Introduction

For nearly thirty years, Moyno, Inc. has been a leading innovator in progressing cavity pump rotor coatings. It has continually invested in the development of new coatings with the performance characteristics necessary to address an ever-increasing array of aggressive fluid transfer applications.

One of the most promising techniques developed to-date is thermal spray deposition, which Moyno supplies under the Moyno® Ultra-Shield™ brand name. Once limited almost exclusively to aircraft/aerospace OEM applications and parts reconditioning, optimized thermal spray technology is beginning to make a niche for itself in the progressing cavity pump industry as a result of Moyno's research and development successes. As a whole, thermal spray technology offers greater value per dollar than any other method of rotor coating application.

Basic Progressing Cavity Pump Theory

A Moyno progressing cavity pump is a positive displacement pump consisting of a single threaded screw (rotor) turning eccentrically within a double threaded nut (stator). This configuration is referred to as a 1:2 element profile because there is one lead on the rotor and two leads on the stator (See Figure 1). The 1:2 element profile is commonplace in most progressing cavity pumps, although any configuration is possible as long as the number of leads on the rotor is $N$ and the number of leads on the stator is $N+1$.

The rotation of the rotor within the Moyno pump forms a series of cavities defined by the areas of contact between the rotor and stator, known as seal lines. The pump cavities are 180 degrees apart from one another and progress from the suction end to the discharge end of the stator. With 1:2 profile elements, the first cavity opens at the same rate the second cavity closes, providing a repeatable, pulsation-less flow rate.

Most Moyno progressing cavity pumps feature stators molded from any number of elastomeric materials. Typically, they form a precise, compressive fit around the hardened tool steel rotor. Over the years, Moyno pumps have developed a reputation for their ability to function reliably under harsh service conditions. The elasticity of the stator allows the Moyno pump to pass abrasive fluids with much greater success than other positive displacement pumps that have metal-to-metal contact surfaces.

Chrome Plating… the Standard Bearer

Traditionally, the rotor has been coated by a layer of chrome plate as a means of protection against corrosion and erosion. Chrome plating has been developed into a cost-effective, reliable, all-purpose rotor coating with years of trouble-free, field-proven service. Its smooth surface is easily polished to a fine micro-finish helping to achieve the required snug compression fit between the rotor and stator. Chrome plating is the standard against which all coating alternatives are compared.
The evolution of Moyno rotor coating research has lead to the development of a second generation of coating technologies with characteristics that extend peak pump performance even under extremely abrasive and/or corrosive service conditions.

The Early Phase of Discovery

The early 1990's saw the beginning of Moyno's thorough evaluation process that focused on a variety of coating types. Of the multitude of coatings available on the market, each one was different in terms of a number of variables – application process, the coating material itself, chemical resistance, performance longevity, cost, etc. As the Moyno evaluation program began to take shape, it became evident that rotor coating testing strategies were in need of some wholesale changes if the results were to provide the depth of information needed to deliver breakthrough performance improvements. Originally, testing consisted of a control pump equipped with a chrome plated rotor, turning at a fixed rate of speed, pumping a sand slurry. The rotor featuring the test coating was placed within the stator of a second pump pumping the same sand slurry. After 300 hours, the test was halted and the coatings were examined. The test coating's wear characteristics were then compared to those of the chrome plated rotor. The results derived from the 300-hour sand slurry testing served to guide the rotor coating evaluation process. But, it soon became clear that improved testing procedures had to be developed to better understand the actual performance characteristics of these new coatings and how they compared to one another.

Refined Testing Methods

In order to improve accuracy, new test procedures had to satisfy two objectives. First, they had to quantify the amount of wear occurring on the coated rotor at different stages throughout testing. The second objective was to effectively isolate the cause of the rotor coating wear.

The revised testing specifications called for the use of two control stators attached to a fresh water loop and two test stators attached to a sand slurry loop. Before any wear testing took place the diameters of the chrome plated rotor and the specially coated rotor were both measured with a micrometer. They were then placed inside the control stators for initial performance evaluations. Since the control stators operated in the water loop under non-abrasive conditions, their dimensions remained unaltered in terms of wear. Once the evaluations were complete, the rotors were removed, then placed inside the test stators for a total of 50 hours of sand slurry pumping. At regular intervals during the sand slurry testing, performance evaluations using the fresh water loop and micrometer readings were conducted. Consequently, any drop in performance noted during the water loop verification testing could be directly linked to the abrading of the rotor that had occurred during the sand slurry pumping test.

After preliminary evaluations, most coating processes were eliminated from consideration. Many were found to be inadequate from a performance standpoint or their production costs were not justifiable.

By the mid-1990's a group of coating techniques known as thermal spray (Moyno Ultra-Shield) processes exhibited test results that were very promising. They seemed to provide an optimized combination of cost efficiency, abrasion resistance, corrosion resistance, bond strength and hardness.

