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THE TRANSFORMATIVE BENEFITS OF CERAMIC COATINGS

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CERAMIC THERMAL SPRAY:

Realized Benefits Leading to Expansive Growth

The heat resistive properties of thermally sprayed ceramics inside combustors are well documented. However, ceramics can provide more than just thermal insulative benefits. In addition to their low thermal conductivity, ceramics are stable at high temperatures, combat wear and erosion, resist electricity (electric insulator) and deter numerous types of corrosion. These characteristics have promoted technical integration into complex systems across many diverse industries. Engineers have been able to further tailor these beneficial properties through the development of new and advanced coating processes. From tiny medical devices that fit in the palm of your hand to large industrial rollers that weigh over 2 tons, ceramic coatings are currently being applied to a wide variety of specialized products.

EARLY COMMERCIALIZATION OF CERAMIC THERMAL SPRAY COATINGS

Starting in the 1960's, the demand to improve the efficiency of jet engines drove rapid innovation and commercialization of thermally sprayed ceramic coatings. These coatings have since evolved in terms of chemistry, architecture, and durability to such a degree that today many ceramic coated products have become "prime reliant" (meaning the engines cannot operate as intended without the coating). In the early days, the commercial jet engine industry was pushing the operational thermal limits of the metals inside the engine. The need for insulative ceramic coatings was born and first utilized by Pratt & Whitney Aircraft in the combustion design of the J58 engine. Throughout the following years, several advancements in the materials and processes were recognized to support the continual increase of combustion temperatures. The low thermal conductivity of the standard thermal barrier ceramic coating, Yttria Stabilized Zirconia (1.1 W/m • K), was so successful at protecting combustion surfaces from over exposure to excessive heat that the coatings were subsequently introduced to the turbine section of the engine. Without the protection of these thermal barrier coatings, the metal components would rapidly oxidize and quickly degrade. With the commercialization and successful performance of thermally sprayed ceramic coatings over the following decades, other applications broadly emerged.

CORROSION AND WEAR RESISTANCE

As previously mentioned, an advantageous characteristic of ceramic coatings used in industrial applications is its chemically inert behavior. Due to the passive nature of ceramics, these coatings are utilized in harsh acidic or caustic environments to protect metals from corroding. Thermal spray materials like Chromium Oxide and Titanium

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Oxide are commonly used as corrosion barriers in industries such as chemical processing, mining, petrochemical, paper and valves. In applications such as on the interior of pump sleeves, ceramic coatings have been used effectively to provide wear protection when pumping highly corrosive media.

While traditional metallic hard-face coatings rapidly deteriorate in these harsh environments, hard ceramics operate for years in service without fault. Historically, plating processes such as chrome plating have been utilized in wear and corrosion applications where metal-on-metal contact degrades parts quickly. However, most chrome plating can only operate in temperatures under 800ºF. Also due to environmental processing concerns and increasing government regulations, chrome plating has fallen out of favor in many cases to ceramic thermal sprayed coatings. With the cost of corrosion in the United States estimated in the multi-billions of dollars annually, the use of ceramics continues to expand. Lower operating costs and extended uptime in key commercial industries are aided by the use of thermally sprayed ceramics to help reduce chemical attack.

DIELECTRIC APPLICATIONS

Ceramic coatings, such as Aluminum Oxide and Alumina Titania, are commonly used because of their electrical resistivity. These types of plasma sprayed ceramics are referred to as dielectric coatings. Since a very low amount of electrical current is able to flow through ceramic thermal spray, the coating is extremely effective when used as an electrical insulator. You can find these coatings being adopted into complex circuitry, and even onto electrical connectors within the telecommunication industry. These coatings have also been employed in automotive heat sink applications for a number of years. This specific application involves applying an Aluminum Oxide coating on top of an electrically conductive plate. Subsequently, a coating of copper is applied on top of the aluminum oxide. After coating, heat sink circuitry is soldered directly onto the copper coating. This results in the heat sink circuit being electrically isolated from its mounting base plate due to the barrier of ceramic between the circuit and the plate.

