III INTERNATIONAL WORKSHOP
KRASNOYARSK, RUSSIA
11 December 2021

ADVANCES in Materials Science

Science and Technology City Hall
KRASNOYARSK, RUSSIA

«III International Workshop on Advances in Materials Science – AMS-III - 2021»

«Surface saturation monitoring of forming products from titanium alloy VT20 with additives»

Vladimir Gadalov, Irina Vornacheva, Anastasia Luchinovich, Dmitry Loparev, Alexander Scherbakov , Vladimir Malikov and Viktoriia Sokolova

Problem statement

- Improvement of the technology for producing large-sized stampings from titanium alloys has led to an increase in the homogeneity of the chemical composition, an improvement in the structure, and the practical elimination of defects in the form of inclusions of refractory or oxide compounds. At the same time, the degree of chemical and structural homogeneity is not only important, but also a defining characteristic, in this regard, any imperfections will be stress concentrators that reduce the strength and durability of products. The high activity of titanium leads to the occurrence of physicochemical processes of interaction with gases, even in the solid state. This creates the likelihood of the formation of non-metallic inclusions during the manufacture of stampings at such technological stages as hot plastic deformation, heat treatment. Modern technology for producing ingots of titanium alloys makes it possible to solve the problem of obtaining high-quality metal by removing the formed alpha layer mechanically. However, in the event of a breach in the production process, defects are found in ingots.
- The formation of structural defects in the form of non-metallic inclusions on the surface of products has been studied little and unsystematically; there are no data on the methods of their control, formation, shape, size, and distribution. Therefore, the study of the conditions of their formation, morphology, distribution in titanium alloys is of considerable practical and theoretical interest.

Solution methods

To check the possibility of the formation of this type of inclusions during the saturation of parts from the surface, depending on external conditions (temperature, environment, time), the process was simulated in the following directions:

- oxidation in air at different temperatures (500 ºC-1000 ºC), holding time two and six hours;
- nitriding in a vacuum furnace at a temperature of 930 ºC, holding time for two hours;
- diffusion saturation from powders of nitride, hydride, titanium oxide and carbon.

The oxidation of the samples was carried out at temperatures of 500 ºC, 600 ºC, 700 ºC, 800 ºC, 875 ºC, 930 ºC and 1000 ºC, for two hours of exposure and at temperatures of 875 ºC, 930 ºC and 1000 ºC for six hours, with air cooling and in the water. Then the samples were subjected to metallographic examination both on the surface and in section at different magnifications (100-1000 times) and on different microscopes, as well as X-ray spectral analysis.

Results

Table 1 - Phase composition of the surface of samples and oxide films of VT20 alloy after various types of processing

Characteristic	Phase composition											
	α	β	Ti_3O_5	TiO_2	TiN	TiO	Ti_2O	TiH_2	TiC	α″	Ti_3Al	I_2O_3
Original	α	β	-	-	-	-	-	-	-	-	-	-
525ºC, 2 hour	α	β	Ti_3O_5	-	-	-	-	-	-	-	-	-
875 ºC, 2 hour	α	β	Ti_3O_5	TiO_2, brookite	TiN	-	Ti_2O	TiH_2	TiC	-	-	-
930 ºC, 2 hour	α	β	Ti_3O_5	TiO_2, rutile	TiN	-	Ti_2O	-	TiC	α″	$α_2$	-
1020 ºC, 2 hour	α	β	-	TiO_2, rutile	TiN	-	-	TiH_2	TiC	α″	$α_2$	-
875 ºC, 6 hour, water	-	-	-	TiO_2, rutile	TiN	-	-	TiH_2	-	-	Ti_3Al	-
1020 ºC, 6 hour, water	-	-	-	TiO_2, rutile	TiN, Ti_2N	TiO	-	TiH_2	TiC	-	Ti_3Al	Al_2O_3
Tape 930 ºC, 2 hour	α	-	-	TiO_2, rutile	-	TiO	Ti_2O	-	-	-	-	-

Conclusions

The tests were carried out on the equipment of the Shared Use Center "Materials Research Center"

(Saint Petersburg).

- The above studies established that during heat treatment in air (oxidation), nitriding, as well as diffusion saturation of titanium alloy samples, nonmetallic inclusions are formed only in the surface and subsurface layers. After heat treatment, it is recommended to remove the gas-saturated layer by mechanical treatment to a depth of 1.5 mm or to protect the base metal by diffusion saturation of the surface with titanium powders from the effects of both aggressive media and to harden the product during cutting or abrasion.

Science and Technology City Hall
KRASNOYARSK, RUSSIA

ADVANCES in Materials Science

Contacts

Irina Vornacheva

South-West State University, Kursk, Russia

E-mail: vornairina2008@yandex.ru