Moyno® Ultra-Shield™
Coating Application Process

In the thermal spray process, the coating material is heated, then accelerated in a high temperature, high velocity gas stream, and propelled against the rotor surface. The molten or semi-molten droplets form thin, overlapping platelets which solidify quickly on the rotor (see Figure 2). Multiple layers of these densely packed platelets, tightly bonded to the substrate, make up the Moyno Ultra-Shield coating. Despite the complex geometry of the rotor shape, Moyno uses a computer controlled, fully automated deposition process to ensure a superior degree of control over the application of the coating for maximum uniformity. Typical Moyno Ultra-Shield rotor coating thicknesses range from 0.002 to 0.020 inches. However, both thinner and thicker coatings are achievable and have been successfully applied.

Most notably, Moyno Ultra-Shield application techniques deposit coatings with very high melting points without significant heating of the base rotor material. Often times,
the temperature of the substrate may be held below 150 degrees C, thus allowing for the application of a coating without distorting the precise geometry of the rotor. By preserving the rotor's dimensions, Moyno is able to maintain precise, repeatable, compressive fit tolerances with the mating stator for peak pumping efficiencies and longer life that the competition simply cannot match.

**Another Moyno Advantage**

In order to ensure peak coating performance Moyno has optimized every aspect of the thermal spray process for exceptional hardness, finish and corrosion resistance. The company utilizes specially formulated, high-tech powder compositions that make its Moyno Ultra-Shield coatings much denser while providing improved cohesive and adhesive properties. Refined application process parameters including particle velocity, application angle, feed rate and the number of passes of the nozzle, result in better overall coating performance.

In addition to further developing the metallurgical properties of Moyno Ultra-Shield coatings and their application techniques, Moyno has made significant technological breakthroughs in the development of advanced surface polishing technology. Now, previously unattainable high micro-finishes of these super-hard coatings are routinely achieved. For example, Moyno has developed the advanced technology necessary to polish the normally dull surface finish of an Ultra-Shield-coated rotor to a shiny, mirror-like appearance. The resultant improved fit within the stator offers greater pumping efficiencies, increased pump life and less downtime for maintenance.

**Performance Characteristics of Moyno Ultra-Shield Thermal Spray Coatings**

Thermal spray-applied Moyno Ultra-Shield rotor coatings have distinct features that offer real benefits to the end user if specified properly. Taking into account factors such as fluid pH and solids content, an experienced Moyno applications engineer is able to suggest the optimum coating in terms of service life, performance and overall customer value.

**Moyno® Ultra-Shield 20™**
- Superior coating applied with the most advanced technique
- Best corrosion, erosion and abrasion resistance
- Highest bond strength
- Smoothest micro-finish attainable
- Lowest micro-porosity of all coatings
- Recommended for highly abrasive applications

**Moyno® Ultra-Shield 15™**
- Superior corrosion resistance
- Very smooth micro-finish
- Sensitive to impact

**Moyno® Ultra-Shield 10™**
- Good corrosion, erosion and abrasion resistance
- Good sliding wear resistance
- Low micro-porosity
- Not suitable for hydrochloric acid, sulfuric acid, sodium hydroxide, ammonium hydroxide and sodium chloride

**The Results Are In**

Field application trials proved successful. In case after case, across a range of industries, Moyno Ultra-Shield coatings proved to be the best value in Moyno pump rotor protection.

**Case Study No. 1**

A leading North American ceramic tile manufacturer was looking for a solution to address the challenges associated with pumping a heavily abrasive clay slurry. To address the situation, the customer arranged for two of his six Moyno PC pumps to be fitted with rotors treated with thermal spray-applied, Moyno Ultra-Shield 20. The coatings exceeded customer expectations by providing months of trouble-free operation. Soon thereafter, the remaining two Moyno pumps were converted as well. Currently, despite the severely abrasive operating conditions, the pumps continue to surpass previous performance standards.
Case Study No. 2
An oil refinery for a major oil company uses a Moyno progressing cavity pump to transfer bio-sludge with a 3 - 7% solids content. Even in this harsh service environment, Moyno felt that the rotors with alternate coatings were not lasting long enough. After the installation of a Moyno Ultra-Shield 20-coated rotor, pump service life increased by 4-1/2 times.

Case Study No. 3
Six Moyno progressing cavity pumps were installed in a Columbus, Ohio wastewater treatment facility for the transfer of primary sludge with a 6% solids. Because of the abrasive nature of the sludge, Moyno Ultra-Shield 20 rotor coatings for the six pumps were specified. The coated rotors continue to operate with no downtime or maintenance required.

Solutions That Fit
Even as abrasive and/or corrosive pumping conditions become more severe, Moyno has developed solutions to ensure sustained Moyno progressing cavity pump performance. The innovative application of thermal spray technology has earned a reputation as a particularly effective solution. Moyno's control over all application and surface finishing variables results in high-density, well-bonded, protective coatings with precisely controlled material compositions and deposition uniformity that differentiate Moyno performance from the competition. Moyno progressing cavity pump rotors coated with Ultra-Shield protection exhibit the highest levels of abrasion and corrosion resistance, which ultimately leads to longer pump life and less downtime in abusive service environments providing greater value for the end-user.