**Sulzer Pumps**
Sulzer Pumps Finland Oy
P.O. Box 66
FIN-48601 Kotka
Finland

# AHLSTAR™ Process Pumps for Fertilizer Applications

by Sakari Hänninen
Sulzer Pumps Finland Oy

Research and development have always played a significant role at Sulzer Pumps. Our main target is to always meet the customer's requirements. Sulzer Pumps' expertise is based on an understanding of the customers' needs and processes. This knowledge is available for clients involved in fertilizer production. Sulzer pumps are tailor-made for difficult liquids, which means that they are the natural choice for liquids that are corrosive or both corrosive and abrasive.

AHLSTAR™ Process Pumps are designed for continuous operation in industrial processes, and the pumps can be used for pumping various kinds of liquids and slurries. AHLSTAR™ pumps are horizontally mounted with the following characteristics: single stage, end suction, back pull-out, ROTOKEY impeller mounting, simplified heavy-duty bearing unit etc. The AHLSTAR™ Process Pump series has standard (A), wear resistant (W), non-clogging (N) and hot liquid (E) hydraulic designs. The series has two solutions for gas handling: an air separating (R) design and a self-priming gas removal (S) design. The gas handling options can be integrated with standard (A), wear resistant (W) and non-clogging (N) hydraulic designs.

**Pumping of slurries, selection of pump type against erosion**

The key issue when selecting a slurry pump is to classify the type of the pumped liquid or slurry. The rough selection of whether to use a wear resistant (W design) pump or an ordinary process pump can be made according to figure 1 below. The table is then used to define the range of recommended operating conditions.

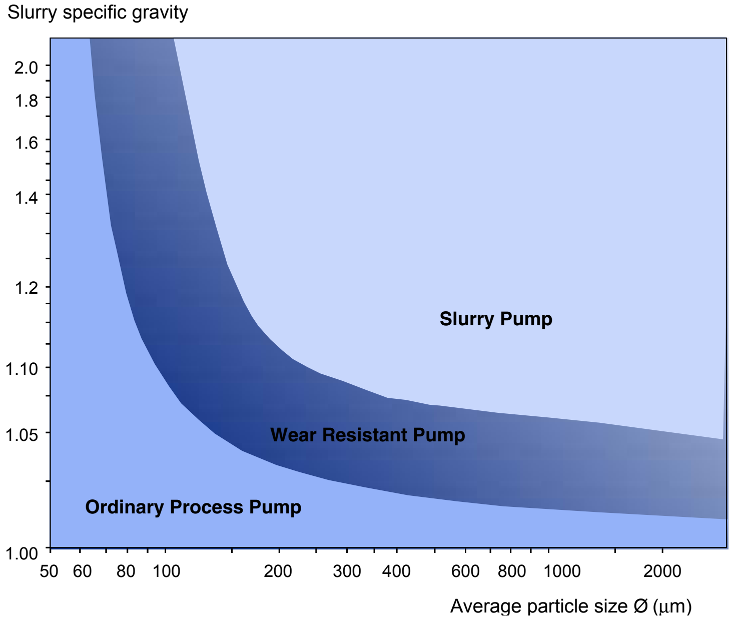



Figure 1. Pump types according to average particle size and specific gravity.

| | Ordinary Process Pump | Wear Resistant Pump | Slurry Pump |
|---|---|---|---|
| Maximum discharge velocity | 12 m/s | 8 m/s | 6 m/s |
| Maximum impeller peripheral speed | 43 m/s | 36 m/s | 28 m/s |
| Range of capacity Q/Q BEP | 30–130 % | 40–120 % | 50–110 % |

The above values may vary, depending on how erosive the particles in the slurry are and how corrosive the liquid is. Selecting the largest available impeller diameter (lower running speed) and keeping the duty point as close as possible to the best efficiency point (BEP) will ensure maximum pump lifetime is achieved. It is also critical to find the correct balance between a good corrosion resistant material and the most suitable hydraulic design of the pump to withstand abrasion. Firstly a suitable material should be found to withstand corrosion. The next step is to check the material has good resistance against the expected level of erosion. Combining these factors with the appropriate hydraulic design ensures the optimum economic solution is achieved.

Sulzer WPP wear resistant pumps are specially designed for corrosive and abrasive liquids. The WPP pump is not a heavy-duty slurry design. Having process pump hydraulics allows efficiencies of the same high level as APP process pump to be achieved. The key difference is that WPPs' flow patterns are specially designed to prevent erosion in the hydraulic parts.

