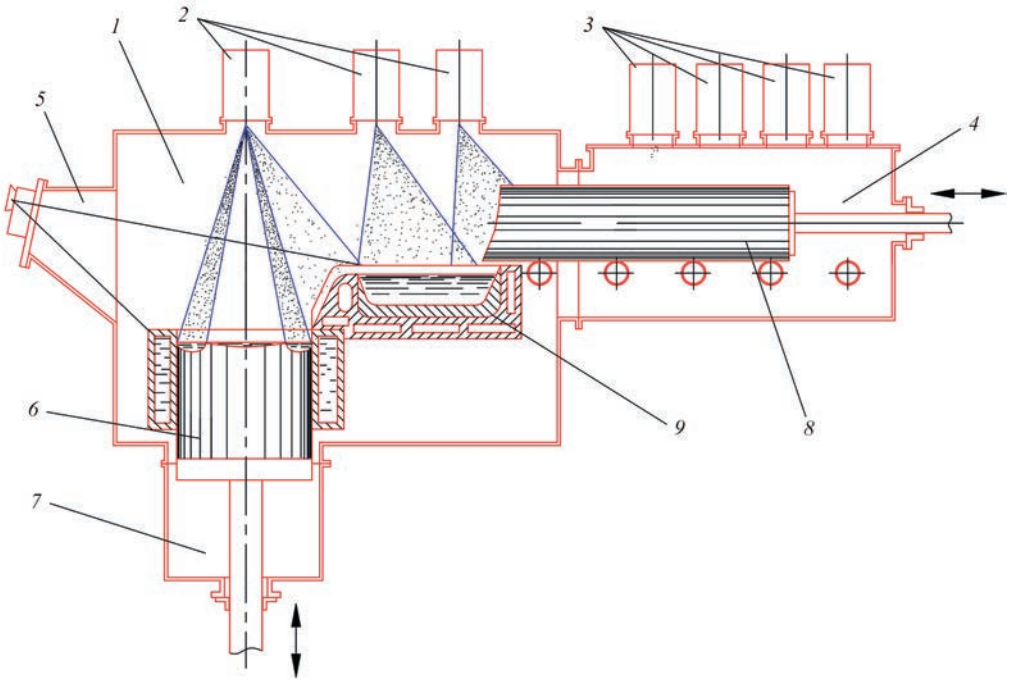

Figure 4. Scheme of UE-5810 unit: *1* — melting chamber; *2* — melting electron beam guns; *3* — glazing electron beam guns; *4* — billet/glazing chamber; *5* — viewing system; *6* — ingot; *7* — ingot chamber; *8* — charge billet; *9* — cold hearth

with 12–70 mm particle size and significantly reduces the costs for production of titanium ingots of up to 1200 mm diameter and up to 4000 mm length from initial raw materials.

Six electron beam guns are installed in the melting chamber to directly conduct the process of producing the ingot, and five electron beam guns are mounted on the billet/glazing chamber for preheating the charge during ingot production or conducting the process of treatment of the ingot surface by its glazing by the electron beams (Figure 4).

Vacuum system consists of three pairs of roughing mechanical pumps of NVZ-300 and 2DVN-1500 type and four booster oil-vapour pumps 2NVBM-630 (Figure 5). Each gun is reinforced by an individual diffusion pump N-160. Vacuum system of UE-5810 unit allows creating rarefaction in the melting chamber space (10^{-2} Pa) and in the guns (10^{-3} Pa), which

