SMALL SIZE ELECTRIC ARC MELTING FURNACE

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The paper deals with the creation of the laboratory electric arc furnace working in the gas pressure range of $p = 1.33 \cdot 10^3$ ... $1.50 \cdot 10^5$ Pa and the current range of $I = 50$ ... 600 A.

In the modern experimental metallurgy the big quantity of metals, essentialy distinguishing by the temperature of liquefaction and the vapor elasticity is applied. Efficiency and quality of its melting, in particular when there is manufacturing of the polycomponent alloys, are determined first of all by the good regulability of a heat flow density from the heating source (i. e. the surface source) and the source capability there is working in the wide pressure range of gas medium.

The modern laboratory furnaces, using the arc discharge with a tungsten rod cathode, work about atmospheric pressure of inert gas into smelting chamber. Energy and technological characteristics of such arc are well studied. The distribution of potential in the interelectrode space, characterizing an energy release in different parts of discharge (the column, the cathode and anode regions), has a “blurred” character. Therefore the arc is outwardly a very uniform plasma formation and the smelting effect of the arc isn’t big enough.

The earlier carried out investigations of discharges with tungsten cathodes in the inert gases about low pressures permitted to determine the existence conditions of the arc with the power release (which is easily controlled and distinctly localized in space) in the range of 10^2...10^4 W/cm^3 and its electrical and heat-physical characteristics [1, 2]. The distribution of potential in this discharge has “stepped” character and namely: the big cathode drop (until 20 V for argon) about very small voltages in the column and the anode region. The external appearance of such discharge is shown in Fig. 1 and is characterized by the spherical cathode zone of energy release localization, brightly shining against a background of the arc column. Dimensions of this zone are increasing with a pressure decrease, a current increase and when of the gases with a bigger ionizing potential are used and it can reach several centimetres. The spectrum of the zone consists mainly of the singly charged ion lines and is re-covered by strong continuous X-ray in contrast to spectrum of the column, containing in the main of the neutral lines. Because of comparatively low level of working cathode temperatures (below 3000 K) the tungsten lines are absent in spectrums. It testifies about the purity of plasma that is especially important when there is technological using of the arc. The cathode unit for the discharge realization doesn't require external forced cooling up to current I=600 A [3].

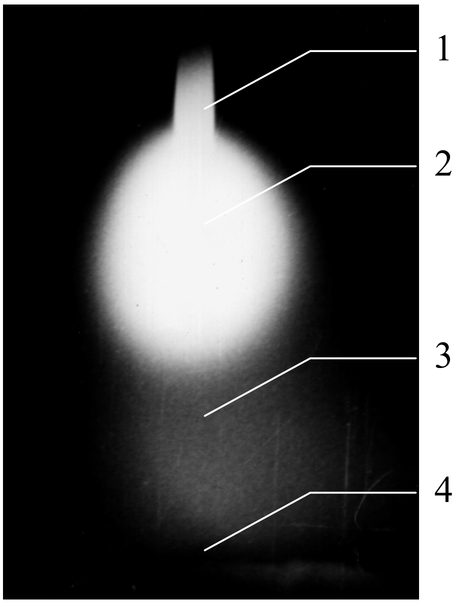

Fig. 1. Arc discharge with a specially formed energy structure: Ar, $p=1{,}33\cdot10^3$ *Pa, I=200 A;* 1 -cathode, 2 - zone of energy localization, 3 - arc column, 4 - anode.

The smelting effect of the low pressure arc (Ar, p= $2{,}66\cdot10^3$ Pa, I= 200 A) when there is a contact of the spherical cathode zone with metal-anode (a interelectrode distance is l_B= 3 mm) is shown in Fig. 2 in comparison with the smelting effect of the atmospheric pressure arc about the same values of I and l_B.

When there isn't a contact of the cathode zone with metal there is a very "soft" regime of heating and it is expedient in a case of the working with fusible metals and of the presintering of powder materials.

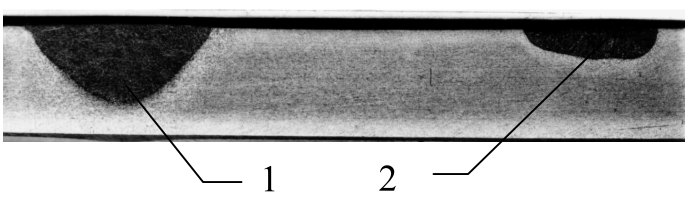

Fig. 2. Macrosections of the stainless steel smelts at equal times of the arc burning with a specially formed (1) and "traditional" (2) release of energy.

Very ample possibilites of this discharge (for example, when there is a contact with the cathode zone even the most refractory metal - tungsten is well smelted) were by precondition for design and creation of the small size electric arc melting furnace with using the present heating supply (see Fig. 3).

Fields of furnace's application are metallurgy of experimental alloys with special properties, precious metal alloys and manufacture of its trade sets for mechanical engineering, instrument-making, aircraft and medical engineering.

The smelting is carried out in copper water-cooled crystallizer (maximum capacity of the melting cell is 120 cm^3) in the wide range of stabilized pressure of inert and recovering gases ($1{,}33 \cdot 10^3 ... 1{,}50 \cdot 10^5$ Pa) (v. Fig. 4). It permits purposefully to realize: refining and degassing of metals; suppression of its vaporability; optimum modes of the smelting of complex alloys; nitriding and surface treatment of the ingots; perspective physic-chemical processes in metallurgy under the active influence of gas medium parameters.

