

Coatings for Abrasive Service



Courtesy of Sulzer Metco Coating Services

The **Heart**
of Your
Process

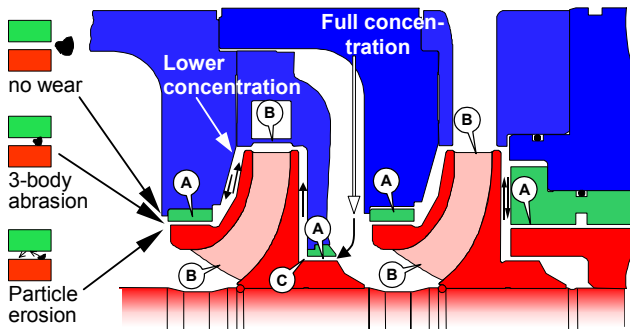
Coatings for Abrasive Service

Abrasive Wear can cause:

- Gradual decay of hydraulic pump performance
- Increased vibration

Wear Mechanism

The wear mechanism is explained on a multistage pump, however the same principles apply to other pump types.



Abrasive particles are transported with the liquid. The material loss due to abrasive wear is highest in areas of high flow velocities (A). On surfaces where the flow velocities (B) is medium less wear is expected. Jet action can cause deep grooves (C). Abrasive wear is approximately proportional to the cube of the flow velocity of the particles. The impeller expels particles away from the suction side wear ring and balance drum and lowers the particle concentration.

Abrasive Particles and Filtration

Abrasive wear is proportional to the mass concentration of the particles.

The type of abrasive particles is dependent on the service and cannot be changed. In some services the concentration can be reduced; for example in a sand settling basin for water injection.

3-body abrasion, the most severe type of abrasion, occurs if the particle size is about the same as the radial wear part clearance. Filtration of the liquid to a particle size of approximately $<100\mu\text{m}$ avoids 3-body abrasion.

Typical Services

Service	Category
Water injection <ul style="list-style-type: none"> • Produced and sea water containing quartz sand 	Light, moderate to severe
Oil pipeline pumps <ul style="list-style-type: none"> • Crude oil containing sand 	Light to moderate
Coker unit pump <ul style="list-style-type: none"> • Slurry oil bitumen containing coke fines, sand, catalyst fines 	Moderate to severe
Slurry Transfer in refineries <ul style="list-style-type: none"> • HC Slurry containing catalyst 	Moderate

Categories of Abrasive Wear

Light



- Wear parts (A) wear evenly within one year.
- Other pump parts are hardly effected
- Wear parts can be upgraded with better materials

Moderate



- Wear parts (A) wear evenly over a shorter period of time
- Light wear can be observed on impeller, diffusers or volutes (B)
- Pump parts can be re-used and upgraded. Re-design may be required
- Check possibility for reduction of abrasive particle concentration in pumpage or filtration

Severe

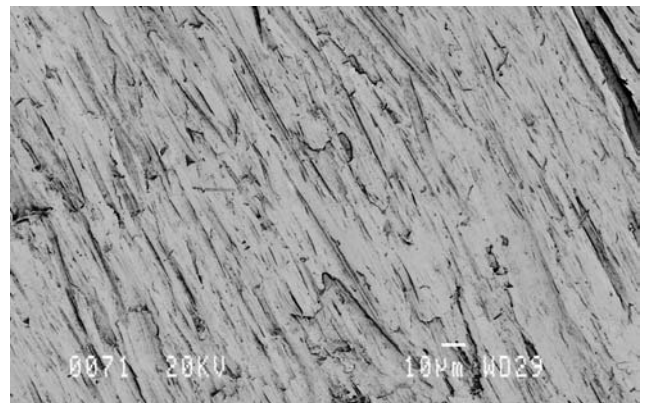


- Wear parts are worn in a short time
- Heavy wear can be observed on pump parts subjected to high and medium flow velocities.
- Pump needs redesign and abrasive particle concentration should be reduced

Engineering Evaluation by Sulzer Pumps

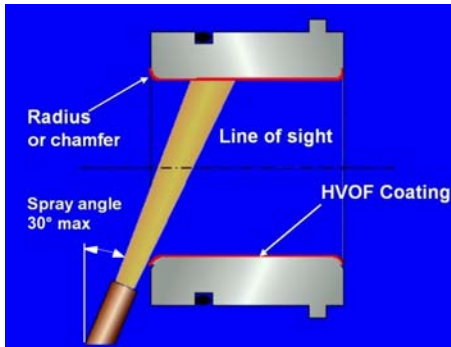
The pump retracted from service is subjected to a thorough evaluation of the damaged pump components. The wear of each part is analysed and documented. A detailed up-grade is proposed to the customer. The up-grade may involve higher-grade coatings, design optimisations and re-designs of pump components. With an empirical method the expected life extension of the coated parts can be estimated.

Metallurgical investigations can help to explain the type of wear mechanism that prevailed. The picture below depicts the scars in a balance drum caused by abrasive particles with a low impingement angle.



