

Newly developed pumps meet market trends in the water segment

# World-class water pumps

Transportation and treatment of water are essential tasks in many industries, and water is a vital resource for all life on the planet. As the result of targeted product development for the water segment, Sulzer Pumps, a leader in pump design and manufacture, has recently introduced two pump ranges for the applications water transportation and desalination. State-of-the-art design and manufacturing processes make these pumps stand out due to their high efficiency and easy maintenance.

Of all water on earth, only 2.5% is not salty, and two-thirds of this freshwater is locked up in ice caps and glaciers [1]. Of the remaining approx. 0.8% (ca. one-third of 2.5%), one-fifth is in remote, inaccessible areas or

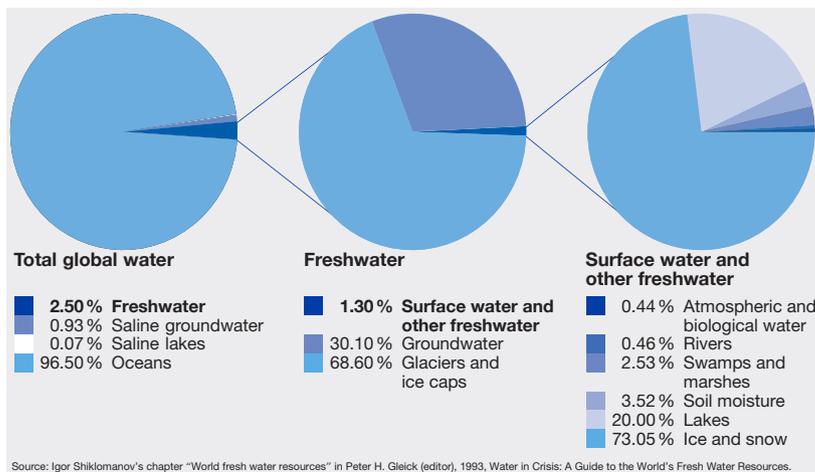
cannot be used easily because it appears as seasonal rainfall in monsoonal deluges and floods. The world's total freshwater reserves are estimated at around 35 million km<sup>3</sup>.

Total global withdrawals of water

amount to about 3700 km<sup>3</sup> annually—a small fraction of the estimated reserve. Even though water is the most widely occurring substance on earth, the ever-increasing demand for water for sanitation, drinking, manufacturing, leisure,

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1 Distribution of earth's water.

and agriculture requires enormous effort to manage and optimize water usage and to minimize the environmental impact of water consumption.

**Specialized in water transportation**

Agriculture and industry are the two largest users of the world's freshwater resources, consuming 70% and 20% respectively. Municipalities account for the remaining 10%. According to a study by the International Water Management Institute (IWMI), more than 1.2 billion people, one-fifth of the world's population, live in areas of physical water scarcity. For a further 1.6 billion people, water scarcity has economic reasons, with lack of investment or insufficient human capacity making it impossible to satisfy the water demand.

Lack of clean water supplies and sanitation remain major problems in many parts of the world. The water

sector needs significant investment and funding for water and sanitation. With two new pump ranges specifically developed for water transportation and desalination, Sulzer is able to support the growth of the water market in two important areas.

Sulzer Pumps has been specialized in delivering pumps for transporting large volumes of water over long distances and high geodetic heights. Based on its hydraulic knowledge, the division has recently developed a new range of single-stage, double-flow, axially split pumps for water applications—including water transportation, municipal water treatment and distribution systems, desalination plants, and circulation pumps in power plants.

Compact in design, these new pumps are specifically developed to provide the high performance and reliability typically required by water applications.

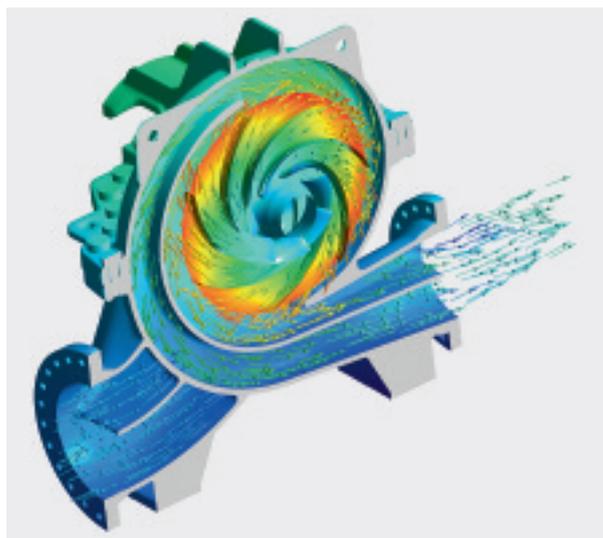
**Optimization supports development**

Automatic optimization tools played an important role in the development of these new SMD pumps. The pump range was developed at the product design center in Winterthur (CH) in close cooperation with Sulzer's global manufacturing locations. State-of-the-art 3D tools including computational fluid dynamics (CFD) 2 for hydraulic design and finite element analysis (FEA) 3 to ensure mechanical integrity were used for the design process.