MOLTEN METAL

For years thermal spray coating technology has represented the gold standard within the galvanizing and aluminizing continuous strip lines across the world. An example is the high-performance roll face release coatings for molten Zinc and Aluminum. These engineered coatings effectively deter dross pick up within the molten metal pot allowing for extended runs at the mills. Even after decades of success using ceramic coatings, new materials and processes are being developed with the goal of setting new records in these lines. Ceramic thermal sprayed coatings have flowed into other areas of the mill as well, as their ability to withstand the aggressive attack of molten metals while combating excessive wear has driven increased adaptation. Continuous improvements of coatings in this market have included the experimentation and ultimate adaptation of new materials through the blending of both carbides and ceramics.

MEDICAL IMPLANTS

One very unique application of thermally sprayed ceramic coatings has been within the biomedical field. Porous hydroxyapatite ceramics were developed for bone graft surgeries. This material, composed of calcium phosphate, promotes biocompatibility and stimulates bone growth for orthopedic implants. One of the unique benefits the plasma process provides is its repeatability, providing the same coating across thousands of

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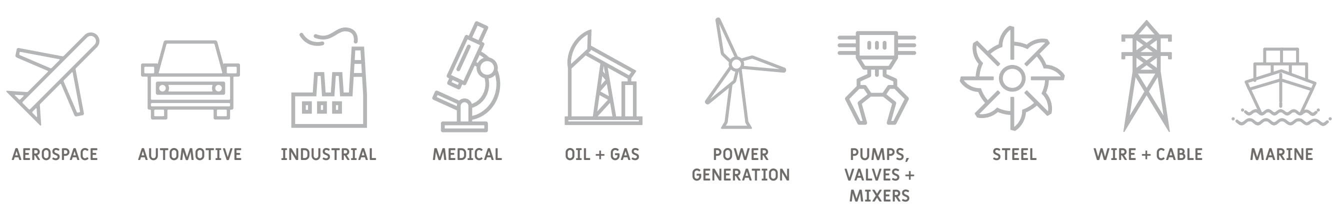
production runs. These biomedical coatings are engineered to contain the proper amount of porosity to enable growing bone to permeate through the coating thus improving the bonding of the implant over time. The thermal spray process was utilized to improve the success of these procedures. Thermal spray is used on millions of prosthetic implants each year.

EVOLVING MARKETS

From a coating shop standpoint, the request for information on ceramic coatings dominates the types of materials being sought after by prospective customers. The benefits of these coatings continually expand as new applications are identified. Melting temperatures of ceramics exceed 3,700°F. The coatings also retain tensile strengths generally higher than 5,000 psi, which is over five times greater than that of traditional paint type coatings. Thermal spray ceramics can be applied thicker than almost any other ceramic coating process, and that leads to a much longer performance life. Sophisticated new thermal sprayed materials are being designed into emerging technologies. For example, solid oxide fuel cells use ceramic coatings to reduce chromium depletion from interconnects, which substantially increases energy efficiency and improves the viability of these new power sources. New rare earth oxides are being doped into legacy zirconia-based thermal sprayed ceramics to further reduce temperatures inside gas turbine engines. This enables engines to burn fuel at higher temperatures, increasing fuel efficiency and helping to reduce carbon emissions. As these examples demonstrate, ceramic coatings are a preferred enhancement used in the development of many new technologies. Thermal spray continues to be far and away the most robust and preferred method of application.

THERMAL SPRAY CERAMIC	PRIMARY BENEFITS	EXAMPLE INDUSTRIES
Alumina Zirconia	Resistant to molten metal attack	Foundries, steel manufacturing
Alumina Titania	High temperature abrasive	Aircraft engine
Aluminum Oxide	Low electrical conductivity	Automotive, instrumentation
Yttria Stabilized Zirconia	Low thermal conductive, thermal shock resistant	Jet engine, power engine
Chrome Oxide	Corrosion / wear resistant	Pump, petrochemical
Titanium Oxide	Dry lubricious high temperature wear resistant	Automotive cylinder bores
Hydroxyapatite	Bioactive, promote faster bone growth	Medical implants, prosthetics



FOR MORE INFORMATION ON CERAMIC COATINGS, PLEASE VISIT THE CTS ONLINE RESEARCH CENTER AT WWW.CTS-INC.NET/RESEARCH-CENTER OR SEND AN EMAIL TO SALESHELP@CTS-INC.NET

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