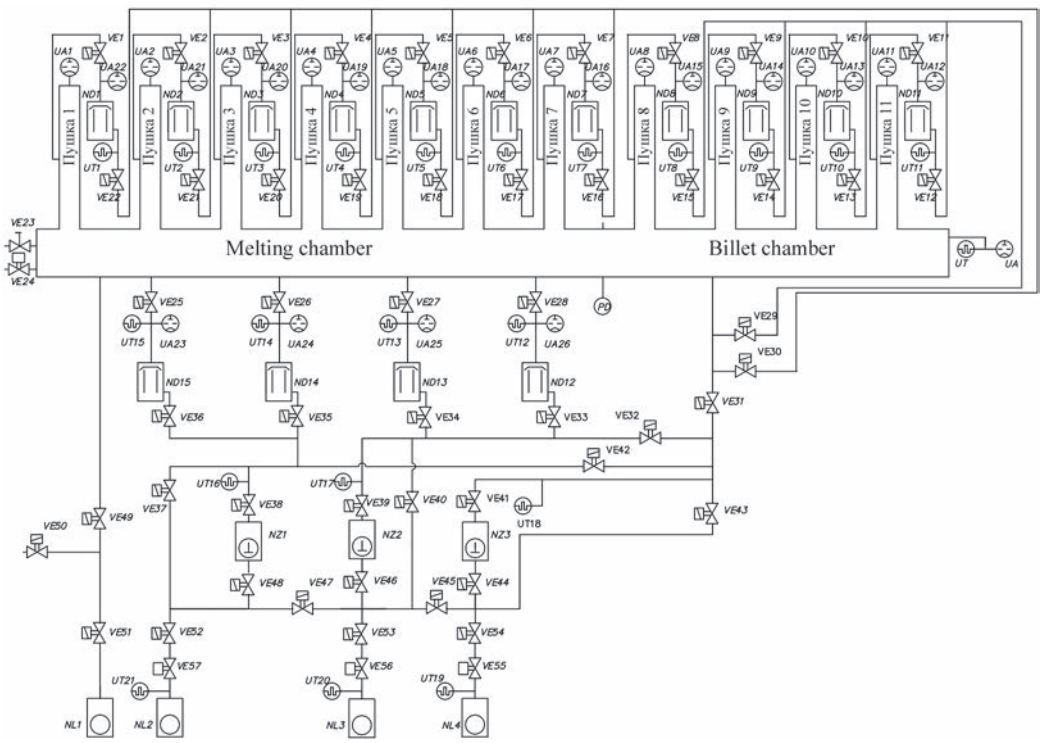

Figure 5. Scheme of vacuum system of electron beam unit UE-5810

ensures trouble-free operation of the guns and the required degree of refining of the metal being remelted during the entire technological process.

UE-5810 unit is fitted with Paton-300 electron beam guns of axial type [1], the total number of which in the unit is 11 pcs (Figure 6).

Specification of Paton-300 gun

Rated power, kW	300
Accelerating voltage, kV	30
Maximum scanning frequency, Hz	1000
Maximal current, A	10
Angle of beam deflection from the gun axis, deg	0–35

Owing to the capability of program scanning with the electron beam over the metal pool surface, the cross-sectional shape of the crucible, and, hence, of the forming ingot, can be different (round, rectangular, square or of some other more complex shape, if required).

During EBM ingot production, their surface can have defects of different casting origin. Traditionally, ingots with such defects are treated by machining, here the amount of wastes in the form of shavings, can be up to 15 %, depending on ingot range. At present the technology of electron beam glazing of the side surface of ingots of a round and rectangular cross-section has been developed and introduced into production [11]. Here, the ingot surface after electron beam glazing is even, defect-free and does not require any further machining [12].

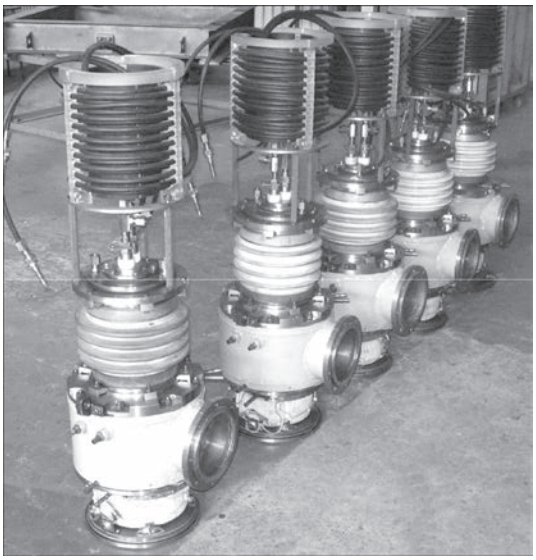

Figure 6. Paton-300 electron beam guns

Therefore, with the purpose of unification of electron beam unit UE-5810 it was designed so as to combine the processes of melting and glazing of the ingot side surface. Here, rotary rolls were mounted in the load chamber, on which the non-consumable box with the charge is directly installed in the ingot production process, or the box is removed and the ingot is loaded onto the rotary rolls for conducting the process of its glazing (Figure 7).

