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Microstructure Morphology Analysis of NiCoCrAlY Alloy Coating Prepared by Cold Spraying

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Abstract: In this experiment, pure nickel, cobalt, chromium, aluminum, and bismuth powders were mechanically mixed for three hours in accordance with a certain ratio of powders. After the coating was formed on the surface of a stainless steel substrate of 310s by low-pressure cold spray technique and analyzed by SEM and EDS. The studies show that the NiCoCrAlY alloy coating prepared by cold spraying has some pores and impurities, the powder particles are not melted, and the voids of the NiCoCrAlY alloy coating after vacuum heat treatment at 600° C./4 h are significantly reduced and the elements in the coating but the diffusion area is shallow.

Introduction

Cold spraying technology is a new type of spraying process developed in recent years. Unlike traditional thermal spray processes, it overcomes porous[1], inhomogeneous tissue, low bonding strength, oxide inclusions, and residual stress hazards[2]. The cold spray technology also has many advantages itself, such as low spraying temperature, low oxygen content of the coating layer, low porosity, and the phenomenon of oxidation, burnout, and phase change during the spraying process is not easy to occur, which makes it possible to prepare oxygen-sensitive, heat-sensitive, amorphous, and nano-material coatings that are difficult to prepare by traditional spray techniques[3] and the application prospects are very broad[4].

High temperature protective coating like MCrAlY has excellent oxidation resistance and thermal corrosion resistance and is commonly used in hot-end components of gas turbines[5-7].Many scholars have studied it. For example, Li Xiangbo[8] prepared a dense NiCoCrAlY superalloy coating with cold spraying under conditions of atmospheric pressure of 2.3MPa, temperature of 600˚C, and helium as carrier gas, the result shows that the original powder particles were sprayed by plastic deformation tightly bonded together without melting. LEE[9] used the mixed powder of Ni and NiCoCrAlY (mass ratio 1:9) to prepare a denser coating under the condition of N_2 carrier gas, but pores still existed at the boundary of different kinds of particles. LI[10] used two different powders (Ni23Co20Cr8.5Al4.0Ta0.6Y and Ni20Cr10AlY) respectively to prepare MCrAlY coatings on the polished high-temperature alloy substrate. RICHER[11] compared the mechanically milled powder after 8h with the sprayed MCrAlY alloy coating and found that the

XRD patterns of the two were closely, indicating that the powders had similar plastic deformation in these two different processes.

The research group would like to use the low-pressure cold spray equipment to prepare the NiCoCrAlY alloy coating, which can prevent the occurrence of chemical reactions and phase transitions.And due to the low spraying temperature and the solid state of the particles, the growth and oxidation of solid particles do not occur easily.The powder particles plastically deformed and achieved tight bonding during the impact,.

The experimental content

Experimental Materials and Parameters

Powder Preparation

Several pure powders of Ni, Co, Cr, Al, and Y were mechanically mixed in a ratio of 4:2:1.5:1:0.03 for 4h. The particle size of the powder was in the range of 25-48μm. The substrate material selected for this experiment was 310s stainless steel. The 310s with a size of 110mm×110mm×11mm was cut into a 10mm×10mm sample to be treated using a spark wire. Before coating, the substrate surface was cleaned with acetone to achieve rust removal. After the purpose of oil removal, sandblasting was performed separately.

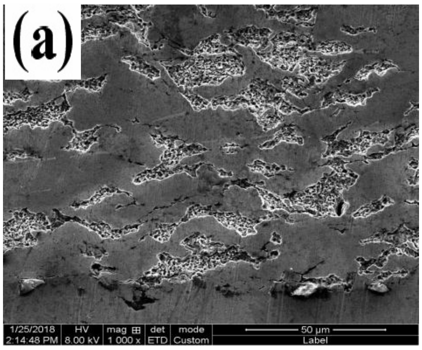
Coating Preparation

Cold spray equipment model GDU-3-15 is utilized.Spraying process parameters are: gas pressure is 0.5~0.7MPa, spraying gas temperature is 500°C, compressed air as the carrier gas and spraying distance is 10mm.

Vacuum heat treatment

The vacuum tube furnace is employed to furnace heating, the vacuum degree is -0.08MPa, the heating temperature is 600°C, and the furnace cooling is performed after the heat preservation for 4h.

Coating microstructure and energy spectrum analysis



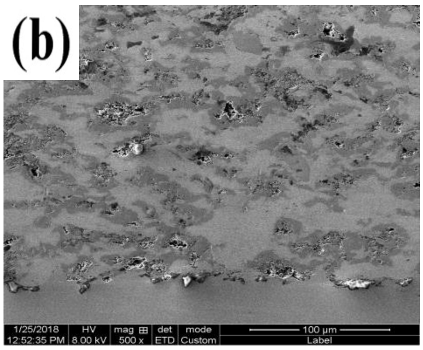


Fig.1 Longitudinal micromorphology of NiCoCrAlY alloy coating

Fig. 1(a) shows the longitudinal micromorphology of NiCoCrAlY prefabricate coating. Fig. 1(b) shows the micromorphology of the NiCoCrAlY coating after vacuum heat treatment**.** It can be observed that the hole in the coating is not Mostly and most obviously after vacuum heat treatment, the coating pores were significantly reduced and as can be observed in connection with Figure 3, the prefabricate NiCoCrAlY coating had an average oxygen content of 1.6%, which in turn demonstrates the coating during cold spraying. The layer is barely oxidized and the oxygen content is very low. After vacuum heat treatment, the average oxygen content of the NiCoCrAlY coating is 1.65%, and the oxygen content has increased. This is also related to the degree of vacuum tube ,but there is almost no change. And the reduction of porosity, which laid the foundation for the subsequent detection of coating oxidation performance.

