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MODIFICATION OF THE SURFACE ENGINEERING PROPERTIES OF (FSX-414) ALLOY AND STUDY OF THE ATTENUATION COEFFICIENTS

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Abstract

Studying the coating of improved and modified alloys with single aluminum and aluminum in the presence of samarium oxide thermal barrier and finding the coefficients of linear attenuation (μ_ℓ), and mass (μ_m), for the alloy, where the surface properties of the alloy were modified by cementation it for four different times (2-4-6-8). hour, per coating. Then study the attenuation coefficients and compare them with the theoretical and practical results of the improved alloy without the coating process, and to find out the suitability of these materials for use in the field of gamma ray radiation attenuation. These atomic parameters were measured using a source (Cs-137) emitting gamma rays with a capacity of (662 keV) and an efficiency (400 KBq), and a source (Am-241) emitting a gamma ray of energy (60 keV) and an efficiency of (74 KBq). Sodium iodide detector $NaI(Tl)$ with dimensions ($1.5'' \times 1.5''$) with integrated measurement system. The radiation dose rate was also calculated using linear attenuation coefficients. The results showed that the values of these coefficients are affected by the change in the coating time and type. It was found that when the coating time for the samples increased, the attenuation coefficients increased. The best results were obtained for samples coated at a time of 8 hours and in the presence of samarium oxide barrier, where there is a good agreement between the obtained values compared with the results of (ICUR), as the extent of difference between these results is less than 5%. The best results obtained for the uncoated sample, where there is a good agreement between the obtained values in comparison with the results of (ICUR), as the extent of difference between these results reaches 17%.

Keywords: Samarium Oxide thermal barrier, FSX-414 Alloy, Attenuation.

Introduction

This part of the research is concerned with the design and manufacture of special tools for conducting aluminum and coating tests to test the alloys under study, and the manufacture and design of the coating system, which includes the package cementation and the oven for the coating process, as well as how to connect the coating system to the vacuum system by means of the vacuum device, and describe all devices Used This part includes most of the experiments that were conducted within the requirements of preparing the study, as well as the coating methods that were used in this study. The studies and research that have been carried out in the field of coatings show that the stages of sample preparation are important steps before coating because it is a key factor in obtaining ideal coatings in terms of the high adhesion of the coating material, as well as the high clarity in the coating layer during microscopic examination with its different structures, given the For the above reasons, the samples were prepared by cutting them with geometric dimensions and shapes that fit with the design of the coating system, and conducting the surface finishing process for the samples by removing the oxides on the surface, through the smoothing machine and using smoothing paper made of silicon carbide and in degrees of different grain size and smoothness Starting from (180-2000), then the samples are washed with water and washing powder and then with methanol to remove grease and suspended fats, then rinsed with acetone for quick drying and then with distilled water to obtain an (ideal) surface suitable for the coating process.

The coating process of the prepared samples was carried out using the cementation pack method, which is one of the widespread methods of diffusive coating. The coating was done by cementing method and for the various alloys under study dealt with in the research, where the cement powder was used, which consists of a powder containing powdered coating material, and what is meant by the coating material here is powder Pure aluminum at 25%, ammonium chloride powder (NH_4Cl) at 5% as an activator, and aluminum oxide or alumina (Al_2O_3) at 70% as a substance that helps prevent clumping of the mixture. This substance is heated to 500^oC to get rid of moisture and cooled to room temperature. After that, the mixture is mixed well and placed with the sample to be painted inside a paint pot made of alumina or quartz, closed on one end, and placed inside the tube inside the oven and connected from its open end to the vacuum device, and for the time periods (8, 6, 4, 2) H, and the oven temperature is fixed at the required degree (1050 ^{o} C), and after it cools, all samples are weighed and kept under the same conditions until tests are carried out on them [4].

Because of the wide uses of gamma rays and X-rays in various fields such as medicine, agriculture, industry and nuclear physics research, many studies have been presented in this aspect about radiation attenuation. Various, living organisms are constantly exposed to ionizing radiation from natural and artificial radiation sources. Radioactive sources are categorized into two categories, natural sources and man-made sources. More than 90% of human radiation exposure is from natural sources, for example terrestrial sources that come from radionuclides in the earth's crust, air, food, water, and cosmic rays. Radiation exposure to the human population occurs primarily from medical uses of radiation and radioisotopes in health care, as well as from industrial uses of nuclear techniques, and from nuclear weapons testing. Radiation exposure can be significantly reduced by adequate safety measures and improved nuclear procedures and practices [6].

