On site validation of carbide coating for Pelton runners

Pelton runner buckets are often subjected to severe conditions, which cause erosion, with obvious detrimental effects on the efficiency and the reliability of the machines. In the Alpine region, for example, wear damage is identified as a problem which is increasingly shortening the operating life of units which have been subject to erosion.

A system has been developed whereby a tungsten carbide coating is applied by a robotized HVOF (high velocity oxy fuel) process on the buckets of a Pelton runner. A runner which underwent this process has been tested in service under a head of 345 m and with a speed of 600 rpm, and performance was compared with the operating life of an uncoated runner. It was found that the coating could double the lifetime of the runner.

The process has recently been tested at the Curon powerplant in Italy, owned by the utility Hydros srl.

The main characteristics of the Pelton runner are as shown in the Table below.

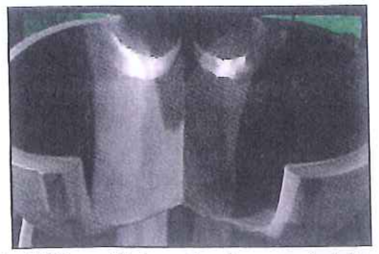
Until a few years ago, the runners for the unit could be operated for three-year periods, with a lifetime of 10 000 hrs. However, in recent years, the rate of wear increased considerably and new runners could only be operated for one year (on average 3000-4000 hrs) before being replaced, as a result of material loss.

Therefore the application of a hard protective coating, to improve the erosion resistance, was considered a reasonable option.

The coating process

The coating which was developed and applied, and which has now been tested in service, consists of a tungsten carbide layer applied by a robotized HVOF process.

Main features of the runner tested	
Outside diameter (mm)	1642
Bucket length (mm)	418
Number of buckets	20
Total weight (kg)	7200
Base material	GXCrNi 13-4



Left, the HVOF process during spraying of the 0.25 mm-thick coating layer; and right, protection from the coating at the end of the bucket.

HVOF processing consists of delivering of the material in the form of powder (within a size range of 5 to 50 microns) heated by a flame and projected by a supersonic gas jet towards a target (the surface of the component to be coated). As it travels to the target, the coating powder material takes the form of liquid or plastic droplets projected towards the target surface, where the splashing phenomenon and subsequent solidification are able to create a holding strength for the deposited droplets and the resulting coating.

The process which was used is known as CABOFLAM H654 (Flame Spray trademark). The chemical composition of the coating alloy was WC 86 per cent; Co 10 per cent; Cr 4 per cent. During the spraying process, the particle speed reached approximately 666 m/s; the temperature of the particles was about 1800°C, and of the base material, < 150°C.

Because of the high temperature and speed of the particles, as well as the consequent noise levels (> 120 dbA), the HVOF coating processing can only be carried out safely by robotized workstations operating within soundproof booths.

Coating quality

The quality of the coating was assessed with regard to its metallurgical and mechanical properties on samples. The microhardness was found, on average, to be 1150 HV, with less than 1 per cent porosity. Adhesion (according to ASTM C633) was > 70 MPa.

Application to the runner

The CABOFLAM H654 HVOF coating process was then applied to the runner. The following optimizations were necessary during the implementation phase.

The complex shape of the buckets required elaborate programming for the robot, so as to achieve a uniform coating thickness.

More than 15 passes with different robot programmes were necessary to achieve an average coating thickness of 0.25 mm, with a standard deviation of 0.1 mm.

It was important to avoid the coating being deposited on the base, and this was achieved by masking the base material, as necessary, with a metallic shield. Also, deposition of the coating on the end of the bucket had to be avoided, so as to allow for adequate NDT monitoring of this critical area during operation.

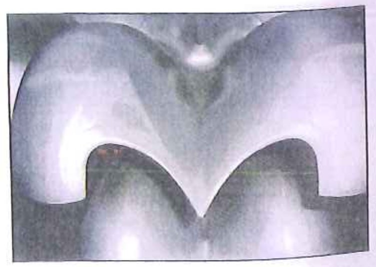
It was verified on the samples that the HVOF coating could be applied in a uniform way, on a minimum radius of 1.5 mm.

The average thickness of the coating layer was 0.25 mm, and the roughness, as sprayed, was 4-5 Ra.

The performance of the coated runner was subsequently evaluated in direct comparison with a standard uncoated runner. Without the coating protection, a runner had had to be replaced after about 4500 hours of operation, as a result of wear on the buckets. It was found that the coated runner, however, could be operated for around 8000 hours before wear damage appeared on the surface, (close to the end of the buckets where the coating had not been applied.)

The target to double the lifetime of the runner had thus been achieved. It is expected that further improvements will be achieved by optimizing the geometry of the coated surfaces.

From left:
The runner in service at the Curon plant in Italy.
Inspection of the coated runner after 4500 hrs of operation.
The coated runner after 6000 hrs of operation.



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