There are many applications where suspended solids can severely damage the pump in a short period of time. The pump can be lost in a matter of weeks if the design and material selection is not correct. If only abrasion has to be considered (non corrosive liquid), a hard material should be selected. One possible solution is chromium iron whose hardness is 600 HB. This material, A532 Class IIIA, contains about 23 – 30 % of chromium to provide high levels of hardness. Chromium iron can resist abrasion from solids whose hardness is less than 600 HB. Sulzer have installed AHLSTAR™ WPP wear resistant pumps manufactured from chromium iron material several applications that are not acidic and have found their life to be about three times that of a normal process pump with CD4MCu material.

**Corrosion**

Corrosion is complicated phenomenon, the result of electric and chemical effects. Corrosion is commonly divided into the following categories:

- general corrosion
- galvanic corrosion
- crevice corrosion
- pitting corrosion
- stress corrosion
- erosion corrosion

The general rule to increase corrosion resistance is to use higher alloyed stainless steels. Pitting and crevice corrosion resistance in particular can be improved by the addition of molybdenum and chromium. In addition duplex stainless steels are resistant to stress corrosion.

Erosion corrosion is typically found when pumping liquids containing corrosive solid particles. Erosion corrosion also happens when pumping clean but corrosive liquids *without* solids when the velocity of flow within the pump is high enough. High velocity of flow is found within the impeller when a pump operates at high rotational speed.

Corrosion is a reaction of the material with its environment. The fundamental reason for corrosion is that the material aims to return to a lower energy level. Chemical corrosion is the reaction of the material with liquids, gas or solids it comes into contact with which results in a new chemical compound being formed. The most common reaction is oxidation; this results in an oxide layer forming on the surface of the material. Electrochemical corrosion is affected by acid, alkali or dissolved salts in a water solution. It is usual for different metals to have different dissolving pressures, and the electrical potential of materials have different values in different solutions. Electrochemical corrosion always takes place therefore within electrochemical corrosion pairs.

If the pumped liquid leaks out of the pump to the atmosphere there is a high risk of corrosion, especially when there is sulphuric acid in the liquid. In particular, the material comes weakened and eaten away by corrosion on the atmospheric side where holes have been drilled and plugged in the volute casing. This is why drillings e.g. for draining the pump, are not accepted in the volute casing. When corrosion and wear take place at the same time in the pump, a metallic material is usually selected for its construction. Metallic components can resist the abrasive attack of solids their surface because their hardness is quite high. Modern high alloy austenitic cast steels can manage simultaneous corrosion and abrasion very well.

A good example of a successful trial was where AHLSTAR™ WPP wear resistant pumps made from Avesta 654SMO (Avesta 654SMO is a trade mark owned by Avesta Sheffield, who has granted Sulzer Pumps Finland Oy a license to produce the material) successfully replaced rubber-lined pumps in a number of erosive/corrosive applications.

Figure 2. WPP32-80 made from Avesta 654SMO.

If corrosion happens within electrochemical corrosion pairs, all the hydraulic parts of the pump should be similar to each other. This means that all parts that are in contact with the pumped liquid must be made of the same material, especially the nuts and bolts.

The other parts of the pump, which are not in contact with the pumped liquid all the time, should have corrosion resistance, especially when leakage from other process equipment takes place due to operational failures. The baseplate, bearing unit or other parts will be lost in a very short time if they are made from cast iron. We have recommended that they should also be made from stainless steel for severe services.

It is always very important to know what kind of a liquid is pumped. If it is not certain what the application is and if there is a clear possibility of chemical corrosion, loss of material during operation will happen in a very short period of time. The customer always has to give full information about the liquids that are in contact with the pump. The level of detail typically required is as follows: Density, temperature, pH, chemicals content, contaminants and solids including content by volume and size.

Nowadays, a pump totally manufactured from stainless steel can be supplied. Such pumps provide a longer operating lifetime and thus offer more reliable pumping solutions.

**New features for dynamic shaft sealing**

The shaft seal is one of the most important factors when attempting to minimize the lifetime costs of a pumps capital, operating, maintenance and downtime costs. Experience shows that at least the shaft seal causes 60% of all problems with centrifugal pumps.

Use of mechanical seals instead of a packed stuffing boxes has brought considerable improvements but significant operating and maintenance problems remain. Conventional gland packing and mechanical seals will wear due to mechanical friction during running and will eventually form a leak path. These seal types require a supply of sealing liquid for lubrication and cooling and often this liquid comes from an outside source. In many applications this means building a complete pipeline system to provide clean sealing liquid to shaft seal.

