2008 UTSR Industrial Fellowship Program

Final Report

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INTRODUCTION

For the UTSR Industrial Fellowship Program, the author was assigned to work at Solar Turbines Incorporated in the Materials and Processes Department on the Surface Engineering Team in San Diego, CA. During the course of her 11-week fellowship, she was given four different projects to complete. Her four major projects were to examine blades for signs of Type II Hot Corrosion, inspect the composition of black discoloration on 903 Alloy and remove it, analyze the condition of several Platinum-Aluminide (Pt-Al) coatings after an oxidation test, and evaluate the Pt-Al coating on nozzles after service.

GENERAL EXPERIMENTAL PROCEDUCE

To view the microstructure, composition, and thickness of the Pt-Al coating, the specimens were cross-sectioned. The samples where then mounted in epoxy, ground, and polished in the Solar Materials and Processes metallography laboratory. The coating was evaluated on a Nikon Epiphot optical microscope and Jeol JSM-6460LV scanning electron microscope (SEM) to inspect microstructure, thickness and phase change. The chemical composition and general microstructure were semi-quantitatively examined at 750X or 1000X magnification with energy dispersive spectroscopy (EDS) equipped with the SEM. Thickness and phase change was measured using Buehler Omnimet Image Analysis. A subroutine has been written for Omnimet Image Analysis that measures the percentage of different phases present in a specimen based on grey-scale. A box was drawn around the area of interest and the area inside of the box is automatically evaluated on the grey scale.

HOT CORROSION

The condition of turbines blades from the past ten years was inspected for signs of hot corrosion. “Hot corrosion is a high-temperature analog of aqueous atmospheric corrosion” [Rapp]. When a thin oxidation layer of sodium and other salts are deposited on the surface of the metallic part or structure in a high temperature area such as the inside of a gas turbine, the surface will erode faster than normal, because the combination of hot gases and salts forms a liquid salt (Figure 1). This molten film dissolves the protective alumina scale accelerating the degradation of the aluminide coating. Constituents such as chromium, silicon, or platinum are added to aluminide coating to improve resistance against hot corrosion attack.

Hot Corrosion typically occurs at elevated temperatures between 550°C and 925°C. Type II Hot Corrosion happens on the lower end of the temperature range up to 750°C. It is caused by the combination of salt and sulfur forming a compound with a low melt temperature. The salt forms an eutectic mixture with a melting point significantly lower than that of the individual constituents [Bose].

The specimens in the study were examined in the area under the platform on blades for Type II Hot Corrosion. The samples were taken from harsh environments that showed signs of corrosion under the platform.

