

SIFCO PROCESS® SELECTIVE PLATING.

IT'S CRITICAL TO **ENHANCE** COMPONENT EFFICIENCY, LONGEVITY AND PROTECTION, **OR** TO **REPAIR** EQUIPMENT. AND, UNLIKE CONVENTIONAL METHODS SUCH AS TANK PLATING, THE SIFCO PROCESS® ISN'T SLOW OR INCONVENIENT. IT RAPIDLY DEPOSITS THE SOLUTION TO MEET YOUR APPLICATIONS' DEMANDS **ANYTIME,** WHICH MINIMIZES DISRUPTION, AND **ANYWHERE** – SO WHEREVER YOU ARE, YOU CAN STAY OPERATIONAL FOR LONGER.

Introduction

The current cost of corrosion to US industry has been estimated to reach as much as \$540bn in 2015 based on the forecasted GDP.

With an infrastructure that continues to age, this cost is likely to rise further and needs to be addressed urgently to maintain component and system performance and reduce unplanned, costly downtime.

This paper examines the causes and impact of corrosion and wear on power generation equipment in the US. Taking an in-depth look

at the challenges facing power companies and the associated costs, it explores the technologies and techniques used to address corrosion, focusing on a solution that is portable, fast and cost-effective.

A critical requirement to combat the economic impact of corrosion and wear damage to power generation equipment is a plating process that can enhance component performance,

longevity and protection or be used to conduct repairs quickly and cost-effectively. The conventional industry approach is to use methods such as tank plating. However, the SIFCO Process® of selective plating offers a portable alternative that can meet the challenges of demanding industrial applications, enabling equipment to stay operational for longer with minimal disruption.

This paper identifies how selective plating using the SIFCO Process®, the definitive selective electroplating system, is already making a difference in power generation applications.

\$540 billion

estimated cost of corrosion in 2015



The cost of corrosion

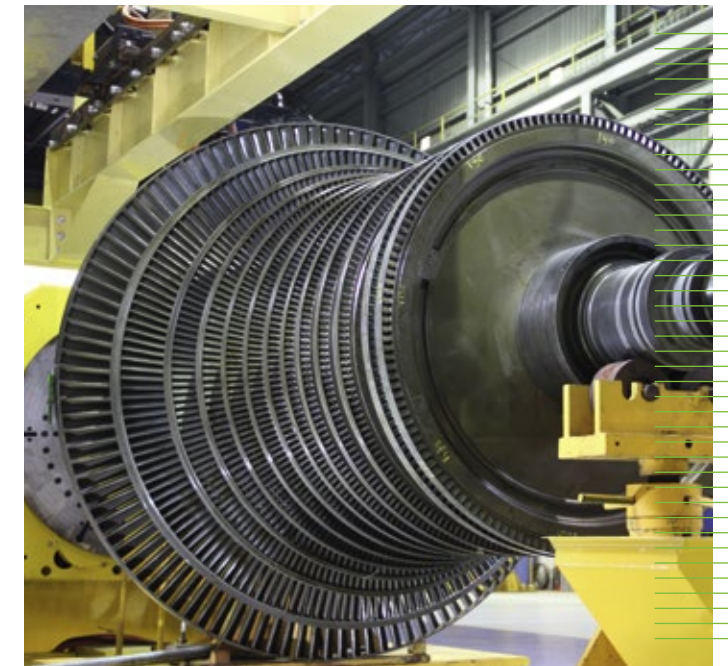
Issues such as wear, corrosion, fretting and conductivity can have serious impacts on the costs and efficiency of operations due to unplanned operation and maintenance (O&M) requirements.

Repair of in-service components can be costly both in terms of time and money

and can lead to disruptive downtime. With the often harsh environments that generators and turbines have to operate in, damage caused by corrosion is a serious issue and the cost of corrosion to industry globally is well documented.

The most accurate estimate for corrosion costs in the Power Generation industry remains the NACE 2002 report *Corrosion Costs and Preventative Strategies in the US*. More than a decade later, NACE International recommends that this report “remains an influential industrial template on the costs and control of corrosion” and that corrosion continues to be a major cost to the power generating industry.