The linear attenuation coefficient (μ_ℓ) is defined as the number of displaced or shielded photons from the beam per unit distance. This coefficient is measured in cm^{-1}. It is one of the most important parameters that show the process of penetration of shields by gamma rays, and it depends on the energy of the photons. When a beam of gamma rays passes through a certain substance, the photons of this beam either come out without interaction or are completely removed from the beam by the process of scattering or absorption. If a beam of intensity (I_0) is shed on a slice of thickness (x), then the intensity of the beam window (I) through the slice is given by the following Beer-Lambert relationship: $I(x) = I_0 e^{-\mu_\ell x}$ ... (1), [3].

Where I_0 and I are the intensity of the incident and depressed beams, respectively, x the thickness of the absorbent material, we can notice from equation (1) that the depressed beam has an exponential decrease in its intensity along the path (x) it travels.

The mass attenuation coefficient (μ_m) is defined as the rate of reactions of photons within one unit of mass per unit area (cm^2/g). It depends on the energy of the photons and the concentration of electrons in the material. The value of (μ_m) will decrease rapidly with increasing energy The photon, moreover, the chance of a photon getting close enough to the electron is higher when the concentration of electrons inside the substance is higher because it is absorbed by the substance. The electron concentration is determined by the density of the material.

Thus, fine-dispersion composite materials for high-density materials provide more interaction potential for photons as well as better radiation protection properties, and it is related with the linear attenuation coefficient through the following equation:

$$\mu_m = \frac{\mu_\ell}{\rho} \quad \ldots (2),$$

[3].

Where the examinations that were carried out during this chapter included microscopic examination of the samples before and after coating, and before and after the attenuation study, to know the crystalline structure of the phases. The comparison, as the samples were photographed with the usual optical microscope, and finally the examination and imaging of the surface of the samples was carried out with the scanning electron microscope (SEM), and the surface analysis of the samples was carried out using the scanning electron microscope (SEM-EDS) to accurately determine the coating elements present through the coating layer in the painted samples.

Practical Part, Results and Discussion:

Coating study: The cementation processes of FSX_414 alloy was carried out, in order to study the effects produced by cementation, and cementation in the presence of thermal barriers, through the use of high efficiency aluminum at a temperature of (1050° C) and for the time period (8 - 6 - 4 - 2) H, in atmosphere (10^{-3} torr). It is clear from the microscopic examination of the cross-section of the samples after performing the surface finishing operations for them that the coating structure consists of a mixture of structures and phases. With the increase in the coating time, the thickness of the layer increases, and it is possible to distinguish between these layers through the density of sediments and secondary phases and the granular size of these layers, which contain deposits as (aluminum-chromium phase) in the middle and inner regions of them and according to the difference in their density [1]. While the inner layer is multiphase and its basis is the result of phase formation (Co_2Al_5) [2]. As for the "diffusion exchange" area, it is a very narrow area and there are no sediments in it, and it is considered a separating area between the base and the layer of paint [4]. Where we can distinguish between the three coating areas after (8 - 6 - 4 - 2) H, as the thickest outer region is affected by the display solution quickly, followed by the second region, which is the inner region, which is less affected by the display solution and is less thick than the outer regions. While the diffusion exchange area is a narrow and sediment-free area (Figure 1-a-b)), Where the results of (XRD) Figure (2a) for the single-aluminum-coated model for the period (4 H) and at a degree (1050 ° C), the presence of peaks perhaps It goes back to the phase (Co_2Al_5) and there are other peaks that may belong to the phase (B_CoAl) [5], so it is expected that the phases (chromium - aluminum) are secondary phases within the coating layer and this is what gave the coating layer A multifaceted look. While it was found from the analysis of the results of (XRD) for the painful model and for the period 8H, Figure (2b), the results of the phases (β_ CoAl / Co_2Al_5) indicate the presence of the phase (Co_2Al_5), as the results confirm the existence of the binary phases. (Al-chromium-aluminum (such as $CrAl_5$ / Cr_2Al / $CrAl_2$), as well as the phase (Cr_3Al_2) became clearer after time (H 8), and that is as a result of the granular size during this period of the alloimmunization period. It appears through the examination In the scanning electronic device (SEM) figure (3a), the diffusion of the aluminum layer is clear through the coating and this is consistent with the quantitative and qualitative analysis scheme of the scanning electronic device (XRD-EDS), as it is clear from figure (3b) that the highest peak belongs to aluminum, and This is in agreement with (SEM) and Energy Dispersion Spectrum (EDS) images of aluminum atoms, as well as other atoms belonging to certain ratios of atoms of other elements such as chromium and others [2].