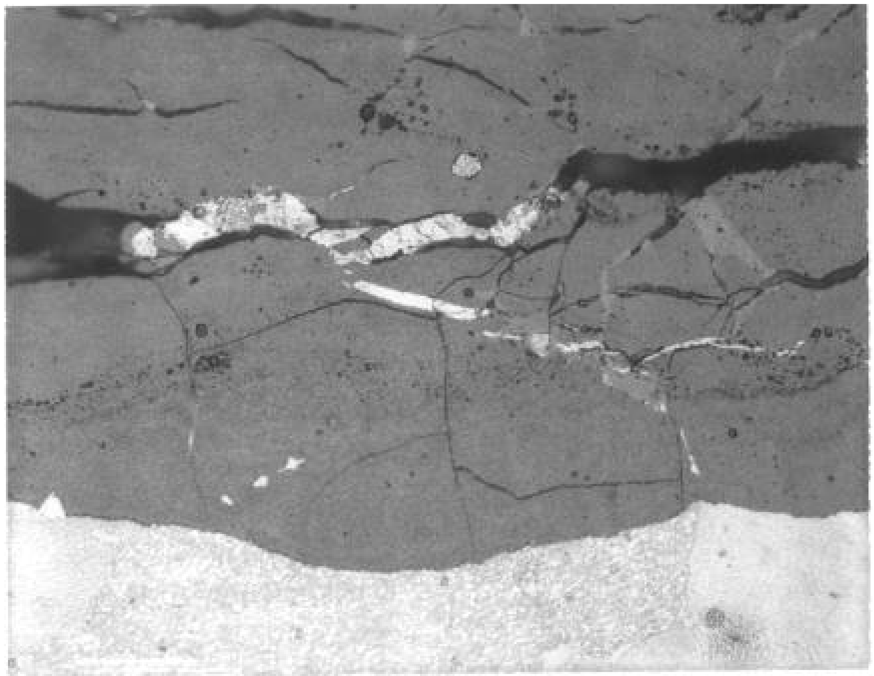

Figure 1: The microstructure of Type II hot corrosion attack

BLACK DISCOLORATION

Black discoloration was seen on semi-finished Nozzle Support Rings for Taurus 70 and Titan 130 engine lines. These parts are made from IN903 and are coated with a simple aluminide. The black discoloration was difficult to remove prior to coating and it is believed to affect adhesion of the simple aluminide coating. Without a nozzle support ring available for destructive testing, a a semi-finished nozzle case also made from 903 Alloy, was also observed to have the discoloration. A region from the nozzle case was cut into one inch squares for the author to inspect the composition of black discoloration and evaluate ways to remove it. The thickness of the discoloration was taken nondestructively by magnetic induction**.** The chemical composition of the discoloration was analyzed in the SEM.

Figure 2: Polished, lightly polished and unpolished samples of a part with black discoloration

Some of the test samples were shipped to a supplier to be cleaned and coated with a simple aluminide coating. Using heavy grit blasting the supplier was able to completely remove the discoloration. However, light grit-blasting only removed part of the discoloration. That is why the discoloration can be seen under the simple aluminide coating on the third and fourth samples in Figure 2. However, the discoloration on the nozzle support rings could not completely be removed by hard grit-blasting. The discoloration on the nozzle case is believed to be a different oxidation from the original support rings.

Figure 3: Nozzle Support Ring with black discoloration

After the analysis had been completed by the author on the test samples of the nozzle case, a Titan 130 nozzle support ring with black discoloration under the simple aluminide coating became available for destructive testing. (shown in Figure 3) It is being inspected to determine the composition of black discoloration and methods for removal. Test coupons are being made of this Nozzle Support Ring. Some of the samples will be sectioned and mounted to inspect the microstructure and composition of the coating with the discoloration beneath it.

PLATINUM ALUMINIDE LIFE PREDICTION CURVE

The conditions of three Pt-Al coatings were analyzed after a long term oxidation test. One coating was applied with the in the pack process and was solutioned to obtain a single phase coating microstructure. The other two coatings were applied with the above the pack process with different processing parameters. The three coatings were evaluated against a baseline to find which one adhered the ES9-275 Type B Coating standard the best after a long term oxidation tests. The microstructures of in the pack and above the pack coating process can seen in Figure 4 and 5 at 200X magnification after the samples tested for a long time at high temperatures.