Mechanical wear, leakage and the need for external sealing liquid has been practically eliminated by the dynamic seal. The operating principle of the dynamic seal is simple. When the pump runs, the expeller generates a liquid ring in the annular seal chamber and evacuates the liquid pumped from the seal cavity. When the pump stops, the static seal tightens against the thrust ring, thus preventing any leakage. Mechanical wear, leakage and the need for sealing liquid have been practically eliminated and no piping for sealing water is needed.

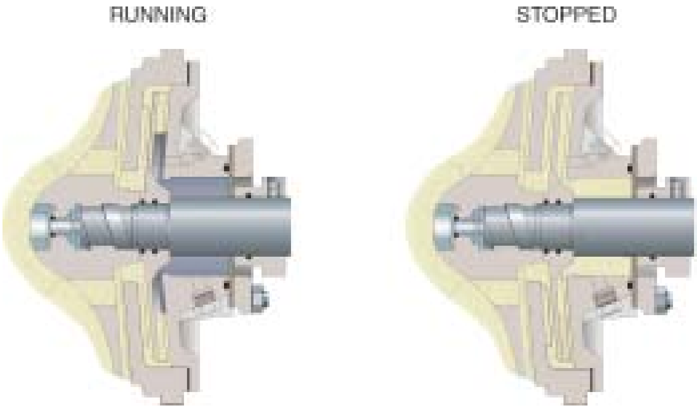



Figure 3. Operation principle of conventional dynamic seal

In a dynamic seal the expeller rotates freely in its chamber without any mechanical contact and therefore without any mechanical wear. When the pump stops, the liquid fills the seal cavity and presses the flexible disc against a sleeve, thus preventing leakage.

When pump starts again, the expeller creates a liquid ring in the expeller seal chamber and removes the liquid from the seal cavity. When the pump is running the flexible disc is no longer pressed against the sleeve.

A conventional dynamic seal needs three operational factors:

- positive incoming head
- liquid temperature less than boiling point
- limit for maximum incoming head

There are, of course, many applications where one or more of these requirements are not fulfilled. For example in evaporator applications there might be negative suction head or high operating temperature. As the dynamic seal has many benefits there has been great demand to expand its operational limits. The latest dynamic seal construction allows for low or high liquid level in pump suction and even light vacuums can be handled. The new design also allows liquid temperatures that exceed boiling point to be pumped.

Sulzer has developed new dynamic seal designs.  Use of these seals requires a full understanding of the pumping application and process conditions. In addition to the requirements of the pumping application, the pressure conditions inside pump and pump duty point also affect the operation of the seal. Sulzer Pumps has solved these problems and is the first company in world to provide these new advanced dynamic seal designs.

**Dynamic seal for negative suction head**

If there is negative suction head to the pump a conventional dynamic seal leaks air from atmosphere into the pump. But in Sulzer's new dynamic seal there are recirculation holes in the casing cover near the impeller edge. Pressure created by the impeller will also increase pressure in the seal chamber. The expeller is then able to operate as on a conventional dynamic seal. When pump is stopped the static seal works as normal.

If there is a constant vacuum on suction side then two static seal are required. One works as with a conventional seal and other prevents outside air entering the process when pump is at stand still. With this seal arrangement impeller balancing holes are not generally used, because vacuum pressure towards the static seal is not permitted when the pump is running.

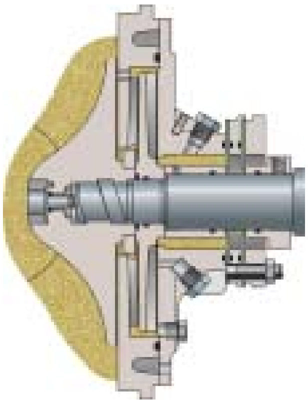


Figure 4. Dynamic seal with double static seal.
This seal can be used in applications where pressure behind impeller is lower than atmospheric pressure.

**Dynamic seal for high incoming heads**

In case there is a temporarily high inlet head to the pump a normal dynamic seal cannot be used. But with the new design Sulzer combined a normal dynamic seal and grease lubricated gland packing. In this case gland packing replaces the static seal.

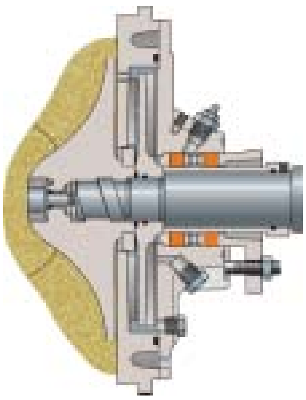


Figure 5. Dynamic seal for high incoming head

**Dynamic seal for liquids above their boiling point**.

One limitation for normal dynamic seals has been the liquid boiling point. Normally when over pressurized liquid enters a seal chamber at atmospheric pressure it vaporizes. In Sulzer Pumps new dynamic seal there is a throttling ring in the neck of the seal chamber that limits liquid flow into the chamber itself. From the chamber there is a connection that leads the remaining exhaust steam to an area of low pressure in the process. By taking pressurized steam away from the seal chamber, stress caused to static seal is minimized.

