A Comparative Investigation of Feedstock Materials on Multiple Properties of HVOF-Formed Cr_3C_2-NiCr Coatings: Size Effects of Powders and Carbides on Sliding Abrasive Wear Behavior

Xinqing Ma, Peter Ruggiero, East Windsor, CT/USA

Nowadays, Cr_3C_2-based cermet coatings by HVOF process are widely recognized for their corrosion and erosion resistance, particularly at high temperatures. These coatings also offer the advantage of being lightweight and exhibiting superior wear, corrosion and cavitation resistance in room applications. Their lightweight nature and high temperature capability make them an attractive alternative to WC-based alloy coatings and hard Cr plating coatings. The objective of this study is to develop optimal Cr_3C_2-NiCr coatings by comparing different feedstock materials, including feedstock with nanocrystalline and/or submicron sized Cr_3C_2 phases. The focus of the investigation is on understanding the impact of feedstock features such as particle size, morphology, and carbide sizes, as well as sliding abrasive wear conditions (specifically SiC grit size and working load), on the coating properties and sliding wear performance. The results of the study indicate that the sliding wear resistance of the Cr_3C_2-NiCr coatings is highly influenced by the features of the Cr_3C_2 carbides. The presence of nano, submicron and few microns sized carbides in the coatings improves their density and hardness, leading to a significant reduction in wear rates under test conditions. Furthermore, the size of the abrasive SiC grit on the counter surface plays a significant role in determining the sliding wear behavior of these coatings. Based on the analysis of the test data, the mechanisms behind the performance of the Cr_3C_2-NiCr coatings have been investigated and used to interpret their sliding wear behaviors. A high microhardness in the coating is considered a reliable indicator of high quality, full density, and satisfactory wear resistance. This study has identified and recommended optimized materials for improved coating properties based on the key findings. These findings contribute to the understanding of the relationship between feedstock features, sliding abrasive wear conditions, and the wear rates of HVOF-sprayed Cr_3C_2-NiCr coatings.

1 Introduction

In the realm of material failures, wear failure stands out as a type of corrosion failure that causes surface damage through the progressive removal of material. This damage occurs either due to the relative movement between surfaces or contact with a substance. To improve the surface properties of wear and corrosion resistance, hard chromium coatings have long been employed in various engineering applications such as aerospace, energy, transportation, oil and gas, and mechanical industries. However, the production of hard chromium plating (HCP) involves the use of chromic acid solutions containing hexavalent chromium and catalytic anions, which are known to be carcinogenic. As a result, these substances are now subject to strict regulations imposed by new legislations aiming to address environmental pollution concerns.

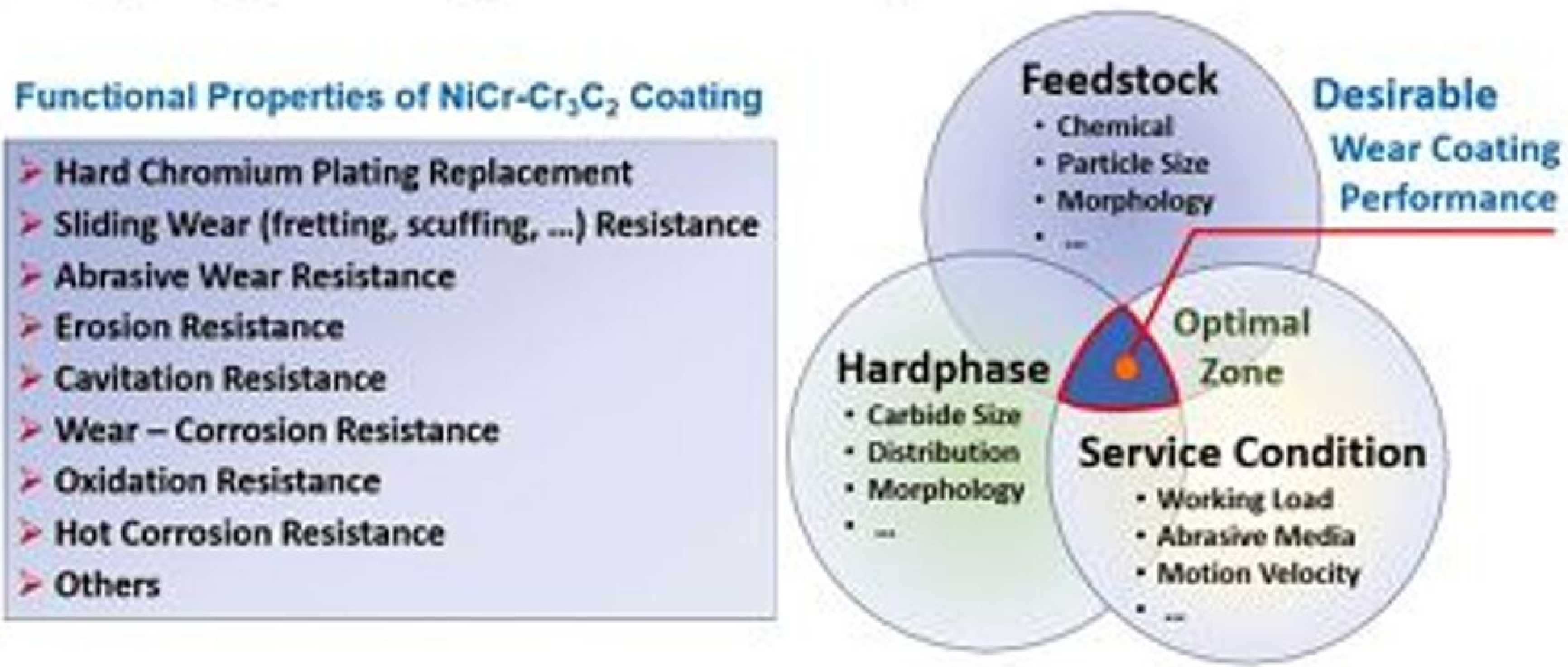

Figure 1. Illustration of functional characteristics of carbide-alloy cermet coatings, specifically Cr_3C_2-NiCr coating. Its exceptional performance can be attained within the ideal range, which depends on crucial factors like feedstock, carbide, and service condition. This is applicable for a thermal sprayed cermet coating.