Hydroelectric equipment repair

POLYMERIC COMPOSITES have been used in many industries for decades. This article focuses on the advantages of polymeric coatings (efficiency enhancement, corrosion resistance) vs. traditional repair methods.

Hydroelectric power generation continues to grow as the front runner in renewable energy. It currently accounts for more than 16%[1] of global energy production and is expected to grow at a rate of 3% per annum for the next quarter century.

In recent years, maintenance of existing hydroelectric assets has become increasingly critical to ensure consistent supply of power. Low water levels due to factors such as higher local demand have resulted in decreased production in high-profile hydroelectric stations, such as the Hoover Dam. There, the problem has become so severe that the resulting drop in pressure difference has caused increased cavitation damage to turbine runners and a 20% decrease in production levels [2].

Ensuring turbine efficiency and up-time are at their maximum is key to achieving optimum production. However, as with any fluid-flow equipment, the effects of erosion and corrosion will detract from this. If left unchecked, erosion and specifically cavitation damage rates increase exponentially to cause severe metal loss. Unbalancing and vibration of turbine runners can result requiring lengthy shutdowns for repair work to shafts and bearings. Loss of surface smoothness also results in increased turbulent flow and lower production rates.

Traditional repair techniques

The recommended procedure to determine the frequency of inspection and repair of hydroelectric runners (and turbines including stay vanes, wicket gates, etc.) is to inspect the equipment at set intervals following installation to ascertain the rate of damage (including erosion, corrosion, cavitation, etc.). Once the rate of damage is known, procedures are put in place to repair the damage once it reaches pre-determined levels of damage (commonly, depth of metal loss > X mm).

Once a maintenance routine is put in place, repairs are carried out as per the recommended procedure. This procedure is often employed to replace the lost metal using conventional metal for metal replacement techniques. Large areas of pitting are repaired by welding plates or sheets of new metal in place as an erosion wear layer, whereas areas of lighter damage are recommended to be repaired by weld overlay which is then ground back to the correct tolerance. The procedure is repeated at the next service interval as dictated by the rate of in-service deterioration.[3] [4] [5]

Cons of conventional repairs

This repair procedure is not without problems, though. The most basic flaw is the replacement of the material which is being lost with more of the same material, a like-for-like repair, so to speak. Reintroducing the same base material simply allows the problems to reoccur and does not identify the root cause of the issue and work to limit its effects. Continued metal loss will result in continued shutdowns. As mentioned earlier, metal loss will — in some cases — result in vibration due to imbalance, and this can cause damage to bearings and shafts.

One of the major drawbacks of replacement of lost metal using hot work is the procedures involved in implementing the repair. From the *United States Bureau of Reclamation Turbine Repair* manual (Volume 2-5, 1989 p. 7): "*Extensive weld repairs can result in runner blade distortion, acceleration of further cavitation damage, and possible reduction of turbine efficiency. Also, extensive repair can cause residual*

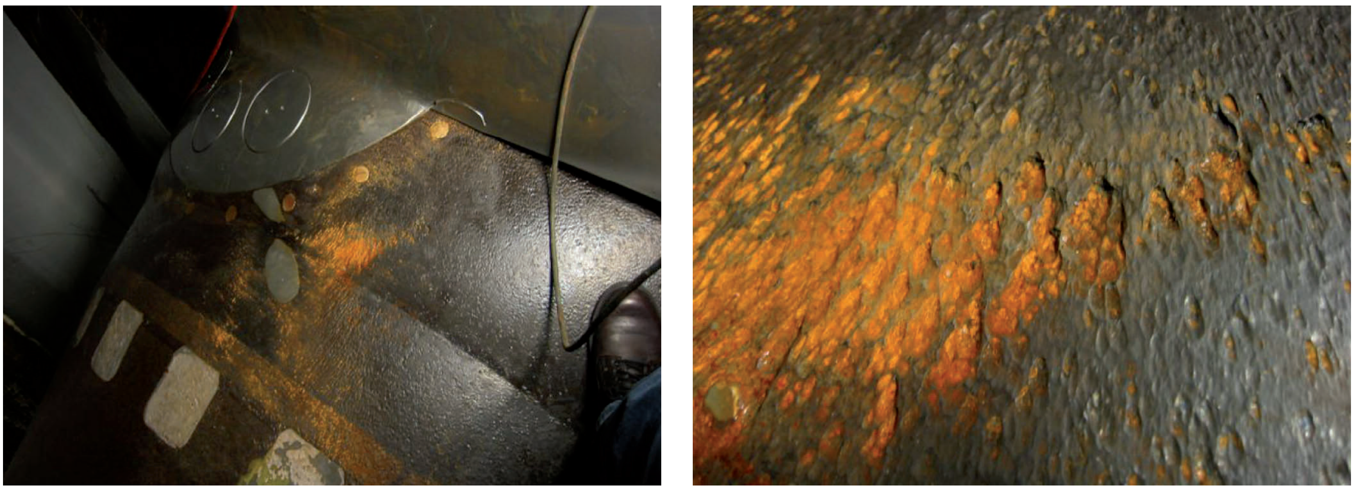

Figure 1. Damage to hub of a Kaplan turbine (L) and close up of the damage (R).