The study found that the total cost of corrosion to the US economy was 3.1 percent of the nation’s GDP (\$276 billion in 2002). Of the total cost of corrosion, 34.7 percent was attributable to



utilities, with electrical utilities accounting for 14 percent of that (\$6.9 billion). Based on the assumption that the percentage of the total cost still stands at around 3.1 and a forecasted GDP for 2015 of \$17,419bn, the current total direct cost of corrosion could have risen to as much as \$540bn. In reality, the figure is likely to be higher as infrastructure ages. Furthermore, these are only the direct costs and do not take into account indirect costs such as sales, administration, taxes and profit which could double the total figure.

Even as new technologies emerge, the challenges of corrosion continue and maintenance expenditure remains a key factor in profitability. For example, a report from consultancy firm GlobalData, states that global maintenance expenditure on wind turbines is expected to rise from \$9.25bn in 2014 to \$17bn in 2020.

O&M work is vital to the commercial viability of wind and minimizing O&M costs can be critical to the profitability of an organization. Unscheduled maintenance downtime, which reduces the availability of the wind turbine

to generate power, leads to increased O&M costs and directly affects the project’s revenue stream. Commercial wind turbines, as with Steam and Gas turbines, consist of a variety of complex systems and failure or malfunction of even a minor component can shut down the turbine.

\$6.9 billion

of total corrosion cost attributed to electrical utilities



Operation and maintenance challenges

The majority of industrial and municipal electric power production in the US is produced by generators driven by steam or gas turbines, with a substantially smaller percentage being produced by wind turbines.

At its core, a turbine consists essentially of a series of rotating blades, the normal mechanics of rotating equipment is one of the factors contributing to a variety of maintenance challenges.

Some problems are more common in gas turbines where corrosion of high-strength, high-cost forged steel components can take place over time.

Corrosion may attack turbine shafting or other components in critical areas and, eventually, weaken a shaft. Within a turbine, corrosion and the subsequent erosion of metal results in what is termed 'bucket rock'. This occurs because the blades within the turbine are not perfectly balanced until the turbine is running at full RPM. So, when a turbine starts up or shuts down the blades rock back and forth until full speed or complete halt is achieved. This rocking causes scraping and rubbing on the shaft, wearing down the metal and creating an area referred to as a bucket – an out-of-tolerance clearance between areas of the shaft and blades. Peak-load GenSets, distributed generating systems located in proximity to the end user, are particularly subject to additional stresses due to the frequency of cycling from on-

line to off-line service. During the off-line periods of low-speed turning-gear rotation, the bucket rock wear problem occurs due to impact and erosion of precision bucket fit-to-wheel tolerances.

Other factors affecting both turbines and generators are high heat and on-going corrosion. Wear or scoring damage can occur on bearing journals or shaft seal areas due to poor lubrication, contamination or overheating. Various atmospheric contaminants and the galvanic potential of dissimilar metals may cause corrosion problems which can often be accelerated by heat, or a variety of fraying surfaces.

According to a report from consultancy firm GlobalData, global maintenance expenditure is expected to rise from \$9.25bn in 2014 to

\$17 billion

in 2020, growth driven by increasing numbers of installations and ageing turbines.



Protective measures

Selective plating is one way to deliver anti-corrosion properties and protect against wear and friction. It can help protect, enhance and optimize the performance of critical components and equipment and can help to improve operating performance, life expectancy, reliability and total cost of ownership.

For the OEM, generators pose a range of unique challenges in design, production and maintenance as static mechanical joints carry huge current loads and the

conductivity and long-term integrity of these joints is essential to output efficiency. Copper and aluminium conductors and other critical grounding locations are commonly electroplated with silver or tin and, in certain applications, nickel.

