MAGNAPLATE
COATINGS ENGINEERED **FOR YOUR SUCCESS**

WHITE PAPER

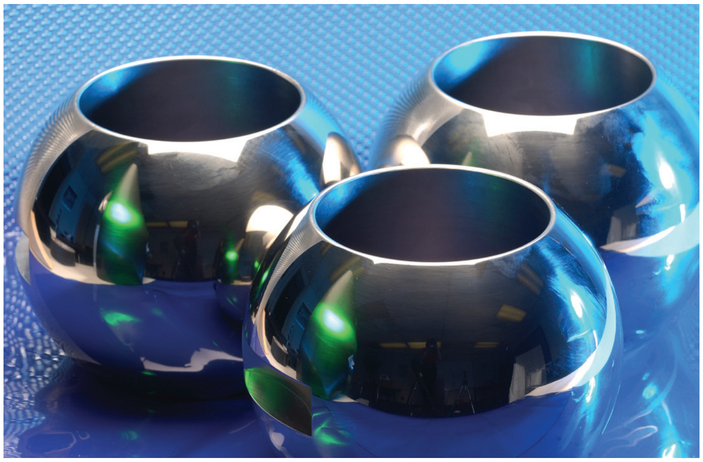
Engineered Coatings Alleviate Drill Tooling Wear

With today's oil and gas wells pushing deeper and deeper, metal drilling tools have to contend with increasingly corrosive conditions. Deep wells not only tend to exhibit concentrations of sour gas, but also subject drilling tools to high temperatures and pressures. Making matters worse, the rotary action of drilling exposes tools to constant wear. Offshore conditions are even more challenging given the difficulty and cost of maintaining drill strings.

Coating technologies can do a fair job protecting tooling against corrosion, galling, pitting and other wear mechanisms that afflict drill strings. These coatings may be as simple as a paint. Increasingly, though, the tough conditions imposed by deep wells require the added protection offered by engineered coatings.

Traditional Coating Problems

Many types of coatings will work adequately when used in the proper application. Standard or traditional coatings such as hard chrome, QPQ, fluoropolymers and tungsten carbides have long been used in oil and gas applications with some success. The problem is that these traditional coatings don't stand up to the levels of sour gas, pressure and rotating contact found in today's oil and gas wells.



Delivering an extremely low coefficient of friction, MAGNAPLATE HMF® eliminates galling that could result in premature wear, leaking and, ultimately, the total failure of valves and other metal parts.

Traditional and fluoropolymer coatings can fail under regular usage. Standard fluoropolymers, for example, are rated 2H in pencil hardness and wear quickly while traditional coatings are rated on the Rockwell scale of hardness but fail to provide lubricity. Sliding components and ball valves in the oil and gas industry work under enormous pressure. Ball valves normally operate between 10,000 and 15,000 PSI in other industries, but can range from 65,000 to 75,000 PSI in some oil and gas tool applications. Under these high pressures soft fluoropolymer coatings yield and 'squish out" causing galling and sticking. Traditional coatings can easily gall and stick.

Some designers still employ a nitride process or quench polish quench (QPQ) to reduce COF and increase tool life, but these treatments case harden the part. QPQ penetrates six to ten thousandths into the part, changing its metallurgy. Tools used to spin, grab or lift QPQ treated components will not grip the case hardened part.

Advantages of Engineered Coatings

New engineered coatings are leaps and bounds beyond these traditional technologies. Take hardness, for example. A NEDOX® synergistic coating with a COF comparable to a 2H-hardness fluoropolymer coating 'ups the ante' on hardness to 68 Rc.

Synergistic coatings can also be modified to provide enhanced functional attributes while the properties of traditional coatings cannot be manipulated. If tungsten carbide is required in the tool, it can be incorporated into an engineered coating, but the new coating can also be designed to have the COF of a fluoropolymer. Tungsten carbide treatment by itself can be extremely expensive, while a synergistic coating such as PLASMADIZE® exhibits similar properties at a fraction of the cost.