Attenuation study: The linear attenuation coefficient μ_ℓ was found using equation (1), and the mass attenuation coefficient μ_m from equation (2), for all prepared samples, for different energies, and the relationship between the linear and mass attenuation coefficients was drawn. And the concentration of the coating material added to the base material as in Figures (4-a-b), (5-a-b)[7]. We note from these figures that the values of the linear and mass attenuation coefficients of the samples change with the change in the time and quality of the coating, as it becomes clear that these values increase with increasing The coating time and for all energies [6], and this can be explained that when the coating time increases, the acquired weight of the coating increases, the attenuation processes in it will increase due to the increase in the distribution of the added coating material within the base material, which leads to an increase in the density of the prepared material in general. Thus, an increase in the attenuation of the gamma rays occurs, and therefore the coefficients of linear and mass attenuation are increased. We also note that Germanization alone is not sufficient for use as an attenuation material, as the addition of thermal barriers increases the attenuation process, which can be used as a radiation barrier material in the field of medicine.

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From the results we obtained, the following can be concluded:

1- The use of the elements samarium and aluminum as a mixture inside the cement pulp is useful in obtaining a coating compound of Sm_2Al_3 instead of Co_2Al.
2- The use of samarium oxide as a primary coating prior to the annealing process reduces the diffusion of aluminum into the surface of the alloy.
3- The samarium oxide Sm_2O_3 can act as a thermal barrier and reduce the possibility of counterproductive diffusion of the alloy elements, thus maintaining a high concentration of aluminum at the surface to ensure the formation of the oxide crust.
4- High thermal stability.
5- The samarium oxide can act as a thermal barrier, thus reducing the potential for continued diffusion of aluminum to the depth of the alloy during heat treatment, thus maintaining a high concentration of aluminum at the surface to ensure composition of the protective oxide shell Al_2O_3.
6- The possibility of using the alloy (FSX-414) in the manufacture of materials and protective shields for body tissues from radiation, and use in nuclear medicine.

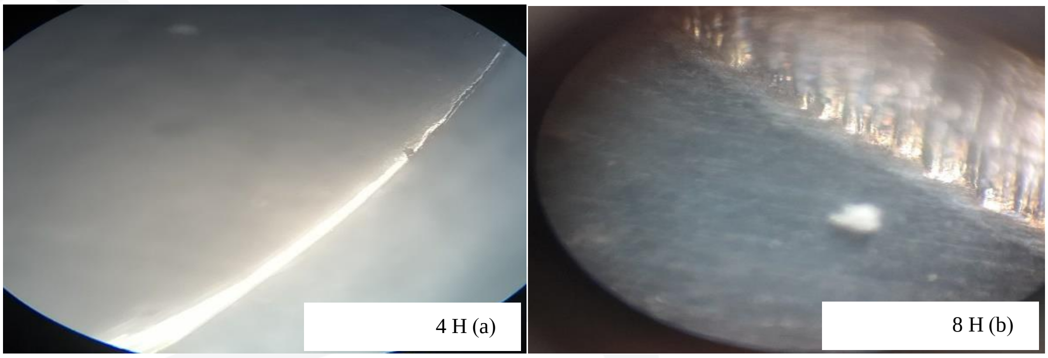

Figure (1) Microstructure of (FSX-414), aluminization for period (8H).

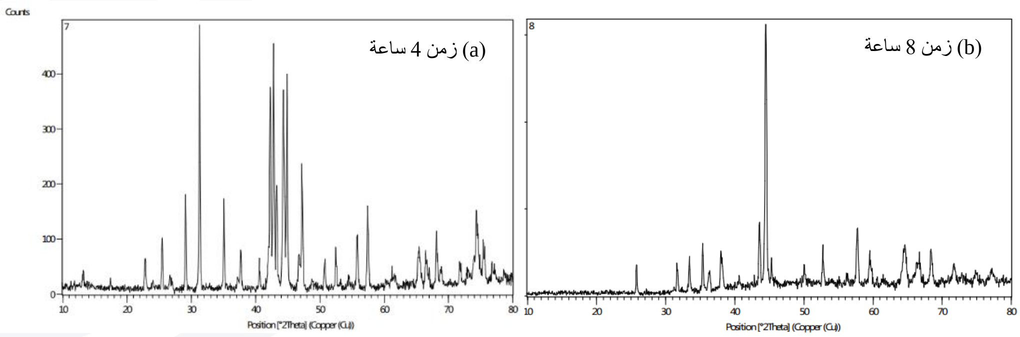

Figure (2) X-ray diffraction of (FSX-414),, aluminization for (4-8 /H)

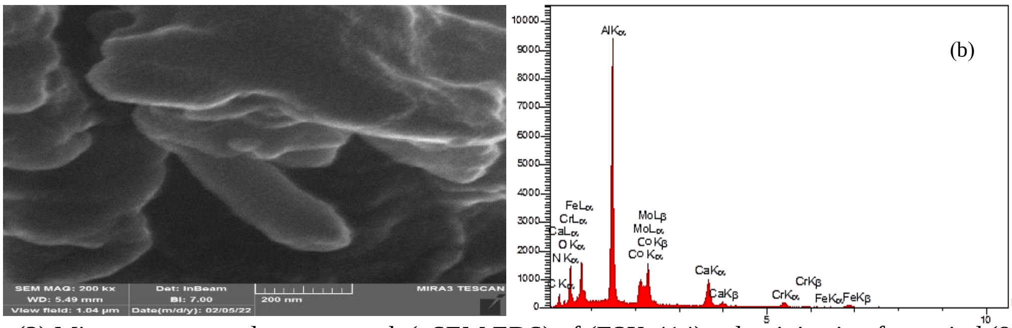

Figure (3) Microstructure and spectrograph (_SEM EDS) of (FSX-414),, aluminization for period (8H).