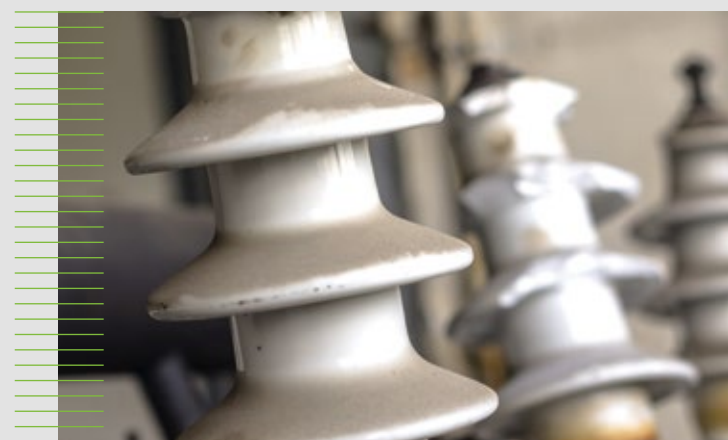
Dynamic joints, which are subject to fretting, may also be candidates for special electroplating processes, particularly when dissimilar metals and galvanic potential are considered in design. Heat sinks present a different set of challenges and, depending on geometry, specific areas of the heat sink may best be electroplated with silver, tin or nickel while the balance of the surface area remains bare or has paint-type coatings applied.

Other areas where electroplating provides an effective solution are collector rings and exciter components that may have design requirements where

electroplated components or specific surfaces of the component will require enhanced conductivity and extend service life. Generator retaining ring inside diameters and the shrink-fit mating area on the rotor/field forging often require enhanced surface treatments to ensure the long-term integrity of the electrical joint, current capacity and proper-fit dimensions.

There is a variety of methods commonly used for mechanical tolerance re-builds and the improvement and protection of current-carrying surfaces, which include weld overlay, metal/thermal spray, mastics and plasticized metals powders, off-site immersion tank plating and selective plating. All have their niches, but none offer the distinct advantages of selective plating.

Significantly faster than tank plating, selective plating minimizes masking, disassembly and downtime, depositing solutions that resist wear, electrical contact and corrosion. It is fast and cost-effective and adaptable for everything from OEM product application to one-off repairs and can be carried out on-site, anywhere.



The evolution of selective plating

In the early days of tank plating, which as the term implies involves components being completely immersed in an electroplating tank, it was common practice to touch up 'bad spots' on plated parts using solution-saturated rags wrapped round pieces of pipe. Today, selective plating and anodizing systems are used to selectively apply engineered deposits and coatings in very precise thicknesses for both OEM and repair applications.

As such, the process is completely divorced from its tank counterpart and although equipment and terms used in each have their similarities, tools, equipment and solutions are unique to each. Selective plating systems are portable and are available

for electroplating, anodizing, and electropolishing. The first North American commercial specification for selective plating was issued in 1956, formally recognizing a portable process as a viable alternative to tank processes. Government specifications MIL-STD 865 and NAV-SHIPS 0900-038-6010 were issued in 1969 respectively and the fact that well over 100 commercial specifications are now documented for selective plating alone confirms the widespread acceptance of the technology.



Applying selective brilliance

The electrochemical selective plating process can be used to repair shafts, housings and journals with low build-up requirements in a much faster and cost-effective way than traditional welding or plating methods. On-site, it provides an improved method for plating bus bars and other electrical connections. It is a solution that can be applied to enhance or repair anywhere at any time, enabling equipment to remain operational for longer with minimal disruption and downtime.

Whereas tank plating requires the component to be brought to the process, selective plating can reverse this process. It involves bringing chemical cleaning and plating solutions in small quantities to the part that needs plating, isolating by masking the area on the part that requires the build-up and applying the metal deposit with the use of electricity – not dissimilar to the principle of carrying out minor automotive bodywork repairs on the owner's premises rather than taking the vehicle to a bodyshop.