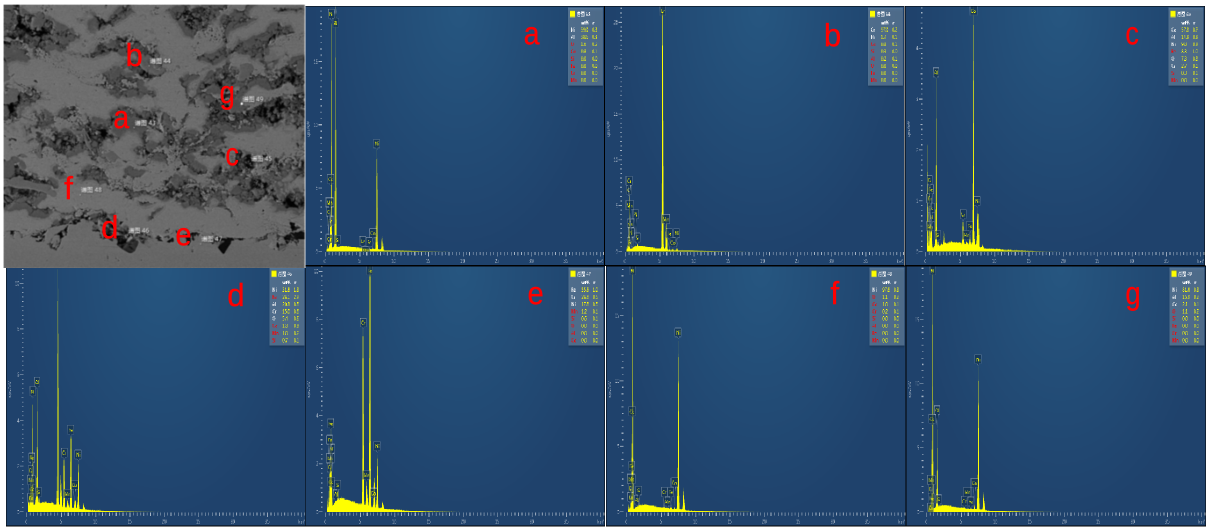


Figure 2. Dot Scan of NiCoCrAlY Coating After Vacuum Heat Treatment

Fig. 2 shows the spot scanning of the coating after vacuum heat treatment at 600°C/4h. It can be observed from Fig. 5 that the deposition rate of Ni is relatively highest, and the oxygen content in the hole-like region is not high in the figure after several powders are mixed, indicating that the coating is not substantially oxidized.

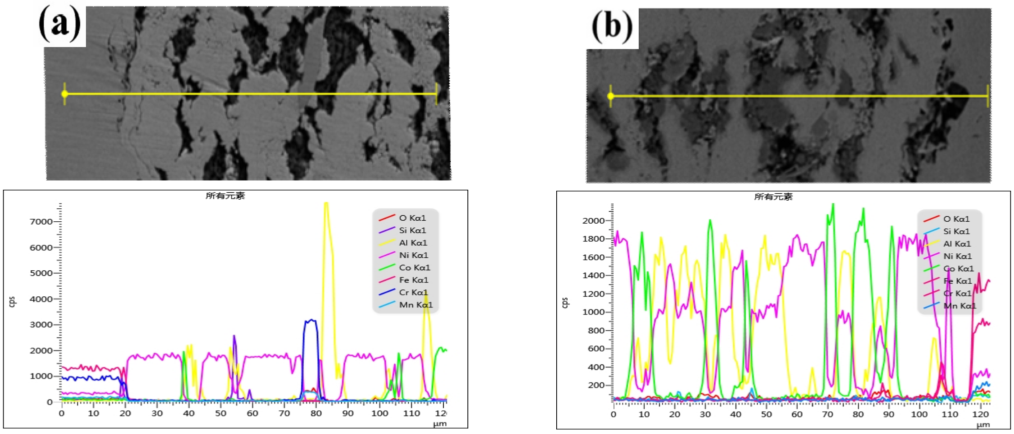


Fig. 3 Line scan of NiCoCrAlY coating

Figure 3(a) is a line scan of a NiCoCrAlY prefabricate coating, and Figure 3(b) is a line scan of a NiCoCrAlY prefabricate coating after a vacuum heat treatment at 600°C/4h. Through the curve change of the interface at the line scan, combined with the analysis of the points at the interface of Fig. 2 , it can be seen that the content of Al and Ni in the substrate near the interface increased, and the content of Fe in the coating near the interface of the substrate increased. Explains that the elements has diffused , but the area is shallow.

The conclusion

(1) The microstructure of NiCoCrAlY alloy coating prepared by cold spraying has some impurities and holes, and the distribution of elements is not very uniform. There is a clear interface between the coating and the substrate, which is mainly manifested in the coating with many holes.

(2) The oxygen content of the NiCoCrAlY alloy coating prepared by cold spraying is very low,

which confirms the fact that it is not easily oxidized during cold spray coating, which laid the foundation for the future application of cold spray.

(3)After 600°C/4h vacuum heat treatment, the coating was uniform and denser than the prefabricate coating. Elemental diffusion occurred between the coating and the substrate. Some small holes in the coating disappeared due to the foundation of diffusion.

Acknowledgments

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