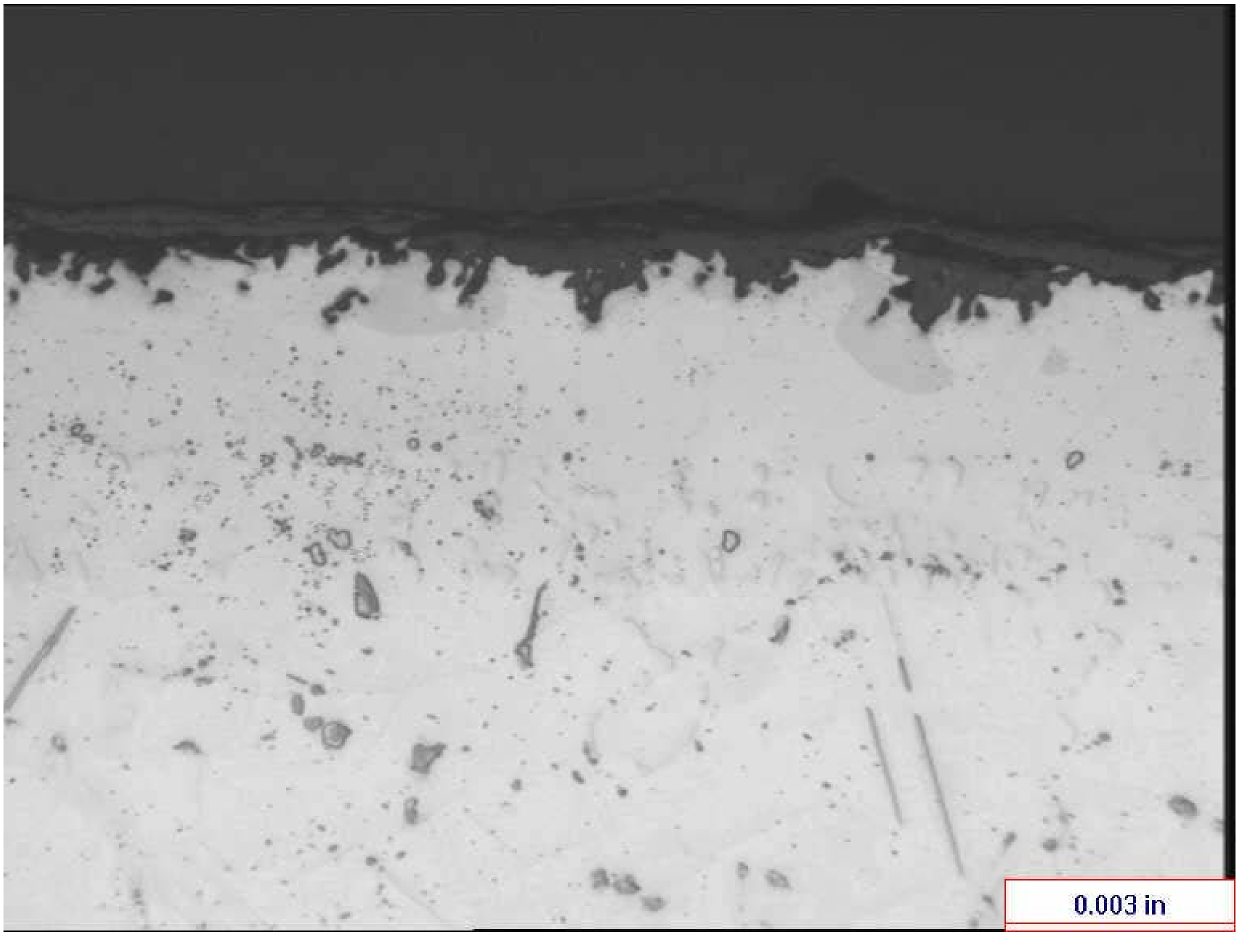

Figure 4: The microstructure of In Pack coating process at 200X

Both, in the pack and above the pack, are metallic diffusion coatings. For an in the pack coating process, the parts are submerged in powder. The typical pack powder mixture is 20% to 60% metallic powder, 0 to 0.25% activator, and balance oxide powder [Bose]. The parts are secured above the powder mixture for above the pack coating process.