When component size, portability or speed of repair is an important factor, selective plating offers critical advantage by being able to take place on-site, minimizing disassembly disruption and shipping costs. However, even when this isn't an issue the SIFCO Process® can also offer a flexible solution. SIFCO ASC operates a global network of job shops where selective plating specialist technicians can prepare and precisely apply the coating. This is particularly useful for enhancing component

performance, modifying operating characteristics and for higher volume applications. Rather than repairing, salvaging or refurbishing components, this approach is particularly suitable for OEM applications and can be specified at the design stage or within the manufacturing process. For OEM applications, selective plating can also be mechanized or fully automated to meet the demands of high volume plating applications.

With the SIFCO Process® it is possible to control the thickness of the deposit to within 0.0002", which in many cases eliminates the need for post-machining. In economic terms, selective plating is best suited in applications where the required build-up provides an overall dimensional change <0.010". With minimal mid- and post-process grinding or finishing, a build-up of up to 0.060" can be achieved.

Compared with tank plating, flame spray and welding, selective plating offers several significant advantages. Masking is minimized, confined just to the area adjacent to that being plated. No heat is involved that risks distorting the part and there are circumstances where parts can be plated exactly

to the desired thickness and returned immediately to service. It is also beneficial where size of the component is an issue – some components are simply too big to fit into a conventional plating tank.

Introduced more than 40 years ago, the SIFCO Process® of selective plating is capable of applying more than 100 metal deposits and coatings and is anywhere from 30 to 60 times faster than the tank plating process. It meets a range of key industry, commercial and military specifications, including AMS 2451, MIL STD 865 and MIL STD 2197 and is widely used throughout the power generation industry in the US where it has proved critical in enhancing component efficiency, longevity and protection both in OEM production and repairs.

Typical selective plating applications and benefits

- Lowering electrical contact resistance
- Improving wear resistance
- Improving corrosion resistance
- Pre-braze coatings
- Anti-galling
- Surface hardness
- Surface etching



Case study 1: Rotor resizing

A major global power generation operation routinely uses selective plating for the maintenance of turbines, saving 50 percent in the time required to return equipment to service. The system is used to build up rotors with nickel to prevent erosion or wear on the shaft and permit optimal performance within the turbine. Re-sizing can be time-consuming and costly; due to the size of a rotor – upwards of 80 to 100 feet long – tank plating be impractical while re-sizing by welding is time-consuming and costly both in terms of the process itself and in the downtime involved.