The results were validated through model and prototype testing. This procedure made it possible to integrate the different analysis tools much faster and better. It also improved control of the full production chain, resulting in an innovative design that permits the optimum hydraulic fit for each duty point. This improvement ensures lower energy consumption and optimized hydraulic performance over a wide range of flows.

**High level of standardization**

To provide a very high level of standardization of the new range, hydraulic coverage was ensured using standardized power levels instead of the traditional approach of using standard sizes and hydraulics of chosen specific speeds. While the new range offers 43 hydraulic



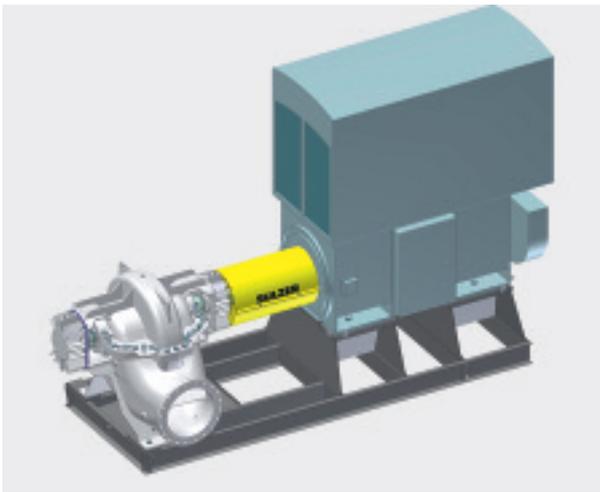
2 The pump range was developed at the product design center in Winterthur (CH) in close cooperation with Sulzer's global manufacturing locations. State-of-the-art 3D tools including computational fluid dynamics (CFD) for hydraulic design were used for the design process.



3 Finite element analysis (FEA) was used during the design process to ensure mechanical integrity.



4 Thanks to the robust mechanical design, the new pump offers low vibration levels and a bearing life of over 100 000 hours, which results in lower life-cycle cost.



5 The standard SMD package consists of foundation rails for the motor and a separate base plate for the pump, or a combined base plate for pump and motor.



6 The new MBN-RO multistage ring section pump has special suction impeller for low NPSH<sub>a</sub>, as well as high-quality cast impellers and stage casings for better efficiency.

designs based on 20 different casings with two or three impellers per casing, the new approach to hydraulic coverage has drastically reduced the number of standard parts to only three standardized shaft diameters, sealing systems, and bearing housings.

Using such an approach, each pump size requires a specific hydraulic design; whereas it is not possible to use a specific standard speed to systematize these designs. The high number of hydraulic designs required called for a new and faster design process. Sulzer Pumps invested significant development effort in coupling an automatic optimization tool with its proprietary hydraulic design tools for impellers and casings and performance prediction using a Reynolds-averaged Navier–Stokes (RANS) CFD code.

#### Low life-cycle cost

Through this automated design process, the new pump range meets the high expectations regarding suction performance and efficiency while having very compact hydraulic water passages. In addition, the innovative volute and cutwater designs dramatically reduce pressure pulsations, shaft and bearing vibration levels, and mechanical stresses. The compact hydraulic dimensions—in combination with the low number of parts—lead to a cost-effective manufacturing process and to a reduction in product and inventory costs.

Sulzer completed extensive model testing to verify the performance of these new hydraulic designs. Because this validation was on the critical path of the development process, model pumps were produced using rapid prototyping methods. Acrylic windows in the models allowed the observation of cavitation development as a function of the net positive suction head available (NPSH<sub>a</sub>). NPSH<sub>a</sub> describes the margin between the pressure at the inlet of the pump and the vapor pressure. The relation of incipient cavitation and NPSH<sub>a</sub> is an important quality measure for a pump. Because the cavitation was observable through the windows, it was possible to determine the NPSH required to avoid cavitation erosion for different impeller materials.

At the same time, dynamic and static components of the axial and radial loads, as well as suction and discharge pressures were measured to verify safe performance of the pumps in their full operating range. Thanks to the robust mechanical design, the new pump offers low vibration levels and a bearing life of over 100 000 hours, which results in lower life-cycle cost 4.

#### Ensuring mechanical integrity

Finite element analysis (FEA) was used to check the mechanical integrity of the new range of pumps. This analysis included several aspects of the pump design.

- Stress levels in the casing and the bolting of the pump during normal operation and for the maximum allowable working pressure, as experienced during the hydro test
- Analysis of the axial split flange sealing and the internal leakage at maximum working pressure
- Natural frequencies of the entire pump and its bearing housings as well as deformation of the casing in the various mode shapes.