UE-5810 design envisages the possibility of glazing round ingots of up to 1200 mm diameter (Figure 8)

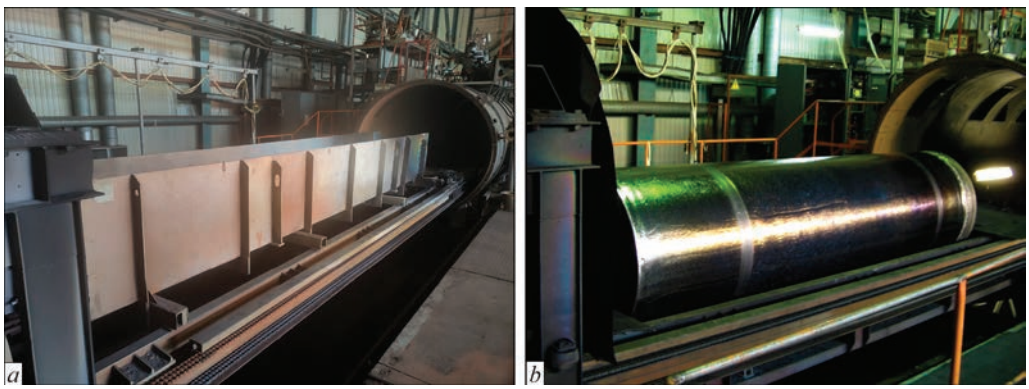

Figure 7. Billet/glazing chamber: *a* — with loaded box with charge for producing the ingot; *b* — with loaded ingot after glazing

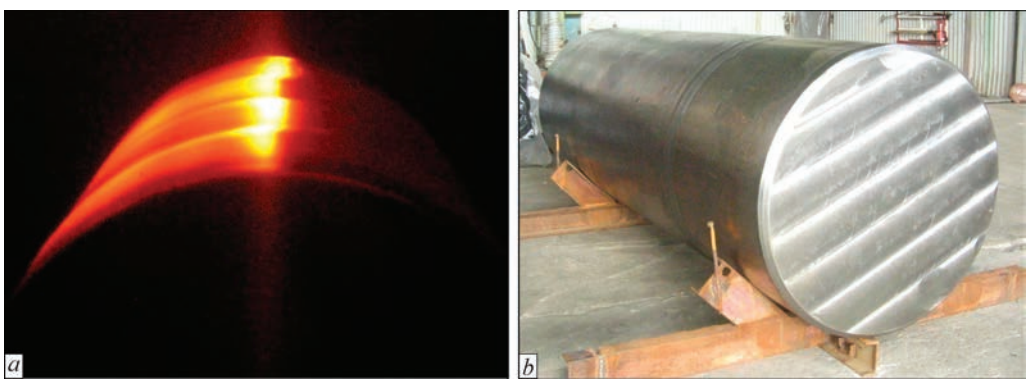

Figure 8. Glazing process (*a*) and glazed ingot of 1100 mm diameter (*b*)

or slab ingots of 410×1310 mm cross-section and up to 4 m length. For realization of this feature, five axial-type electron beam guns are mounted in the upper part of the load chamber. The load chamber proper accommodates the mechanism of ingot rotation for its glazing, which consists of two rotary rolls located in parallel. Four viewing systems are mounted on the load chamber side wall to the right of the operator to allow the technologist to control the glazing process.

During the entire operation period, electron beam unit UE-5810 proved to be a reliable high-efficient installation of industrial type for producing highly reactive metals and alloys, as well as treatment of the produced ingot surface by glazing.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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