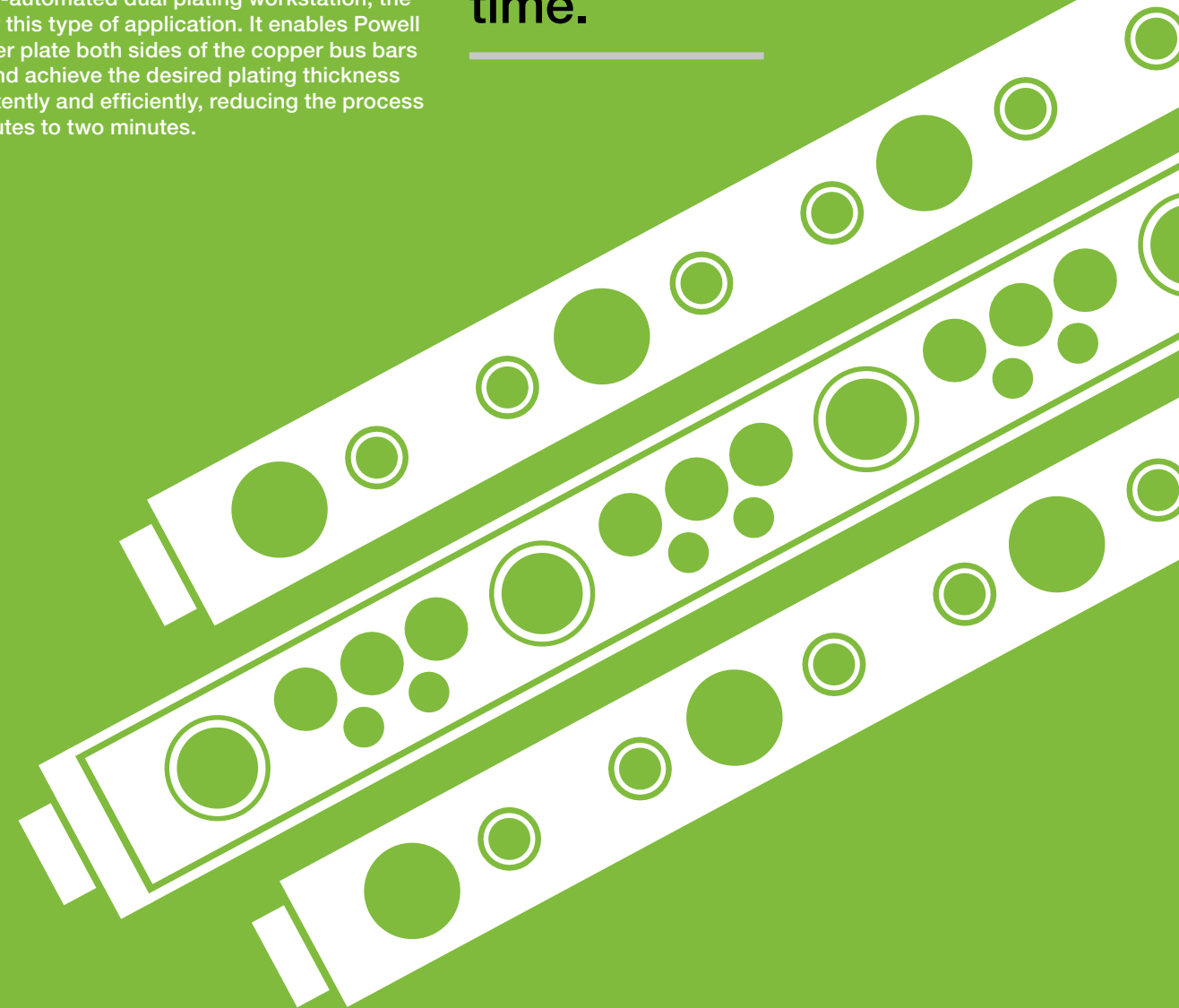
50%
time saving
achieved

Case study 2: Automating copper bus bar plating

Automating the SIFCO Process® at an OEM level has meant that Powell Electrical Systems Inc, Delta/Unibus Division has reduced the process time taken to selectively plate each side of copper bus bars by 90 percent per part and save approximately \$100,000 in labor costs. The bus bars play an important role in conducting electricity through distribution networks and need to be manufacturing to an exacting standard that permits carrying very high currents across mating bus connections with minimal contact resistance. A typical bus bar has four distinct faces that require silver plating, a process that had been carried out manually, one face at a time. The manual process was time-consuming and, at times, led to inconsistencies in thicknesses.

Following discussions with the customer, SIFCO ASC developed a semi-automated dual plating workstation, the first of its kind for this type of application. It enables Powell to selectively silver plate both sides of the copper bus bars simultaneously and achieve the desired plating thickness uniformly, consistently and efficiently, reducing the process time from 21 minutes to two minutes.

