A New Technology of Hardening Porous Materials of Titan Powders

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Abstract

A technology of hardening porous materials of titan powders has been elaborated. The technology is based on passing alternating current with duration of ~10^{-1}…10^{1} s through porous (35…40%) blanks made by method of Sintering by Electric Discharge (SED) by passing a pulse of current with duration of ~10^{-5}…10^{-3} s. The influence of technological regimes of porous blanks treatment on their structure and properties is investigated. Geometry and dimension of contact necks between powder particles of obtained samples are evaluated. Variations of porosity and strengths as well as microstructure of porous samples materials before and after treatment are investigated. Optimum range of treatment technological regimes is determined within which porosity of 30…35% with maximum strength values.

Keywords : Porous material, porosity, titanium powder

1. Introduction

The technology of manufacturing of the porous titanium articles, consisting in sintering in vacuum of porous half finished products formed by the method of Sintering by Electric Discharge (SED) by a passage through the powder of titanium of a pulse of an electric current by duration ~10-5…10-3 sec [1,2] is known. During the SED process a local heating of powder particles in a contact zone take place and their sintering with formation of contact necks between particles of a size of 0,1 …0,2 of a particle diameter. The given technology allows to refuse the use of the binder materials depositing to a host material alien admixtures, and the further sintering in vacuum with a residual pressure of ~10-3 Pa allows to increase durability of samples. In this case the process of a vacuum sintering proceeds at a lower temperatures without us of high-melting forms and activators. The minimal shrinkage allows to avoid the formation of crack and to save accuracy of the geometrical sizes and forms of articles. The form of powder particles and porosity after sinterin in vacuum also remains practically constant, and contact necks between powder particles increase up to 0,3…0,4 of a particle diameter [3].

However such method of porous articles manufacturing has low productivity, and its main deficiency is the formation of a coarse-grained structure of titanium what has an negative effect on durability of porous articles [3].

Replacement of a vacuum sintering of porous half finished products by the Treatment by Electrical Discharge (TED) consisting in an additional passage through porous half finished products of AC pulses of a duration of 10-1…101 sec, will allow to eliminate the formation of a coarse-grained structure, will increase the size of contact necks and will reduce the size of grains and will increase the physical and mechanical properties of obtained porous articles.

The purpose of the given work is the development of technology of strengthening of porous materials from the titanium powder obtained by the SED method with help of TED method, and also the investigation of influence of TED modes on the shrinkage, on electrical resistance, on the structure and the durability of porous materials from titanium powder.

2. Experimental and Results

In process of TED with increase of a discharge energy occurs the reduction of the specific electrical resistance of porous titanium samples and the increase of their shrinkage level. The shrinkage of samples at increase of a specific energy of the discharge in 10 times has made 0,5…3 %, that corresponds to the alteration of their porosity from 0,3 to 2 %.

It was determined in the result of the specific electrical resistance measurement of the porous titanium samples obtained by the method of SED with consequent additional sintering in a vacuum furnace at temperature of 1350°C, value of their specific electrical resistance was $12{,}7 \cdot 10^{-6}$ Ohm·m. The samples obtained by the SED method with subsequent TED, have the electrical resistance of about $11 \cdot 10^{-6}$ Ohm·m what gives the basis to suppose that such samples have the area of interfractional contacts commensurable with the samples obtained by method SED and subequent additional sintering in vacuum.

For control of this supposition the investigations of fractogrammes of a brittle fracture of samples obtained by the method of SED, of SED with subsequent TED and of SED with subsequent additional sintering in a vacuum furnace have been carried out.

The comparative analysis of fractogrammes has shown, that the porous titanium samples obtained by the method of SED have the size of a contact neck equal to 0,1…0,15 of the diameter of a particle; the size of a contact neck of samples obtained by the method of SED with subsequent TED, makes 0,3…0,4 of the diameter of a particle; the samples obtained by the method of SED with subsequent additional sintering in vacuum also have the size of the contact neck equal to 0,3…0,4 of the diameter of a particle. I.e. the size of contact necks in porous titanium samples obtained by SED method with subsequent TED is commensurable with the size of contact necks of samples obtained by method SED with subsequent additional sintering in vacuum.

Results of tests of cantilever bending of porous titanium samples obtained by the method of SED with subsequent TED, have shown, that their maximum strength has made 53 MPa. It is determined that at a specific energy of the discharge less than 7,2 kJ/sm^3 the increase of the s strength on cantilever bending does not occur.

For comparison the tests of cantilever bending of porous titanium samples obtained by the method of SED with subsequent additional sintering in vacuum have been carried out. In the result of tests it is determined, that their maximum strength has made 55 MPa, what only on 4% it is more than in the samples obtained by the new technology.

The factogrammes analysis has shown that at SED on the surface of destruction in a contact zone of samples facets of a brittle fracture are precisely visible. The fraction of a gliding fracture is augmented on destruction surface in the contact zone in samples after SED with a subsequent TED, on what indicates appearance of equal holes on fractogramme. The samples obtained by method of SED with a subsequent additional sintering in vacuum, on the surface of destruction in the contact zone on fractogramme also is observed the predominance of equal holes. I.e. the samples obtained by the method of SED with a subsequent additional sintering in vacuum and the samples obtained by the new technology have a similar structure of surface destruction in the contact zone, what once again confirms the similarity of properties of porous titanium samples obtained by the method of SED with subsequent additional sintering in vacuum and of samples obtained by the new technology.

3. Summary

During executed work optimum modes of SED of porous titanium samples are determined. It is determined, that porous titanium samples obtained by the new technology and the samples manufactured using SED and the subsequent additional sintering in vacuum have similar properties. This is confirmed by investigations of specific electrical resistance, investigations of contact necks size, by tests of durability and by investigations of surfaces destruction structures in contact zones of particles. It is determined that the porosity of samples in process of SED changes on 0,3…2% and makes 33…34,7% at a maximum durability on cantilever binding of 53 MPa.

4. References

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