Particular attention was given to the packaging design, especially to the pump and drive baseplate. The design of the packaging is executed in 3D using a parametric approach, which allows for fast response in designing the complete package specific to each order 5. It also allows for analysis of the mechanical integrity of the package using finite elements in calculating the natural frequencies of the baseplate.

Depending on the hydraulic configuration, the new SMD pump can handle flow rates of up to 16 000 m<sup>3</sup>/h and deliver heads of up to 260 m.

Sulzer's use of fully 3D design and associated modern numerical tools for hydraulic and mechanical design were crucial in developing this new range of compact pumps without compromising efficiency or suction performance. These new designs, together with the reduced number of standard parts, make this range of single-stage, double-flow; axially split pumps a competitive choice in water applications in terms of both cost and performance.

## Production of drinking water

In addition to water transportation, production of fresh water is a most important field in the water segment. Sulzer Pumps is a full-range supplier of highly efficient pumps for seawater desalination plants using reverse osmosis (RO) or multieffect distillation (MED). Reverse osmosis is a membrane filtration method used to remove larger molecules and ions from solutions by pressurizing the fluid on one side of a selective membrane. The solute is retained on the pressurized side whereas the pure solvent passes through the membrane. This process is widely used to purify drinking water from seawater by removing the salt and other substances from the water.

The reverse osmosis process requires high pressure, and, moreover, it requires reliable equipment, as the plants generally operate around the clock. Often, these plants provide water to industrial installations, e.g., mines, or human settlements in areas where no other freshwater resources are available.

## Designed for high pressure

The newly developed MBN/MBN-RO ring section multistage pumps [6] have been specifically designed for the high-pressure and high-efficiency pumping applications in small-to-medium seawater reverse osmosis plants [7]. The MBN-RO addresses the special need for a high-pressure pump for the reverse osmosis and desalination markets. It

covers flow ranges up to 1100m<sup>3</sup>/h and handles pressures up to 90 bar.

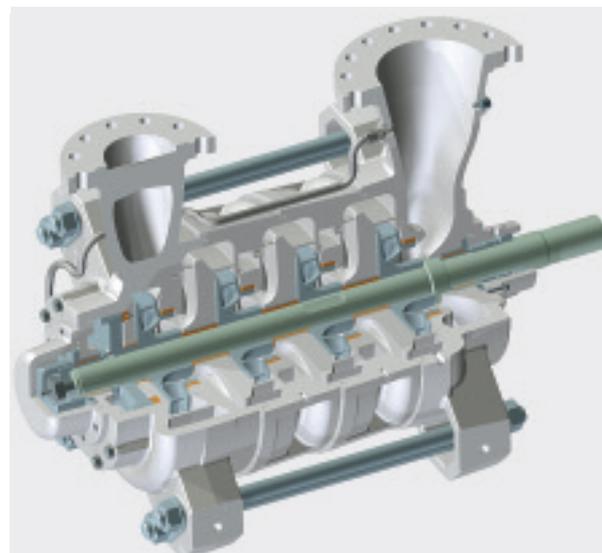
Its improved hydraulic performance makes it suitable for any other high-pressure application with clean liquids. Particularly its high efficiency, a key requirement in the desalination market, is an exceptional feature of the new pump range.

The MBN-RO range is manufactured in duplex or superduplex as standard materials for a variety of seawater qualities to avoid pitting and crevice corrosion. By using the same improved low-NPSH impellers for every stage, the pump becomes highly modular, and its simplicity allows for ease maintenance. Main wear parts, such as mechanical seals or bearings, can be accessed quickly and easily without disassembling suction and discharge nozzle.

## Ease of maintenance

The new pump is available for the two specific speeds nq 29 and nq 33. Specific speed is a relation of flow rate and head of a pump and describes the geometry of a pump impeller. Low specific-speed radial impellers are generally low-flow/high-head designs, whereas high specific-speed axial flow impellers are high-flow/low-head designs.

In order to achieve a modular design with a minimum number of parts and good interchangeability, as many common components as possible are used for both the nq 29 and nq 33 hydraulics [8]. Parts such as suction case,



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stage case, shaft, bearing parts, and sleeves, as well as some sealing and balance disk parts are interchangeable between both types. Discharge case, diffuser, and impeller are designed specifically for each specific speed. However, suction and stage impeller use the same hydraulic and mechanical design, thus reducing manufacturing and inventory cost.

With the targeted development of new pump ranges for water transportation and desalination, Sulzer Pumps has moved to the forefront in the market for water pumps. Sulzer engineers are aware of the specific requirements for these important applications and have managed to develop highly efficient and cost-competitive pumps. At the same time, these pumps are easy to maintain, thanks to the forward-looking modular design that involves a reduced number of parts.

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