HVOF Process Control Study with Almen Strips

ALMEN STRIPS are recognized as the industry-standard tools for achieving process control in shot peening. The test coupons are now getting attention in the field of High Velocity Oxygen Fuel (HVOF) coating sprays.

HVOF utilizes combustible gas and oxygen to produce a flame that is directed at very high velocity through a gun by use of a converging, diverging nozzle arrangement. Powder is injected into the hot gas stream and softened, then impacted with very high kinetic energy onto the work piece layer by layer until the desired thickness is built up. The resultant coatings approach theoretical density and exhibit outstanding performance characteristics. (Source: Cincinnati Thermal Spray, Inc. website: www.cts-inc.net/index.php/resources/thermal-spray-processes)

Because HVOF is used on critical components that are subject to fatigue—for example, landing gear—process control is becoming increasingly important in this thermal spray industry. John Sauer, Sauer Engineering, and Purush Sahoo, formerly with Cincinnati Thermal Spray, published their research with Almen strips in a paper titled, "HVOF Process Control Using Almen and Temperature Measurement." We've reprinted a portion of the paper here; download the complete paper from the library at www.shotpeener.com.

HVOF PROCESS CONTROL USING ALMEN AND TEMPERATURE MEASUREMENT

Abstract

The HVOF process with reduced heat effect on the substrate and therefore minimal degradation of fatigue properties is now finding wide application in fatigue critical applications. The critical parameters for process control are residual stress in the deposit and maximum substrate temperature. Quality control tools for these parameters are deflection of Almen Strips (similar to shot peening) for simulating residual stress and the use of infared pyrometry for temperature measurement. Both of these methods are technique sensitive particularly in spraying of coupons to evaluate the effect of coating on material properties. Lessons learned will be presented and recommendations made for applications of these tools in controlling the HVOF process.

Introduction

With the increased use of thermal spray coatings in more critical applications involving properties like fatigue, the subject of process control is also receiving increased emphasis. In addition to the normal quality control (QC) techniques such as metallography, tensile, and hardness, methods such as Almen strip deflection and infrared temperature measurement are now being implemented to monitor process output.

Although these different tools are not new quality developments, widespread use in the industry is just beginning to occur. The Almen method is used to measure the relative amount of residual stress imparted to the coating/substrate combination during spraying. This is critical for applications where residual stress has a major impact on fatigue properties. Infrared temperature measurement monitors temperature of the part being coated as a non-contact method. This is important where increased heat transfer to the part can affect near surface substrate properties in applications like landing gear fabricated from the family of 4340 materials. Thus, both methods are essential to process control and a final product with the intended properties for the application. As with many of the quality control methods, standard procedures or specifications are not available or do not provide sufficient guidance/identification of the critical variables that govern test performance. Standardization of test procedures across the industry is an important need and is an area of concentration for many companies/industry committees. With the implementation of Almen/temperature measurement, this is an ideal time to consider the standardization issue.

The purpose of this paper is to summarize the same practical testing framework for Almen/temperature measurement as related to thermal spray and identify the critical variables. It is suggested that with the knowledge of the important parameters, procedures can be written that will produce consistent feed back for the thermal spray process. It is recognized that different techniques can and will produce valid results. This article will not endeavor to identify the "best" or "only" test method. General procedural summaries will be given and variables identified. Examples will also be given showing possible process variation and allow people to understand test output when comparing data from different sources/locations.

Again, the complete paper is available for download in the online library at www.shotpeener.com.