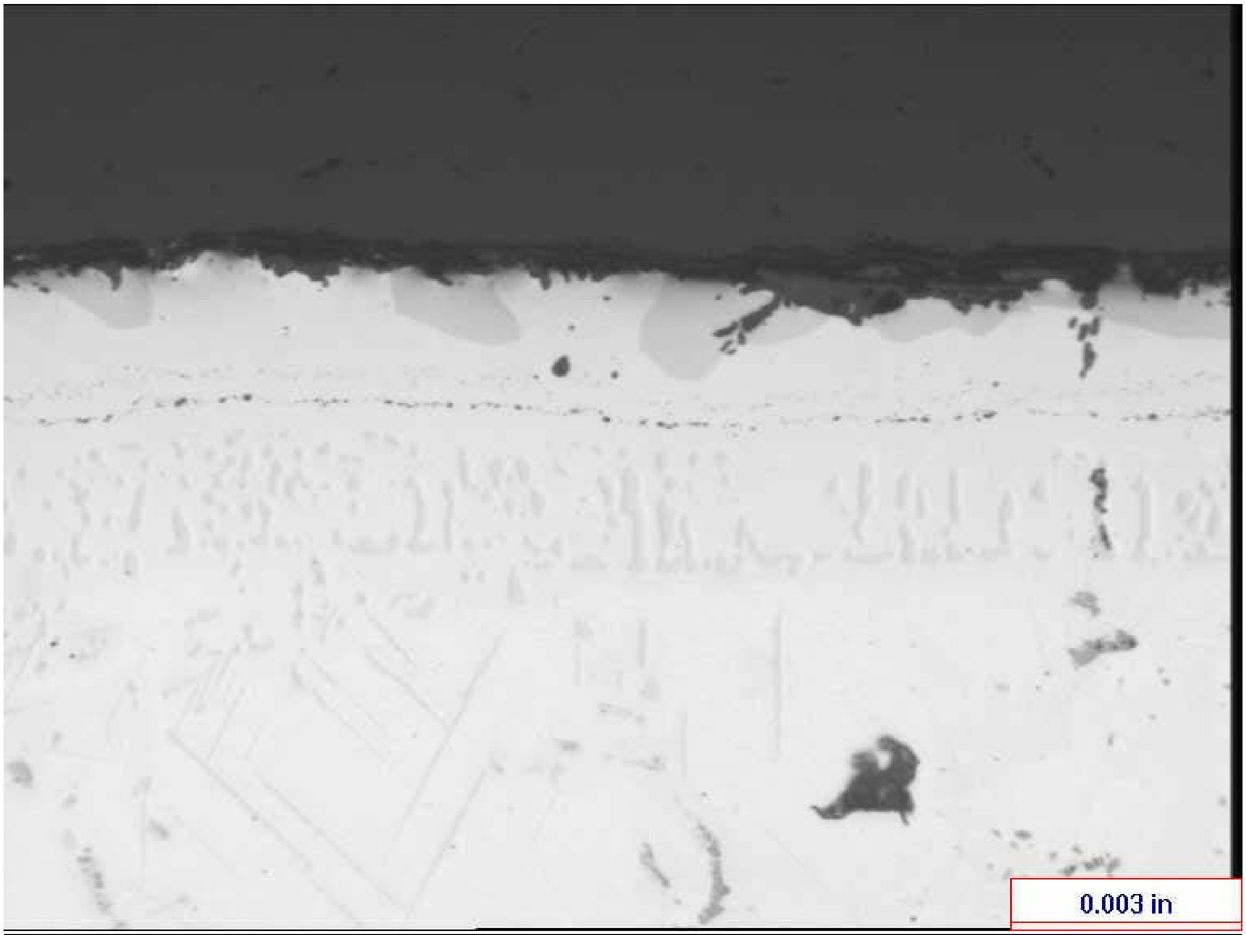

Figure 5: The microstructure of Above the Pack coating process at 200X

After an oxidation test was completed, the three different Pt-Al coatings were evaluated to compare with baseline life prediction test data.

EVALUATION OF PLATINUM ALUMINIDE COATING FOR NOZZLES

The microstructure and composition of Pt-Al coating were evaluated on Taurus 65 Stage 1 nozzles after service. Seven regions on the nozzles were inspected as seen below in Figure 6.