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Figure 2. Completed replacement of leading edges damaged by cavitation following extensive repair work.

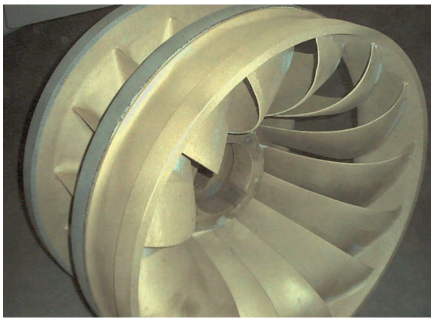

Figure 3. Francis turbine following preparation by grit blasting.

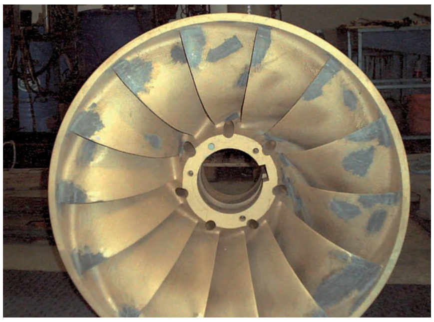

Figure 4. Turbine following rebuild using a paste-grade material to in-fill areas of erosion damage.

stressing in the runner, resulting in structural cracking at areas of high stress".

Coupled with this is the complexity of carrying out hot work repairs. In order to avoid distortion of finely honed parts, extensive rigging and supports are recommended. Hot work is recommended to be carried out gradually, i.e., heating up the entire part first prior to application of the repair technique and allowing lengthy cool-down times between application of the repair to avoid excessive heat distortion. Care is also required when selecting the repair metal (plates or welding rods), as different materials can introduce local galvanic corrosion, initiating even more repairs.

Alternative technologies – coatings

Modern polymeric repair systems offer an excellent alternative to traditional repair materials. These materials are supplied in either paste grade (filler type repair composites used to infill damaged areas and restore profiles) or coating-grade products used to provide long-term protection to equipment against specific damage. Advanced polymeric coatings completely halt corrosion by isolating the metals and closing the corrosion cell.

Polymeric coatings have been used for more than 60 years in many different industries, from hydroelectric generation to off-shore and onshore oil and gas production to pumps, sewage treatment, etc. and have repeatedly proven themselves in these environments. Solvent-free epoxy technology means that these products are very safe to use, even in enclosed spaces.

Specialized filler materials, such as ceramics and aluminium oxide, allow epoxy coatings to achieve incredible wear resistances, where required. Exceptional bond strengths mean these epoxy coatings combine with the metallic substrate to provide a composite component with huge advantages in terms of on-going maintenance. This is all down to the ease of application of the epoxy polymer systems.

Application

Prior to application, thorough surface preparation is required in the area to be repaired. This is commonly achieved by grit blasting locally to clean and roughen the metal, allowing the polymer to form an intimate bond with the base metal.

Polymeric repair and coating composites, such as Belzona, are supplied as two-part products. These can be easily mixed in situ on site using spatulas and bowls or by paddle mixers for larger applications. This mixing initiates the chemical reaction, which will see the product solidify to its final form.

Generous application times allow the applicator to carefully apply the product to the area to be repaired. Application is commonly carried out using trowels for paste grade, rebuilding composites and by brush for coating-grade epoxies. Many products can also be applied by airless spray, allowing for rapid repair times over large areas. The product is then simply allowed to cure for a period of time before the equipment can be returned to service.

Since modern epoxy polymer materials are cold-curing, they immediately eliminate the requirement for hot work as necessitated when using traditional repair techniques described previously. This avoids problems such as:

- Risk of distortion of equipment
- Requirement for specialist rigging and jigs
- Lengthy repair times required to allow cooling of welds
- Grinding and finishing of weld overlay
- Health and safety hazards associated with hot work
- Need for specialist welding rods

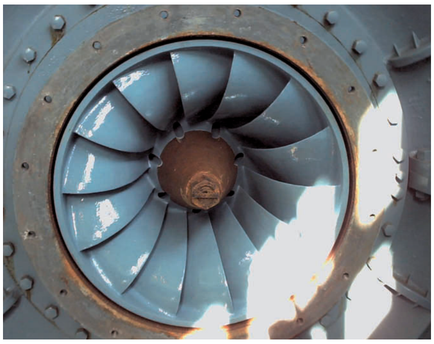

Figure 5. Application of Belzona 1341 (Supermetalglide)® in progress to runner. This coating has been proven to reduce surface friction, resulting in higher operating efficiency in fluid flow equipment such as turbines and pumps.

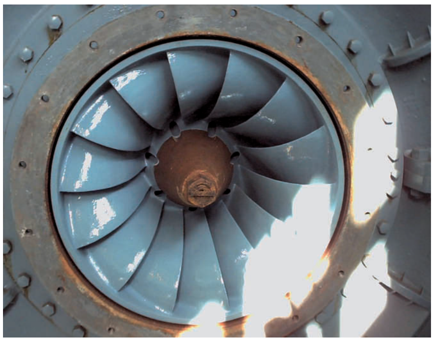

Figure 6. Completed runner installed and ready to return to service.