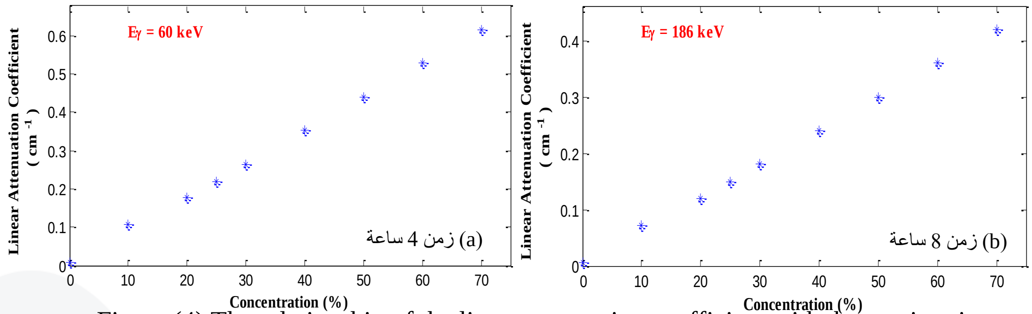

Figure (4) The relationship of the linear attenuation coefficient with the coating time

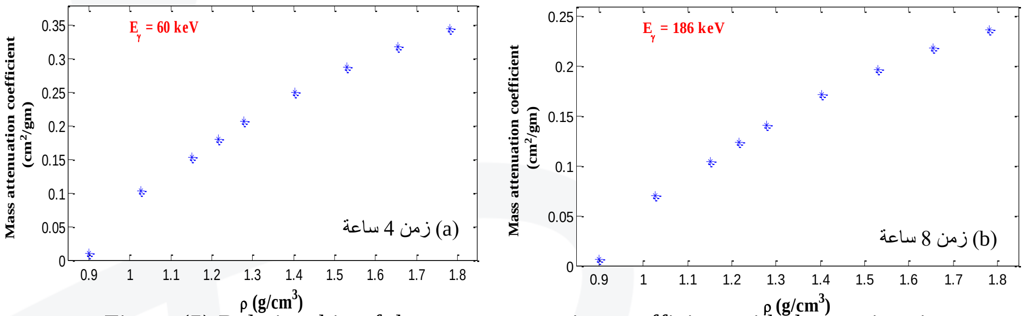

Figure (5) Relationship of the mass attenuation coefficient with the coating time

References

1. Amy J Goodfellow, Lewis R. Owen,Kateria A.Christofidou, Joekelleher , Mark C.Hardy and Howard J.Stone (2019)"The Effect of Tempertatur and MO content on the lattice Misfit of Model Ni-Based superalloys ". *Metals*, *9*(6), 700; https://doi.org/10.3390/met9060700.
2. Aure´lie Vande Put, Djar Oquab , Eve Pe´re´ , Aymeric Raffaitin and Daniel Monceau ,(2018)" Beneficial Effect of Pt and of Pre-Oxidation on the Oxidation Behaviour of an NiCoCrAlYTa Bond-Coating for Thermal Barrier Coating Systems ". Oxidation of Metals, vol. 75. pp. 247-279.
3. Eskner , M . Ph D Thesis, Royal Institute of Technology , Stokholm .

4. Feng Xie , Dingjun Li and Weixu Zhang (2020)" Long-Term Failure Mechanisms of Thermal Barrier Coatings in Heavy-Duty Gas Turbines ",Coatings 2020, 10, 1022; doi:10.3390/coatings10111022.
5. François Saint-Antonin, Williams Lefebvre and Ivan Blum (2019) "Niobium Base Superalloys: Achievement of a Coherent Ordered Precipitate Structure in the Nb Solid-Solution “Crystals, 9, 345; doi:10.3390/cryst9070345.
6. Iliadis, C. "Nuclear physics of stars",2nd edn. John Wiley & Sons, (2015).
7. Salit, M. S. "Tropical natural fiber composites: properties, manufacture and applications", Springer, (2014).
8. Wanjala, M. E. " Assessment of human exposure to natural source of radiation on the soil in tongaren constituency of bungoma county, Kenya ", PhD Thesis, Kenyatta University/ Kenya, (2016).