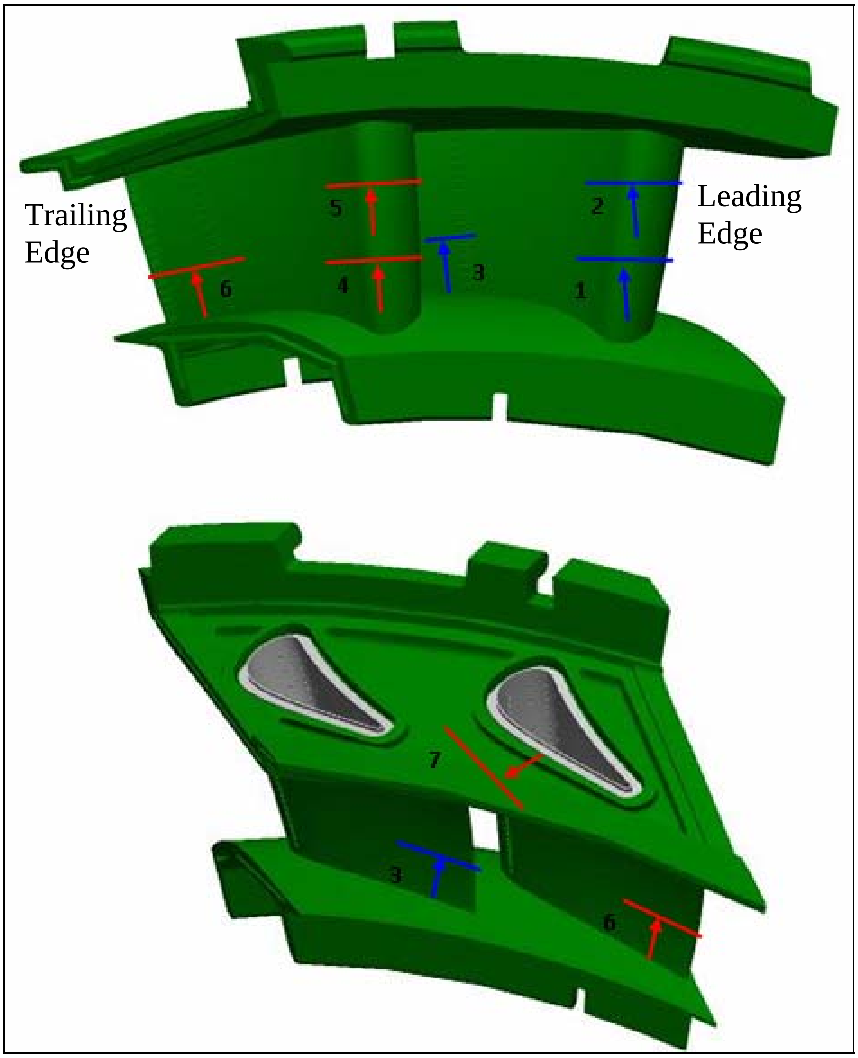

Figure 6: Location of the seven of different temperature zones

The thickness, chemical composition, microstructure and phase change of nozzle coating was analyzed to observe if the coating was adhering the ES9-275 Type B Coating standard and to find what region has the most wear after service.

CONCLUSION

The author found her opportunity at Solar Turbines Incorporated to be very informative. She worked on four unique projects over the course of her fellowship and each one taught her a different lesson. Several types of coating processes were confusing to understand at first, but her mentor did an excellent job explaining and educating her on the different methods. Monthly teleconferences she attended demonstrated the importance of proper verbal communication describing the problem or concept to individuals on the other line. The tours of Solar Turbines facilities were informational and displayed numerous subgroups needed to construct a turbine. The only recommendation she has for Solar is a more detailed information package on San Diego area would be helpful to someone who is unfamiliar with the area. She would recommend the UTSR Program to anyone interested in conducting research in gas turbine industry or in the field of propulsion.

ACKNOWLEGDEMENTS

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