ТЕЗИСЫ ДОКЛАДОВ

МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ

«Физическая мезомеханика. Материалы с многоуровневой иерархически организованной структурой и интеллектуальные производственные технологии»,

посвященная 90-летию со дня рождения
основателя и первого директора ИФПМ СО РАН
академика Виктора Евгеньевича Панина

в рамках
Международного междисциплинарного симпозиума
«Иерархические материалы: разработка и приложения для новых технологий и надежных конструкций»

5–9 октября 2020 года
Томск, Россия

Томск
Издательство ТГУ
2020

DOI: 10.17223/9785946219242/350

AN EFFECT OF ION-PLASMA NITRIDING ON THE MICROSTRUCTURE AND PHASE COMPOSITION OF ADDITIVELY-MANUFACTURED AISI 321 STAINLESS STEEL

[1]Moskvina V.A., [1]Astafurova E.G., [2]Ramazanov K.N., [1]Astafurov S.V., [1]Melnikov E.V.,
[1]Maier G.G., [1]Panchenko M.Yu., [1]Reunova K.A., [1]Rubtsov V.E., [1]Kolubaev E.A.
[1]Institute of Strength Physics and Materials Science SB RAS, Tomsk
[2]Ufa State Aviation Technical University, Ufa

The influence of post-built ion nitriding on the structure and phase composition of AISI 321-type stainless steel fabricated using additive manufacturing method was investigated. The AISI 321 stainless steel was obtained by electron beam wire-feed additive manufacturing method (EBAM), which was performed in vacuum chamber using layer-by-layer strategy with 55 parallel layers. The wire of stainless steel with a chemical composition Fe-17.8Cr-9.7Ni-0.6Si-1.2Mn-0.9Ti-0.2Cu-0.08C, mass. %, had a diameter of 1.2 mm and was used in EBAM process to build 110 × 35 × 6 mm^3 walls (billets) on stainless steel plate substrate.

The AISI 321-type stainless steel billets produced by the EBAM method possess a substantial anisotropy of structure, phase composition and mechanical properties. Specimens with different orientations relative to the deposition direction (transverse and longitudinal) have been cut for the research from as-built billets. The specimens were divided into two portions. The first type of specimens was studied in as-built condition. The second type was ion-plasma nitrided (post-built ion nitriding) in a 70 vol.%N_2:30 vol.% H_2 gas mixture with gas pressure of 300 Pa (an ELU-5 device) at the temperature of 540°C for 12 h.

According to X-ray diffraction data, as-built AISI 321-type billets possessed a two-phase heterogeneous microstructure: γ-austenite and δ-ferrite. Austenitic phase has a chemical composition: Fe-(16.5-17.7)Cr-(9.6-9.9)Ni (mass. %). The chemical composition of the δ-ferrite phase is different from austenitic one – it depleted in Ni and enriched with Cr: Fe-(20-22)Cr-(4.6-5.7)Ni (mass. %). Such microstructure is typical for the electron beam additive manufacturing and is produced during solidification in melting of wire process and further multiple heating/cooling of the billet until all layers are deposited. Analysis of the images obtained using light microscopy and scanning electron microscopy shows that as-built billets had a columnar coarse-grains of austenite which follow the layer-by-layer EBAM growth of the billets.

Ion-plasma nitriding caused the formation of a surface modified layers in additively manufactured AISI 321-type stainless steel specimens. The thickness of the hardened surface layers is very inhomogeneous, which partially follows the macroscopical inhomogeneity (layered macrostructure) of the additively produced billet. Ion-plasma nitriding led to a solid-solution hardening of austenitic and ferritic phases, appearance of nitrides, which contributes to the hardening of the specimens. The high fraction of interphase boundaries (dendritic ferrite in coarse austenitic grains) promotes nitride formation as compared to single-phase coarse grained cast specimens. Ion nitriding promotes a substantial surface hardening and changes the microstructure of the surface areas of the EBAM-produced stainless steel specimens but does not change a macroscopically and microscopically anisotropic structure in the inner part of the specimens.

The work was performed according to the Government research assignment for ISPMS SB RAS, project No. III.23.2.7.