

INVESTIGATION OF THE BEHAVIOR OF MAGNESIUM
IN ARC MELTING OF TITANIUM INGOTS
AT PRESSURES OF UP TO 140 ATM

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Until recently such elements as magnesium, potassium, calcium, lithium have found no practical use in alloying of titanium, because in usual vacuum arc melting it proves impossible to obtain alloys with the above elements. Due to this fact some authors referred these elements to a category of ones failing to interact with titanium.

We assumed that the point was not in the absence of interaction, but first of all, in an intensive vaporization of these elements in the process of melting. Therefore to manufacture alloys with the above elements the melting should be performed at such an inert gas pressure, so as to inhibit the vaporization.

A number of experiments has been carried out to obtain titanium-magnesium ingots by consumable-electrode arc melting at a high pressure (up to 140 atm) in the argon atmosphere.

Electrodes 80 mm in dia. were prepared by pressing a mixture of titanium sponge and magnesium chips or by introducing weighed quantities of magnesium into commercial titanium ingots.

Electrodes were melted in a furnace with a copper water-cooled mould 120 mm in dia. Experiments were performed in a specially designed arc furnace, in which melting could be performed at pressures up to 150 atm. Since the pressure increased during the melting the maximum pressure at the beginning of the mel-

ting was less than 140 atm. The melting parameters were as follows: current - 2.5 kA; voltage 55-60 V; argon pressure 1-140 atm.

The content of magnesium was assumed to be 2.5 and 5.0%. The ingots obtained were cut along the diametric plane, then the magnesium content was determined in the central part of the ingots and near their surface. In some cases for more detail study of magnesium distribution in the ingot bulk the ingots were lathed to take samples in different zones on the side and end-face ingot surfaces. In this case the sample analysis becomes averaged over the whole zone.

The analysis of ingots melted at different pressures shows the growth of magnesium contents in the ingot central zones with increasing the pressure up to 140 atm. (Fig. 1). The maximum magnesium content in the ingots was 0.9%. With the increasing pressure magnesium distribution over the ingot cross section changes (Fig. 2). At low pressures when the intensity of vaporization is especially high the magnesium content through all the cross section is rather low, but as the pressure increases the magnesium concentration rises in the ingot central zone and especially in the peripheral layers. Such a magnesium distribution in the ingots melted at a pressure of 140 atm is similar to the manganese distribution in vacuum-melted titanium alloy ingots, containing 1.5-3.5% of manganese [1, 2], while the manganese distribution in ingots melted at a pressure of 45 atm and lower is similar to chromium distribution in molybdenum ingots (containing 3-5% of chromium) [2]. Therefore as the pressure increases up to 140 atm magnesium concentrates more and more in the ingot peripheral zones at the level of melting zone, and simultaneously its content rises in the melt forming the ingot central zone. In the ingot peripheral zones titanium alloys with magnesium are formed, which contain up to 60% of the latter. The estimates show that for ingots melted at a pressure of 140 atm the magnesium concentration averaged over the cross section is close to the calculated one. Our results show that it is possible to manufacture alloys with the magnesium concentration up to 0.9% at a pressure of 140 atm, although some quantity of magnesium will still be evaporated. The relationships between the pressure and the resultant magnesium

concentration in the bulk of the ingots differ from those established previously [1]. This, obviously, can be explained by the fact that magnesium vaporizes mainly from weight quantities of pure magnesium overheated to the titanium melting point and by rather a significant local overheating of the melt.

The use of alternative charging techniques eliminating the vaporization of pure magnesium will close the gap still farther between the actual and design concentration. This can also be achieved by the repeated melting under the conditions eliminating vaporization.

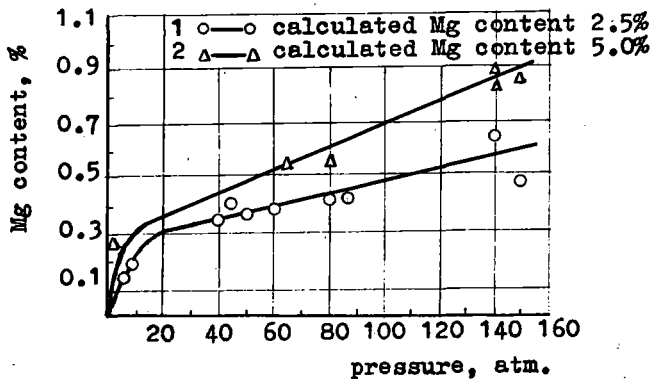


Fig. 1 Mg content (%) in Ti-Mg ingots vs. melting pressure and calculated Mg content.

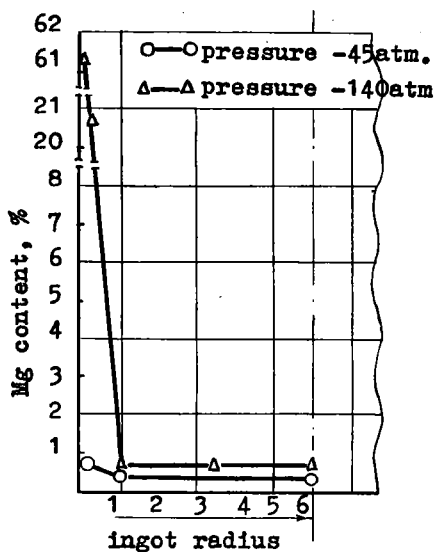


Fig. 2 Mg distribution across the ingot section and on the side surface vs. melting pressure.

References

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2. N. F. Anoshkin. Zonalnaya khimicheskaya neodnorodnost slitzkov (Russ.), Metallurgia, M., 1976.