Solutions Flash
Robust coating solutions for hydropower turbines extend operating life and maintain efficiency
Today’s situation
Increasing global energy demands is driving the growth of renewable energy technologies for primary electrical power production. Overall, renewable energy resources are predicted to increase from a 19% share of electric power production in 2008 to at least 32% by 2035.

As a result, hydropower is enjoying a worldwide renaissance. Well-recognized as one of the most environmentally-friendly energy production technologies, large numbers of new facilities are currently in development or recently commissioned. In addition, many existing facilities are undergoing expansion; often with retrofits of newer, more efficient technologies.

However, hydropower turbines are subject to efficiency losses from corrosion and erosion (hydro-abrasion, fluid erosion and cavitation). Influencing factors include the type of hydroelectric power plant, the design of the hydro turbine (Francis, Kaplan or Pelton), and the specific operating conditions such as the corrosive potential of the water and the size and amount of the silt, sand or gravel debris in the water. At the same time, as utilities strive for greater profitability, installations exploit higher heads (water pressure and velocity) and have expanded into less accessible, more contaminated waterways. These factors have increased the levels of wear mechanisms acting on the turbine components.

The Oerlikon Metco solution
Oerlikon Metco has partnered with leading hydropower turbine manufacturers and users to provide successful coating and wear prevention solutions since the 1930s. We provide our customers the ability to select the best solution from a number of existing coatings or to further develop an existing coating to fulfill the customer’s unique turbine requirements.

Our long experience, backed by extensive in-house testing, gives us a thorough understanding of the mechanisms to which hydropower turbine components are exposed. We tailor coating solutions to withstand the specific operating environment of your turbine using our broad portfolio of materials and application equipment. In addition, if you need an experienced service partner to apply the coatings, our Coating Service facilities offer robust, off-the-shelf solutions and many years of application know-how.

In many cases, hydropower turbine components coated with our solutions outlast those of uncoated components by 3 to 5 times. Thus, using our solutions, hydropower turbines can operate for longer periods and maintain power output efficiency, further contributing to the effectiveness of these renewable energy resources.
Solution description and validation

Wear Mechanisms in hydropower turbine components

The wear mechanisms in hydropower turbines vary considerably, depending on the service conditions that the individual components are exposed. Turbines operating in high head conditions, such as Pelton turbines, may be exposed to greater wear from water erosion. On the other hand, turbines exposed to low head conditions, such as Kaplan turbines, may be exposed to greater wear from entrained debris in the water.

The type of entrained debris in the water must also be considered. Wear effects will be significantly different depending on whether the entrained debris is silt, sand or gravel, and differences will also be evident depending on the amount of debris. Finally, different head waters will have different corrosion potentials, further complicating the means to mitigate the wear effects.

Some components may be exposed to sliding wear primarily caused by the dynamic interaction between mating components. Here, wear coatings can also prove to be an effective deterrent.

While no coating will completely stop these effects, coatings are an effective means of greatly prolonging service life and efficiency. But for the coating to be optimally effective, all factors must be considered.

These erosion tests indicate that service conditions, material choice and application method all play important factors in choosing a successful coating.
# Proven Oerlikon Metco hydropower coating solutions

