

Nanostructured Titanium Oxide Coating for Hydrometallurgical Application

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ABSTRACT

High pressure acid leach (HPAL) exposes low grade ore to very severe processing conditions in order to hydrometallurgically recover metals such as nickel, cobalt, and gold. Ball valves play a critical role in containing and directing the flow of the very hot acidic slurry within the autoclaves. A nanostructured titanium oxide ($n\text{-TiO}_2$) coating has been developed with dramatically superior abrasive and erosive wear resistance. Ball valves with the $n\text{-TiO}_2$ coating are currently being used in ten HPAL installations around the world.

KEY WORDS: Nanostructured; coating; thermal spray; high pressure acid leach; titanium oxide; wear; corrosion.

INTRODUCTION

In 1996, United States Office of Naval Research's (ONR's) Dr. Lawrence T. Kabacoff initiated a program entitled, "Thermal Spray Processing of Nanostructured Coatings". This program generated a number of successful coatings with practical and economical values (Kabacoff, 2002). Coatings exhibiting enhanced toughness, superior wear, and increased adhesion, have been developed, qualified (MIL STD 1687A) and applied onto Navy components.

The high-pressure acid-leach (HPAL) process is currently being used to extract nickel, cobalt, and gold from low-grade ore. The HPAL technology relies on very severe processing environment to economically leach and extract metal. The current processing environment consists of very hot ($\sim 260\text{ }^\circ\text{C}$) and corrosive (up to 95 % sulfuric acid) slurry (20 wt% solids) at high pressures (4,700 to 5,500 kPa).

The severe conditions found in Ni/Co HPAL require the ball valves to have protection against abrasive wear, erosive wear, and extreme corrosion. To extend the life of the ball valves while meeting the general mechanical requirements of the components, titanium alloy balls and seats are treated with various surfacing techniques. Amongst the surfacing technologies available, thermal spray application of single- and multi-layer coatings is predominantly used.

Past and present specifications use top coats of chromia-blend or titania on titanium balls and seats with or without a metallic bond coat. Failure analysis carried out by the author on actual thermal sprayed components has revealed chemical attack of some ceramic top coats and all metallic bond coats. The electrochemical attack in bond coat is associated to the production of hydrogen which in turn accelerates the degradation of both the bond coat layer and the substrate.

In May of 2000, Mogas Industries, FW Gartner Thermal Spraying Co., and Perpetual Technologies initiated the first thermal spray nanostructured coatings development effort for use in a non-military application. The objective was and remains to be, "to develop a superior protective coating for the HPAL industry with enhanced erosive-abrasive wear resistance, superior adhesion, and excellent corrosion resistance."

PROCESS DESCRIPTION

The general approach to the processing of nanostructured thermal spray ceramic coatings is illustrated in Fig. 1. The major components of the approach included processing well-bonded agglomerates of nanostructured or ultrafine particles, thermal spraying of the agglomerates to deposit a coating, and characterization/testing of the coating.

Once an adequate powder feedstock was secured, different thermal spray processes and parameters were used and developed, respectively, to optimize bond strength, microstructure, microhardness, and crack propagation characteristics.

EXPERIMENTAL METHODS

- The nanostructured TiO_2 feedstock powder was purchased from Altair Nanotechnologies (Reno, NV) and consisted of nanoparticles ($\sim 20\text{ nm}$) agglomerated to 15 to 53 μm size distribution. The conventional sintered and crushed powder, Metco 102 (Sulzer Metco USA), had a size distribution between 20 and 50 μm .