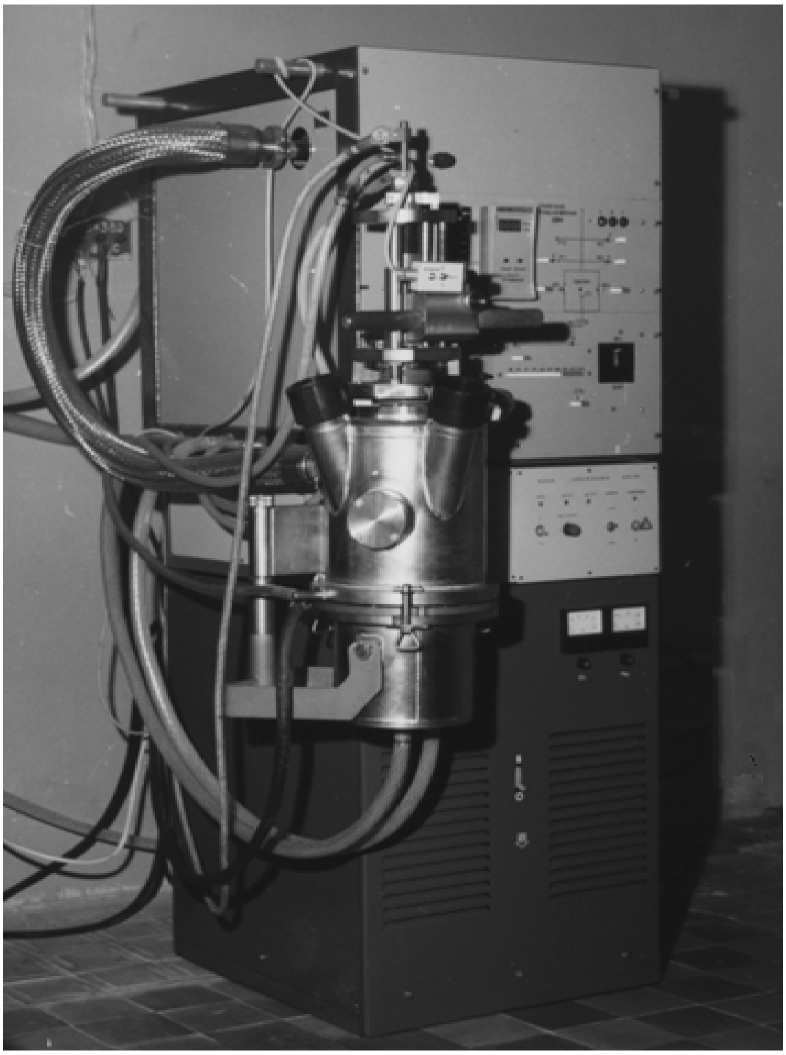

Fig. 3. The small size electric arc melting furnace.

At low pressure ($<1{,}33 \cdot 10^4$ Pa) the smelting is conducted under conditions of a special formed plasma energy structure with the power release density (which is controlled and distinctly localized in space) in range of $10^2 ... 10^4$ W/cm^3. It permits: to change smoothly the amount and density of energy, conducted to a heated metal at the constant discharge current value; to increase essentially the melting effect of the arc; to change over a wide range the plasma contact area with a metal; to carry out the smelting of metal powders (because of the low gas-dynamic effect of the arc); to reduce considerably the inert gas expenditure when metals with low degrees of vaporisation are being smelt; to ensure high service life of the cathode at high discharge currents (500...600 A).

The furnace has a convenient configuration, containing: the automatized vacuum-gas block with control and measurement system; the small size power supply with the block and the panel of arc controlling; the water-cooled smelting chamber with the moving electro-vacuum input of the cathode unit.

In conclusion we note that the furnace has essentially smaller mass-overall characteristics in compared with electric arc plants (which have analogous destination) and the principle merits are may realize the perspective physic-chemical processes [4, 5].

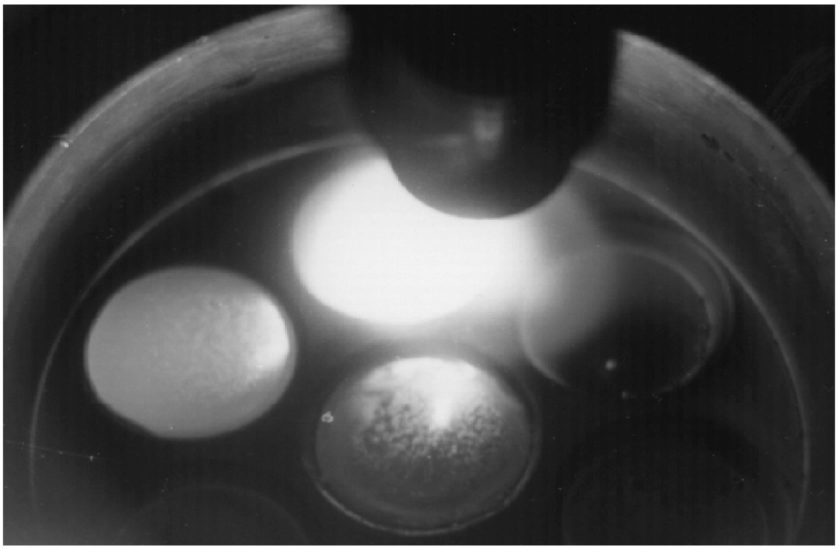

Fig. 4. The obtaining of experimental titanium alloys in the cellular crystallizer.

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