HVOF Coating (High Velocity Oxy Fuel) Process

Powder is injected into a high velocity flame and particles are sprayed onto the base material to form a dense uniform coating. During the HVOF coating process the temperature of the base material is controlled by cooling to prevent any alteration of the



base material properties. The application of HVOF coatings is limited to surfaces within line of sight of the gun and therefore geometric limitations to bushing bores and pump casings apply. Even though the powder can be composed of a wide variety of materials, Sulzer recommends the powders

consisting primarily of tungsten carbide with a various metallic binders.

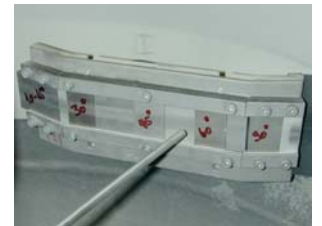
Coating tests

Extensive abrasion tests have been carried out on coating systems at Sulzer Innotec. With the so called 'Heli' test, where quartz sand is shot on test specimens with different impingement angles, many materials applied with various HVOF systems have been tested at different sand velocities. Best results have been achieved with Sulzer Metco coating



systems referred to as SUME[®]PUMP.

Test specimens with sand feeder tube located inside the 'Heli' test rig.



HVOF Coatings Selection Guideline

Coating trade name 3)	SUME [®] PUMP SH 30 4)	SUME [®] PUMP SA 30 or SA 60	SUME [®] PUMP SL 20
Material type	WC / CoCr	WC / CoCr	WC / CoCr
Micro Hardness	>1100 HV _{0.3}	>1000 HV _{0.3}	>1050 HV _{0.3}
Coating thickness	300µm	300 or 600µm	200µm
Relative wear resistance to Duplex 1)	9.4	7.5	6.4
Abrasive wear category 2)	severe to moderate	severe to moderate	moderate
Pump type 2)	high speed, multistage	high speed, multistage	direct drive, multistage

Note:

- 1) these values are true for low angle impingement (angles less than 20°)
- 2) these are guidelines only. The type of actual abrasive particles and their concentration influence the selection of coating system. The final material selection is made based on the actual damage evaluation and the metallurgy of the pump to be repaired.
- 3) Some coatings may not be available in every country.
- 4) Shall only be used on stationary wear parts where no heat is used for assembly.
- 5) SUME[®]PUMP coatings are corrosion resistant to all listed services.

Operating Experience

Line shaft bearings in a vertical turbine pump used in crude oil export service

This 6-stage pump operated at 1800 rpm for the first 7 years without any problems with carbon type line shaft bearings. After this period, the operator changed from seawater injection to produced water injection, which caused a lot of sand to be transported back from the well and through this oil export pump.

The pump was taken out of service due to high vibration. All bearings and impeller wear surfaces showed excessive wear. The pump was retrofitted with a fiber resin bearing, which did not last much

longer than the original carbon bearings. This prompted a thorough investigation including rotor dynamic analysis and a detailed investigation of the type of wear that was being experienced. It could be demonstrated that the sole cause of the damage could be attributed to the high content of quartz sand in the system.

The worn bearing bush (up to 6 times increase in bearing clearance) and the heavily scored bearing sleeve are shown in the photographs below. This bearing failure also caused the mechanical seal to fail due to the high vibration and to decrease the generated pump head and flow. The MTBF was 6 months, which was not acceptable to the user.

The bearing bushings and the bearing sleeves were

then coated with the SUME[®]PUMP SH coating system. The parts could be replaced without changing the pump design. Now, the pumps have been in operation for 22 months without any increase in vibration or performance degradation.



Worn resin bearing bush



Worn bearing sleeve

Wear parts for produced water injection pumps

These injection pumps started to pump produced water in 1996, after many years on seawater injection duty. The pumps are rated at 750 m³/hr at a head of 2280 m run at 5230 rpm. The original pump design had duplex stainless steel and Stellite 6 wear parts. The pump had to be taken out of service after only 6'700 hours due to high flow in the balance water line and associated problems with the mechanical seal. After disassembly, heavy wear due to sand abrasion in the close running clearances at the impellers and balance drum were revealed. The result of the sand

content investigation showed a sand concentration of 5 to 90 g/m³ and an average grain size of 600 µm.

Based on the results of the coating development and the experience in pump design for abrasive applications, the SUME[®]PUMP SA coating system was selected for all the impeller wear parts and balancing device. In addition the expected part life for the given condition was estimated with the empirical method and was also used for the coating selection.

These upgraded pumps have now been in operation for 3 years with good success. The photos below show an impeller from the pump, that was taken out of service for inspection after 4800 running hours. The coated impeller eye wear surfaces showed hardly any wear and the coated impeller hub wear surfaces had a slightly increased running clearance and some score marks generated from 3-body abrasion.



Coated impeller eye ring



Coated impeller hub ring

Value Added

- Sulzer Pumps Engineering performs thorough evaluations and provides pump up-grades, re-design of components, pump performance and rotor dynamics analysis
- Sulzer Innotec tests material for their performance in abrasive and /or corrosive environment using abrasive particles of the specific service.
- Sulzer Metco supply high quality parts coated with state of the art powder and spraying equipment. Sulzer Pumps may subcontract parts to other qualified companies.
- Sulzer Pumps Service Centres perform upgrades and repairs of damaged pumps worldwide to the high Sulzer quality standard.

Sulzer Pumps Service Centre Organization

Please contact our service centres. Addresses are available on the Internet.

www.sulzerpumps.com Customer Support Services