ABSTRACT

The present investigation was carried out based on the idea to use nanometallic particles in thermal spray powders to give much more homogeneous metal binder phase in the sprayed coating with associated enhancement of the corrosion resistance. The nanosized particles of metal binder were made by spray pyrolysis experiments using microwave heating technology. The results achieved in this project clearly demonstrate the ability to make powders with nanometallic films deposited on WC particles. However, there was a huge oxygen problem related to the process and equipment employed. Moreover, this problem also caused metal loss during spray pyrolysis, as shown for both Co and Cr. Therefore, the oxygen problem should be eliminated during further experimental testing. The present way of making pre-alloyed metal binder deposited on WC particles represents huge potential for rapid implementation of advanced nanotechnology principles into practical industrial use, also allowing high volume production.

KEY WORDS: Powders for thermal spraying, WC hard phase, nano-sized pre-alloyed metal binder, spray pyrolysis.

INTRODUCTION

In thermal spraying of erosion and corrosion resistant ceramic-metallic (cermet) coatings, the corrosion resistance is dependent on the metallic binder phase (Berget, 1998, Berget et al, 1997a, 1997b), while the erosion resistance is taken care of by the ceramic particles with WC as the best candidate (Rogne et al, 1999). Conventional production of powders for thermal spraying is based on agglomeration of WC powders with particles of single metals with final sintering and sieving. The use of such pure metal particles will inevitably provide very inhomogeneous metal binder, which may give insufficient corrosion resistance in certain applications. Therefore, the present investigation was carried out based on the idea to use nanometallic particles in thermal spray powders to give much more homogeneous metal binder phase in the sprayed coating with associated enhancement of the corrosion resistance. The nanosized particles of metal binder were made by spray pyrolysis experiments using microwave heating technology.

In selection of the metal, it is important that it is electrochemically compatible with the substrate (the alloy to be protected by thermal spraying) and other materials being in contact with the coating to avoid galvanic corrosion, and hence, short lifetime of the component. An example is that WC coating with pure Co or Ni as binder may be a good solution for use on carbon steel since the steel itself will provide cathodic protection of the coating. On the contrary, such binder phase will not be sufficient for use on stainless steel, and will serve as sacrificial anode. Selection of appropriate materials for coating of components will be extremely important where repair and maintenance are difficult, either because of costs or accessibility. Examples here are subsea components in the oil and gas industry.

PRINCIPLES OF MICROWAVE SPRAY PYROLYSIS

Particle synthesis by spray pyrolysis involves atomization of a precursor solution into discrete droplets. These droplets are subsequently transported through a furnace where the solvent is evaporated from the droplets and the dissolved species react to form the particulate product. Each droplet has the same composition, thus the desired material particles can be easily synthesized by controlling the chemistry of the precursor solutions. The heating stage was done by the use of microwaves, and nanometallic particles were deposited on WC powder. The metal particles were produced from precursors with spray at 550 to 750°C through the following chemical reaction:

$$\text{Co(NO}_3\text{)}_2 \cdot 6\text{H}_2\text{O(lq)} + 2\text{H}_2\text{(g)} \rightarrow \text{Co(s)} + 8\text{H}_2\text{O(g)} + 2\text{NO}_2\text{(g)}$$

A general form of this equation will be (with Me as metal, m and n as integers):

$$\text{Me(NO}_3\text{)}_m \cdot n\text{H}_2\text{O(lq)} + m\text{H}_2\text{(g)} \rightarrow \text{Me(s)} + (m+n)\text{H}_2\text{O(g)} + m\text{NO}_2\text{(g)}$$

In order to achieve the best possible corrosion resistance of the metal binder phase, nanoparticles of pre-alloyed CoCr metal were made, i.e., Me(NO$_3$)$_m$·nH$_2$O (Me = Co, Cr). For Co m=2, n=6. For Cr m=3, n=9.