PRODUCTION OF STICKS OF VT1-0-TYPE ALLOYS BY A RESOURCE-SAVING INGOT-FREE TECHNOLOGY

I. S. Pol’kin, S. M. Golubev, L. A. Snegireva, V. A. Zenin, and V. M. Pavlov

We studied the possibilities of a resource-saving ingot-free technology for the production of sticks of VT1-0 alloy by the method of direct phased deformation of titanium sponge. We developed and examined experimentally several schemes of the basic technological operations: high-temperature degassing of titanium sponge, including determination of its temperature-time parameters, designing and production of accessory for high-temperature vacuum compaction of titanium sponge, trial pressing of a stick from a compact blank on a press (2 MN) with obtaining experimental specimens of sticks ∅ 30 mm, and trial forge-rolling of blanks with obtaining strips of thickness 2.0 mm.

The most widespread technology for the production of titanium semifinished items consists of the manufacture of ingots by the method of vacuum arc melting (VAM) with a consumable electrode [1, 2]. For ensuring the necessary quality of a titanium ingot, one should apply two- to threefold VAM successively. This method is characterized by high energy intensity and technical difficulties.

The industrial application of technologies guaranteeing the economy of energy resources and decrease in labor consumption corresponds to the general direction of perfection of metal working.

In the seventies to eighties, attempts were made to manufacture semifinished items of commercially pure titanium by the method of sponge compaction. However, the developed experimental technologies did not find wide industrial application, and the corresponding investigations were held up after the assimilation of VAM of titanium sponge [1]. The last method has a series of unquestionable advantages as compared with direct pressing (compaction), and the main of them is the possibility to organize full-scale production of ingots of both commercially pure titanium and alloys based on it by means of alloying with different elements. In the present work, we study the possibilities of developing a resource-saving ingot-free technology for the production of semifinished items of VT1-0-type alloys by the method of direct phased deformation of titanium sponge. This will enable one to increase the material yield by 15% in the production of general-purpose semifinished items, to decrease the expenditures for their manufacture, and, hence, to reduce the prime cost of production.

Initial Material

We studied a VT1-0-type alloy, i.e., commercially pure titanium, obtained from sponge of grade TG-110 with a size of fraction of 12 ± 2 mm (Table 1).

We tested the schemes of obtaining a solid compact for subsequent deformation into a stick or a strip.

We developed two main schemes of the production of compacted blanks for pressing and rolling, based on the method of manufacture of vacuum-packed (at high temperature) briquettes.

For manufacturing sticks of diameter 20–40 mm, we proposed and tested the following technological operations: packing (compaction) of titanium sponge in a capsule, degassing of the compact obtained (800–850°C),
Fig. 1. A capsule (yoke) for compaction of titanium sponge of mass 200 g for pressing: (1) TG-110-150 sponge, (2) steel capsule, (3) its titanium bottom.

Table 1. Chemical Composition of Spongy Titanium of Grade TG-110

<table>
<thead>
<tr>
<th>Hardness, HB</th>
<th>Fe</th>
<th>Si</th>
<th>C</th>
<th>Cl</th>
<th>N</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>0.075</td>
<td>0.002</td>
<td>0.006</td>
<td>0.04</td>
<td>0.01</td>
<td>0.04</td>
</tr>
</tbody>
</table>

and hot pressing of the blank according to three schemes: in a steel jacket with the use of two technological oil washers, in a steel jacket with backup by a technological washer, and of a blank with a jacket taken off (press 2 MN).

Packing of Titanium Sponge without Heating. We placed a batch of sponge into a technological steel capsule (yoke) 80 mm in diameter and 170–190 mm in height (Fig. 1) and packed it by stages in an open hydraulic press. Afterwards, by hydrostatic weighing, we determined the density of filling of the capsule (2.4 to 2.7 g/cm³), which constituted 55–60%. We detected open porosity, favoring the removal of gases and air in vacuum at high temperatures.

Degassing of Compacts. We degassed and packed sponge in a VPDS-2 vacuum facility of diffusion welding, consisting of a vertical hydraulic press with a force of 2.5 MN and a water-cooled vacuum chamber. Heaters inside the chamber warm the specimens to 1000–1100°C. The limiting vacuum in it is 13.3–6.7 mPa. The facility ensures uniform and fast heating of the materials as well as the removal of escaping gaseous admixtures and efficient degassing of the materials in the course of their high-temperature heating with subsequent isothermal forge-rolling for one cycle.