Coatings applied to hydropower turbine components can extend service life, thereby maintaining turbine efficiency and decreasing maintenance costs. Oerlikon Metco has decades of experience with proven and highly effective coating solutions for hydropower turbine components. Some commonly applied Oerlikon Metco coatings are listed below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Coated Area</th>
<th>Coating</th>
<th>Wear Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kaplan Turbine</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge ring</td>
<td>Partial or entire discharge ring</td>
<td>Wire combustion sprayed 15 mm thick Metcoloy 2</td>
<td>Erosion (hydro-abrasion, fluid erosion)</td>
</tr>
<tr>
<td>Kaplan blade</td>
<td>Partial or entire blade</td>
<td>HVOF 0.4 mm thick WCCoCr Wire combustion sprayed 5 mm thick Metcoloy 2</td>
<td></td>
</tr>
<tr>
<td>Guide vane ring</td>
<td>Between planar surface and draft tube liner</td>
<td>Wire combustion sprayed 5 mm thick Metcoloy 2</td>
<td></td>
</tr>
<tr>
<td>Protective sleeve</td>
<td>2-part sealing elements</td>
<td>HVOF 0.3 mm thick WCCoCr Wire combustion sprayed Metcoloy 2</td>
<td>Seal area, abrasive wear</td>
</tr>
<tr>
<td>Radial bearing</td>
<td>Applied to new or repair components</td>
<td>Wire combustion sprayed Sprababbitt A</td>
<td></td>
</tr>
<tr>
<td>Crank</td>
<td>Slide bearing area</td>
<td>Wire combustion sprayed Sprasteel LS</td>
<td>Sliding wear</td>
</tr>
<tr>
<td>Crank pin</td>
<td>Slide bearing area</td>
<td>Wire combustion sprayed Sprasteel LS</td>
<td></td>
</tr>
<tr>
<td><strong>Francis Turbine</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheek plate</td>
<td>Complete area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guide vane</td>
<td>Complete guide vane, also disc and face side seals</td>
<td>HVOF WCCoCr</td>
<td>Erosion (hydro-abrasion, fluid erosion)</td>
</tr>
<tr>
<td>Turbine cover</td>
<td>Clearance and labyrinth area, wear ring area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runner wheel</td>
<td>Clearance and labyrinth area, runner inlet channel</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pelton Turbine</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pelton bucket</td>
<td>Inside and edges</td>
<td>HVOF WCCoCr</td>
<td>Erosion (hydro-abrasion, fluid erosion)</td>
</tr>
<tr>
<td>Pelton needle</td>
<td>Area subject to wear</td>
<td>HVOF WCCoCr Plasma sprayed Cr₂O₃</td>
<td></td>
</tr>
<tr>
<td>Needle spear</td>
<td>Area subject to wear</td>
<td>Wire combustion sprayed Metcoloy 2 or Sprabronze</td>
<td>Sliding wear</td>
</tr>
<tr>
<td>Nozzle tip</td>
<td>Entire internal contour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nozzle tip insert ring</td>
<td>Area subject to wear</td>
<td>HVOF WCCoCr</td>
<td>Erosive and abrasive wear</td>
</tr>
<tr>
<td>Jet deflector</td>
<td>Area subject to wear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet deflector cover</td>
<td>Area subject to wear</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Materials technology
The wear behavior of a material for a hydropower turbine application cannot be predicted by its simple physical and mechanical characteristics such as hardness, elastic modulus and tensile strength.

For example, there are many WCCoCr materials available on the market. Despite having practically identical chemical compositions, these products can have different particle shapes, morphologies, particle size distributions, primary carbide sizes and bulk densities. As such, the various products can have substantially different wear behavior in service and under various service conditions. Yet, while these differences may be evident through wear testing and in-service performance, such factors cannot be ascertained through the usual hardness tests carried out for coating quality assurance.

Oerlikon Metco has a broad portfolio of standard carbide materials. Many of those materials, including popular WCCoCr materials frequently used to protect hydropower turbine components, are offered in variety of products that vary by powder manufacturing process, particle size distribution and apparent carbide size and density. Oerlikon Metco WCCoCr products frequently chosen for hydropower turbine applications include WOKA 3652, WOKA 3652 FC, WOKA 3653, Oerlikon Metco 5847, Armdry 5843 and Diamalloy 5849.

We are also well-known for our portfolio of proven thermal spray wire products used to protect hydropower turbine components applied using our Metco 16E combustion wire spray gun. These include Metcoloy 2, Sprabronze, Sprasteel LS and Sprababbitt A.

A few hydropower components are best protected using chromium oxide applied by atmospheric plasma spray. Here, too, Oerlikon Metco can provide optimized chromium oxide powders and the application equipment.

WC-CoCr 4Cr coating materials. Above: An agglomerated and sintered material. Below: A sintered and crushed material. Both of these materials are successfully used to prevent wear in hydropower turbines, however, they are used for different turbine applications and exhibit different in-service characteristics.