The major advantage of engineered coatings versus other types, such as paint-on varieties, is that the particles in synergistic coatings become an integral part of the substrate. Engineered coatings are mechanically bonded to the metal and the resulting new surface layer resists chipping, flaking, peeling, or rubbing off. Because these coatings create metal surfaces that offer superior performance to both the original base metal and conventional coatings, these surface enhancements are said to be synergistic. Further, because the engineered surfaces either duplicate or surpass the performance characteristics traditionally provided by metals such as chromium, cobalt, cadmium, and manganese, use of these expensive materials can be reduced.

Synergistic Coating Application Process

Engineered coatings are applied to substrates in a multi-step system that begins with specialized cleaning processes. Next, the substrate's surface is enhanced by applying a base coating using plating, conversion, deposition, thermal spray, or a mix of these techniques, depending on the specific coating formulation.

The process then continues with a controlled infusion of various engineered polymers or other dry-lubricating particles or metals. For example, on some metals, a hard layer of nickel alloy is deposited on the surface. The micro pores are enlarged, and polymer particles are then infused into the surface layer. A second-stage treatment ensures thorough integration into the top layer.

Design and Coating Considerations

Because the stakes are high in deep and offshore wells, standard industry test time for new materials and coatings is twelve to eighteen months. Often, traditional coatings are specified when engineered coatings with superior performance characteristics should be considered.

Too often the surface enhancement of parts is an afterthought for design engineers. Rather than being a part of the discussion in the early stages of design, designers try to solve problems with coatings at the point of manufacturing – or even after manufacturing. While each type of surface treatment (anodizing, electroplating, thermal spray etc.) provides its own unique set of properties and benefits, each of these processes also has considerations that should be addressed early on in the design process to ensure optimal performance.

When considering coatings, design engineers should discuss base metal choices, tight tolerances, small or blind holes, masking (coating all over vs coating only selected areas) and components of different materials with their coating vendor. Common mistakes such as attempting to combine two coatings, each requiring different application processes, to be specified on one part can be avoided. Each coating process has specific thickness and tolerances to which the coating can be applied. Depending on the process selected, parts may or may not require machining after the coating is applied. Engineers should pre-size parts to accommodate coating thickness and tolerances wherever possible.

System Design Advantages

Engineered coatings can improve drill string components as well as gate valves, impellers, rotors and mud pump components providing protection from corrosion and chemicals as well as reducing friction and wear. Synergistic coatings such as PLASMADIZE, NEDOX and MAGNAPLATE HMF allow tool designers to make the drilling operation and extraction more efficient by downsizing casings and making components smaller. Initial tool costs can be lowered by employing reduced amounts of tooling material and less expensive metals. Longer term, the improved COF and chemical resistance of surface enhanced parts increases the working life of tool and minimizes down time. System design advantages, such as power reduction, can also be realized with increased COF and smaller, lighter tools available with engineered surface enhancements.

APPLICATION EXAMPLES

Problem: A failsafe safety valve, placed 300-500 ft below the ocean floor, was being developed by a tooling company. Following two years of research and development, the most common failure mode was determined to be galling produced by attempted rotation after metal to metal pressure had exceeded 30,000 PSI. A number of traditional and engineered coatings were tested on the valves.

Solution: A NEDOX engineered coating was used to coat the steel ball valves to prevent corrosion, galling and seizing. Once this synergistic coating was applied, the failsafe safety valve performed exceptionally well under the harsh conditions. NEDOX is produced by a proprietary, multi-step process employing specially developed processing equipment.

Problem: Engineers discovered galling on the stainless steel balls used with powdered metal seats on some of their valve models. It was found that micro deposits in the polymer-impregnated electroless nickel coating used to protect the balls was responsible for the galling. If left uncorrected, the galling would result in premature wear, leaking and ultimately, total failure of the valve.

Solution: Synergistic coating MAGNAPLATE HMF solved the problem by creating an exceptionally smooth, slippery, amorphous, non-crystalline micro finish that has the appearance of chrome. Because the surface is so extremely smooth, wear resistant, and corrosion resistant, it exhibits a much lower coefficient of friction (COF) than other coatings. This reduced the galling and saved the ball seats. MAGNAPLATE HMF is produced by a proprietary, multi-step process employing specially developed processing equipment.