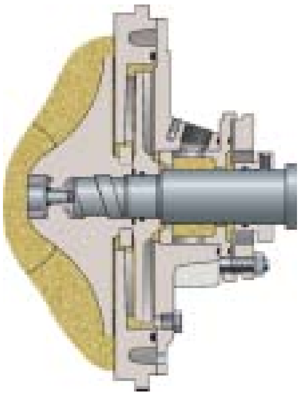


Figure 6. Dynamic seal with steam re-circulation.

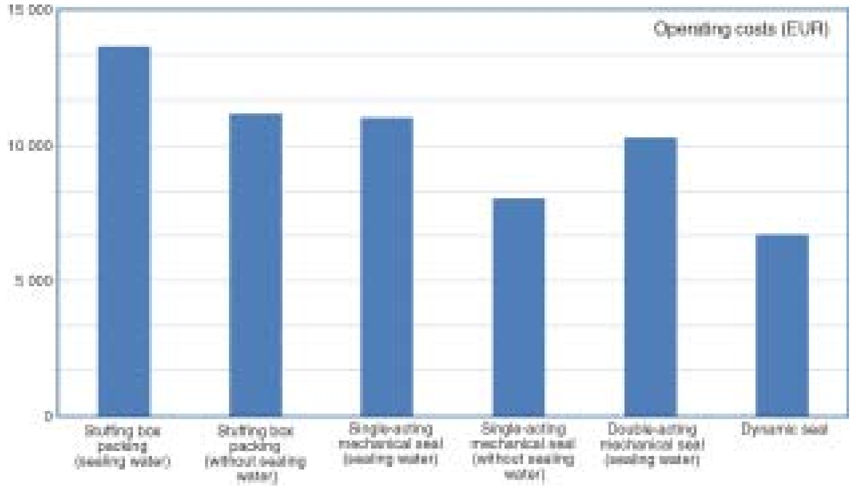
These new dynamic seal designs expand operational possibilities greatly. But the use of these seals is highly process dependant. All applications require knowledge of process and systems. But with all seals described above, the benefits of dynamic seals are available where none were previously available.

**COSTS OF SHAFT SEALING**

When examining sealing costs, the costs have to be calculated over a sufficiently long period of time. Calculations below have been made over a 10-year period, which gives a comprehensive idea of the structure of a lifetime costs of a pump. As far as all sealing costs are concerned, the dynamic seal is the most inexpensive sealing method. The dynamic seal also gives excellent reliability, meaning that there are no costs resulting from seal damage.

The following variables have been used in calculation of the graphs below:

| | Lifetimes | Sealing liquid amount* | Power consumption** |
|---|---|---|---|
| Cord packing | 6 months | 4 l/min | 0,4 kW |
| Mechanical seal single | 3 years | 2 l/min | 0,1 kW |
| Mechanical seal double | 5 years | 2 l/min | 0,3 kW |
| Dynamic seal | 10 years | 0 l/min | 0,8 kW |




*Sealing liquid EUR 0,08 / $m^3$
**Electricity EUR 0,045/kWh

Fig 7. Cost of different shat sealings

Operational costs are highest with seals that require a sealing liquid. The costs of sealing liquid vary greatly between various mills, but the essential things to consider ate the production, investment and disposal costs of sealing liquid as they are actually accrued.

If maintenance costs are concerned, it should be remembered that cord packings require adjustments and many changes of parts during their lifetime. This increases the cost of packed stuffing boxes.

Significant costs are created in continuous processes when unexpected faults occur in equipment critical to the main process. In the worst case the entire plant has to be stopped during production. When calculating costs for unexpected shut down at least the following costs should be considered:

- Production losses
- Product waste as a result of fault
- Spare parts and replacement work
- Line start-up costs to achieve normal production

The final cost of a shut down become very high if it is difficult to obtain spare parts for some reason, consequently extending the shutdown.

The dynamic seal essentially improves operational reliability and costs accrued during the operation of a pump. Mechanical wear and leakage of the seal has been practically eliminated. The Sulzer Pumps' dynamic seal is suitable for almost all pumping applications in the fertilizer industry.

For more information please contact
Fertilizer-info.pumps@sulzer.com