Other materials commonly used to protect hydropower turbine components. Above: One of many chromium oxide materials offered by Oerlikon Metco. Below: A variety of wire materials that can be applied using combustion wire spray.
Coating application technology

Just as differences in material characteristics can have a large effect on service performance and coating endurance, the method used to apply the material has an equally important role, particularly for HVOF-applied coatings.

While some customers may feel that lower particle temperatures, higher combustion pressures and higher particle velocities will always result in the “best” coating, in practice the coating application technology and parameters must be as carefully chosen as the coating material. The drivers for the choice of application equipment are always those of in-service coating performance and cost efficiency.

Oerlikon Metco offers both gas-fuel and liquid-fuel HVOF coating application equipment. Each has its place in the application of hydropower turbine coatings. Through decades of hydropower turbine coating experience, we can offer the right combination of material and application technology for the specific turbine component service environment.

We tailor our coating systems to the specific needs of our customer for part size, weight, manipulation requirements and desired automation level. All systems are designed to the latest applicable safety codes.

Only Oerlikon Metco offers both liquid-fuel and gas-fuel HVOF application technologies that cover the full regime of HVOF coatings available. This allows us to optimize coatings for hydropower turbine applications and ensure the best coating performance.

(Note: Tafa JP-5000 gun model 5220 is a product of Praxair. The WokaJet-410 and 5220 gun are based on the same design licensed from James Browning).
Testing and analysis
Determining successful coating candidates for hydropower turbine components requires the employment of specialized testing procedures.

While standardized tests are used to determine the basic wear behavior of materials under well-defined loading conditions, specialized testing is needed for specific conditions and components. The results of these tests can usually be transferred directly to the operating conditions for the turbine component.

Oerlikon Metco has access to fully equipped test benches for both standardized behavior studies and tailored, application-specific coating development. These include a variety of cavitation, erosion, abrasion, sliding wear and corrosion test benches.

Abrasion and erosion testing clearly differentiates the wear behavior of different coatings and aids in the selection of a potentially successful coating candidate for a hydropower turbine application. As can be seen from these tests, the Oerlikon Metco HVOF coatings perform well.

Summary
Protective coatings can greatly extend the service life of hydropower turbine components. However, the coating material, application equipment and parameters must be carefully chosen for optimal coating performance. Seemingly similar materials and application technologies can perform very differently in service.

Customer benefits

Environmental friendly
- Application of optimized coating solutions enhance hydropower turbines, and have a positive influence on hydropower as a renewable, environmentally-friendly source of power.

Effective
- Oerlikon Metco long experience with all types of hydropower turbines (Francis, Pelton and Kaplan) is your assurance of a partner who can deliver a total solution package.
- Oerlikon Metco can optimize coating solutions to the specific service environment of the turbine, through the correct selection of material, application equipment and coating parameters.
- As a full-source supplier, Oerlikon Metco works in close cooperation with its customers, from initial consultation through coating production and beyond.
- State-of-the-art materials technology for coatings that results in very minimal seal wear during rub interactions and maintains steam path design clearances.
- Only Oerlikon Metco offers all coating application technologies, including the full range of gas-fuel and liquid-fuel HVOF equipment; thus we can provide the best coating application technology for the application.

Economical
- Optimized coatings can increase the service life of components up to 3 to 5 times that of uncoated components, reducing operating and replacement costs.
- Working with an experienced partner, such as Oerlikon Metco, will decrease your overall project time and cost.

Oerlikon Metco has extensive experience in coatings for hydropower turbine applications. Our broad portfolio of materials, equipment, application know-how and our testing capabilities allow us to provide both standard and application-specific coating solutions that are optimized for hydropower turbines.

Jet Kote and Stellite are brands of Deloro Stellite Holdings Corporation
TopGun is a brand of IBEDA Sicherheitsgerate und Gastechnik GMBH & Co.
JP-5000 and Tafa are brands / products of Praxair

Information is subject to change without prior notice.