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Investigating the Tribological Properties of MoS_2/Ni Composite Coatings Produced by Magnetron Sputtering

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1. Introduction

MoS_2 is the predominant materials used as solid lubricant has been widely used many tribological applications. MoS_2 coating is strongly influenced by the test atmosphere. It has been mostly used as a solid lubricant in space and vacuum application. MoS_2 is too highly sensitive to humid air. The temperature limitation at 400ºC is restricted by oxidation.

In order to improve the properties of MoS_2 coating using the co-sputtering method, several authors have studied adding metals and materials into MoS_2 matrix structure. The composite coatings have shown better performance compared to pure MoS_2 coating in terms of hardness, wear resistance, and adhesion to the substrate. The addition of Ni into the MoS_2 coating in recent years has drawn attention because of the significant improvement of the oxidation resistance and tribological performance dependent on the humidity in ambient air. In this investigation, MoS_2/Ni composite coatings were investigated to give some insight into the effects Ni conternt in MoS2/Ni composite coatings on the microstructure and mechanical properties and tribological performance in the ambient air.

2. Experiment

Samples of Ck45 (AISI 1045) plain carbon steel, measuring 10 mm×5 mm×2 mm were used as substrates. The MoS_2/Cr coating was fabricated in DC magnetron sputtering ion plating equipment. MoS_2 (99.8% purity) and Cr (99.99% purity) with 0, 5, 10, and 15 wt% composite targets of a 50 mm diameter fixed on a magnetron-effect cathode were used. The composite targets were fabricated by ball milling the mixture of pure MoS_2 and Cr powders, followed by pressing the mixture under a pressure of 60 MPa in an Ar atmosphere at 850°C. The MoS_2/Cr ratio in the coatings was controlled by sputtering the composite targets. The chemical characterization was performed using EDX (energy dispersive X-ray analysis) and the structural characterization was accomplished by X-ray diffraction (XRD) studies. The mechanical properties of coatings were analyzed by nanoindentation experiments. The tribological behavior of the coatings was investigated using the pin on disc test at room temperature

3. Results and Discussion

Figure 1 shows specific wear rate of MoS_x/Ni composite coatings as a function of Ni content. The results are x typical of those obtained for the composite coatings with a performance better than the pure MoS_x coating. In contrast, despite its high hardness and good coating Cohision, the MoS_2–Ni 22 at% coating shows a high friction coefficient and poor wear resistance.

Figure 2 shows the wear coefficients of MoS_x/Ni composite coatings. Within the Ni content region of 0–15 at%, increasing the Ni content led to a significant decrease of the coating’s wear coefficient. This indicates that the doped Ni improved the tribological properties of pure MoS_2 in the atmospheric environment. The optimum composition of coatings are MoS_2/Ni_x% with x=13% level. A reasonable explanation is due to the increase of both hardness and adhesion of the MoS_2/Ni coatings with the increase of chromium content to 15 at%.

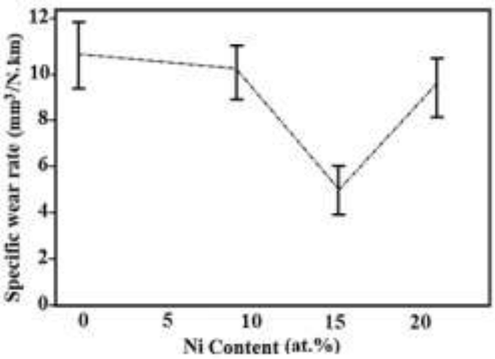

Figure 1. Wear rate of MoS_x/Ni composite coatings as a function of Ni content

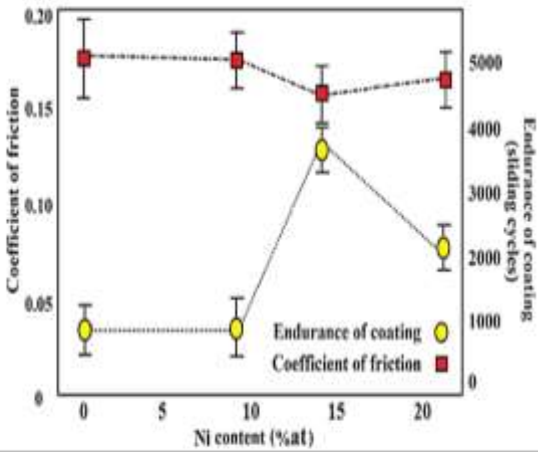

Figure 2. Average friction coefficient and endurance of coatings test results of MoS2/Ni composite coatings with different Ni contents

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4. Conclusion

The MoS_x/Ni coatings exhibited a steady state friction coefficient from 0.15 to 0.19.

Adding Ni to MoS_2 coatings improved their adhesion to steel substrate and hardness as well as increased the wear performance of MoS_x coatings under atmospheric conditions. The main wear mechanisms in the MoS_x and MoS_x/Ni coatings were therefore abrasive and adhesive, respectively.