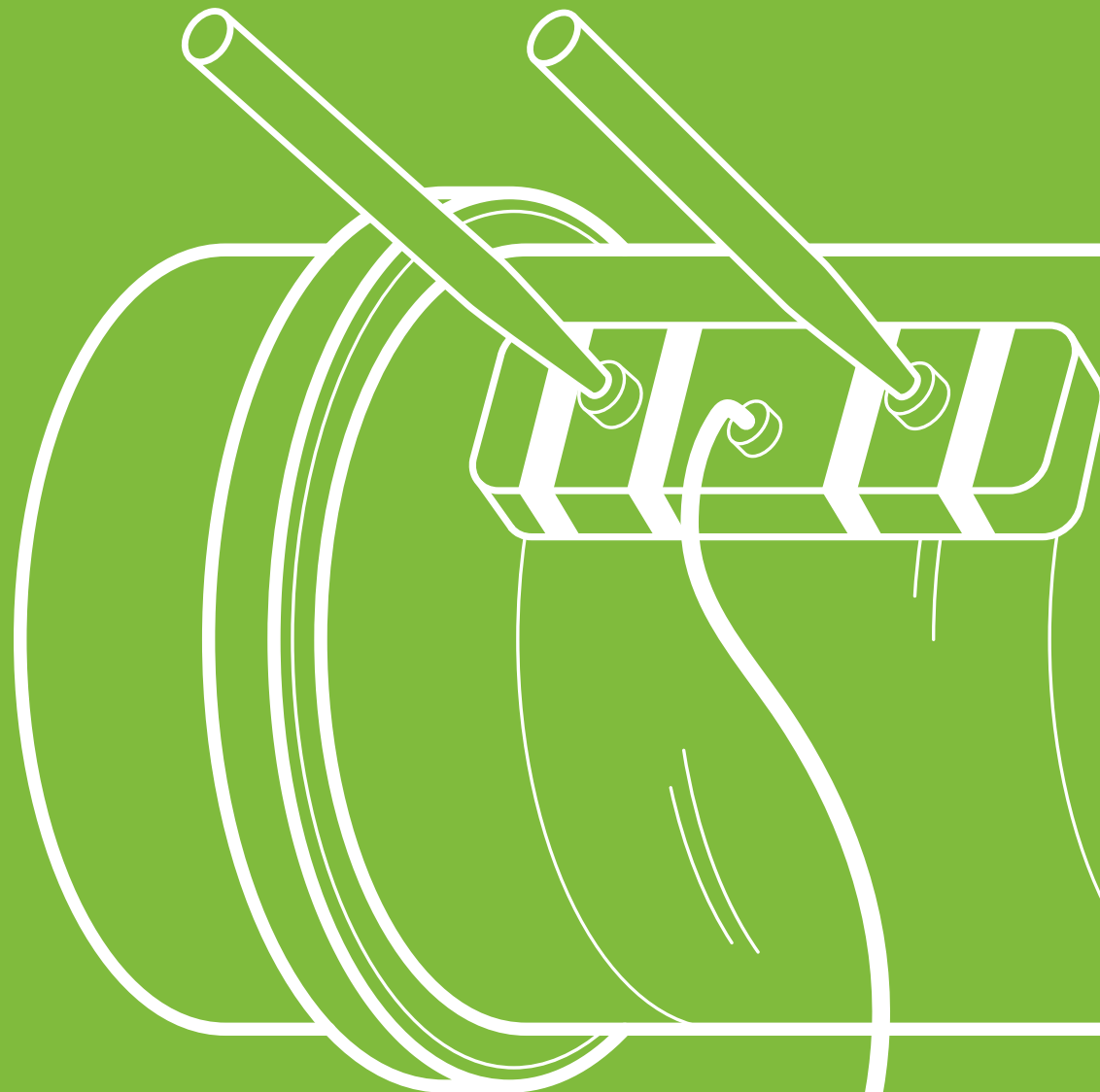
\$100,000
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Case study 3: Generator rotor/field tolerance rebuild

On a steam turbine, the outside diameter of a generator rotor/field forging was undersized, preventing acceptable shrink-fit installation clearance of the retaining ring. In addition, the silver-plated amortisseur bars were worn down exposing the copper base. The friction from the exposed copper on the retaining ring caused a “hot-spot,” depleting the energy output to the generator. In accordance with repair procedures outlined in Mil std 865, the SIFCO Process® was used to dimensionally restore the generator rotor to size and increase the conductivity between the amortisseur bars and the retaining ring.

On-site restoration



60%
of homes in
the US are
serviced by
power-gen
companies
who rely on
SIFCO ASC

Case study 4: Up-tower wind turbine repair

Damaged bearing journals and slip rings can be repaired up-tower using selective plating technology and equipment. This eliminates the need for costly disassembly and transportation associated with traditional repair processes, significantly reducing downtime. While carrying out an up-tower repair, SIFCO ASC technicians can also return valuable generator equipment to its original tolerances and specifications.

SIFCO PROCESS® SELECTIVE PLATING
FOR THE US POWER GENERATION INDUSTRY



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