

PUMPS AND SYSTEMS FOR WATER SUPPLY

GOOD DESIGN REDUCES OPERATIONAL COSTS

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The water supply forms an essential part of urban infrastructure worldwide. Pumps that operate within water supply systems have to be reliable and efficient in order to reduce outage time and operating costs. The correct specification and selection of water transport pumps is of key importance in the planning of new water supply networks.

Sulzer Pumps has extensive expertise in this field and assists clients and consultants in defining the specifications for large water transport pumps. The examination of major water transport systems throughout the world reveals how the right choice of pumps enhances availability and reduces ownership and operating costs.

Water transport pumps are used to supply drinking water to cities located

at higher elevations than the water sources, e.g., in Colombia, Mexico, and Venezuela, as well as to consumers located far from water sources, e. g., in the Middle East (Fig. 1). The selection of water transport pumps is predominantly based on their cost-effectiveness, which is determined by factors such as low energy consumption, the cost of energy, and the flexibility of their transportation capacities. A key consideration is the achievement of low system life-cycle costs.

Reduction of life cycle costs

In a water transport system, the operating costs significantly outweigh the purchase price and must therefore be kept as low as possible. The efficiency of the pumps has to be taken into account when calculating economic performance. A deficit in peak efficiency of as little as 0.5% can lead to additional operating costs of several hundred thousand US dollars over the operating life of a large pump. An approximate breakdown of the costs of a water transport system indicates the relationship between initial and operating costs. The specific energy requirement in kilowatt-hours per cubic meter depends on the length of the pipeline and the geodetic head.

- Costs of pipeline 37%
- Costs of pumping station 20%
- Costs of pumps and base plates 1%
- Operating costs of pumps for 20 years 42%

Several methods exist to improve the efficiency of a pump, the costs of which

Fig. 1: Water supply systems often cover significant distances from the source to the point of use. Pictured here is the water transport system El Pao La Balsa, Venezuela. Sulzer Pumps has extensive experience in the specification and design of large water transport pumps.



Fig. 2: Experienced pumping station designers can obtain the highest possible level of efficiency by selecting a suitable number of pumps and an appropriate rotation speed.

are generally low compared to those of the entire plant.

Entire system considered

The distribution of the total delivery flow over an appropriate number of pumps determines which types of pumps are required for a specific application (Fig. 2). In order to minimize the total cost of ownership, it is necessary to consider the cost-effectiveness of the pumping installation as a whole. It is important to achieve the lowest possible energy costs, operational simplicity, and operational flexibility. Consequently, the main objective when designing water transport pumps is to produce a compact design that is easy

to maintain (see STR 2/2005 p. 4). The selection of pump types for the transportation of water depends on certain aspects of hydraulics (e.g., cavitation, efficiency, specific speed), engineering (e.g., test pressure, rotor dynamics), and the plant system (e.g., the intake system, drivers, liquid properties, water hammer).

Operational flexibility

Pipe systems have to be analyzed to determine their initial and final flow rates and the storage capacity of the intermediate reservoirs. The plant design should offer operational flexibility by enabling capacities to be increased at any time without any alteration to the pump concept.

The required flow and head of drinking water pumps are calculated according to the size of the town that has to be supplied, as well as the elevation difference and distance between the water source and the location of the consumers. The demand for water fluctuates on a seasonal, monthly, daily, and even hourly basis. In developed areas, the demand per head varies between 150 and 500 l/day, depending on the proportion of domestic and industrial water consumption. However, the peak demand rate can be much higher, meaning that water transport pumps must be capable of delivering water over a wide operating range, depending on demand. A number of units have to operate in parallel to achieve this level of flexibility.

Running at best efficiency

In new pumping stations, operational flexibility can be achieved by arranging the pumps symmetrically. In the initial phase, one transport pipeline is sufficient to cope with the flow capacity but provisions are made to install 2 parallel main pipes. A number of pumps, as well as one standby pump, are installed for each pipeline. The distribution of pump flows is arranged in such a way as to ensure that the minimum flow rate can be pumped in a range of 80-110% of the pumps' best efficiency flow rate.

Several pumping stations

It is sometimes necessary to transport desalinated seawater over several hundred kilometers to consumers. Where large distances are involved, a single



Fig. 3: *Booster pumps (left) are much smaller than the main pumps. They provide the necessary suction pressure to ensure the smooth operation of the main pumps.*



Fig. 4: *The horizontally split casing facilitates maintenance. Suction and discharge connections are located in the lower part of the pump.*

pumping station is not sufficient to transport the water due to high frictional losses.

If a single, very powerful pump were to be used, the pipelines would have to be designed to operate at higher pressures and the thickness of their walls would have to be increased, making the pipeline more expensive. However, the cost of installing additional pumps and motors is relatively insignificant compared to the potentially higher costs of the pipeline. The required total delivery head is therefore distributed over several pumping stations.

Variable speed drives

When distributing the pumping sta-

tions according to the topographic nature of the terrain, a distinction is made between open and closed systems. In closed systems, the pumps in the first station deliver water directly to the pumps in the next station, thus providing the suction pressure required for the subsequent stations. It is often necessary to install speed controlled drives in order to increase the operational flexibility of this type of system. The topography of the terrain must be taken into account by the plant design engineer when determining whether an open or closed system should be used.

The appropriate distribution of the flow and head over several pump units

leads to high overall pumping station efficiency over the complete operating range. Every pumping station should have the same splitting and pump-unit sizes in order to limit the need for spare parts and reduce maintenance costs.

Controlling pressure surges

In pipeline systems, any change in the operating state leads to dynamic pressure changes, which can cause serious damage. Water hammer and pressure surges must be taken into account in the planning and operation of these installations. The design of the pipeline system and the pumping stations must allow for any deliberate changes in the flow rate, such as the start-up of a pump or accidental changes in the flow rate, such as a power failure. Additional safety devices must be provided to safeguard against pressure surges caused by power failures in particular.

A pressure surge investigation can determine the size of the device required to protect a specific pipeline or can indicate whether a better line profile will allow significantly smaller protective devices to be used. However, this valuable information can only be

utilized if the transients are examined in the planning stage of the project.

Less civil works

A variety of pump configurations can meet the specifications of a planned pumping station with each different configuration having an impact on civil engineering aspects, e.g., the space required or the excavation depth, and on the electromechanical equipment, e.g., the rotational speed or number of pumps required. The available net positive suction head (NPSH) depends on the minimum reservoir levels and limits the speed of the water transport pumps. If the pump foundation is lowered in order to achieve better suction conditions, the cost of civil works will increase. In this case, it is advisable to install booster pumps, which are flooded at the minimum reservoir levels (Fig. 3). The pump manufacturer can often propose the available NPSH value during the project phase to ensure the smooth operation of the system. The layout of the pumping station is evaluated by analyzing the cost of the civil engineering work and electromechanical equipment. The

skilful arrangement of the pumps can reduce the overall cost of the project, even if additional pumps may have to be installed.

Easy pump maintenance is very important in a water transport system. Water transport pumps should therefore have horizontally split casings (Fig. 4), which can be easily taken apart without any disruption to the suction and discharge flange connections.

A great deal of experience is required to select the correct pumps: the selection criteria cannot be specified using a few rules. A final decision regarding the type of pump to be selected can be reached by the pump manufacturer and the plant design engineer following careful consideration of all of the advantages and disadvantages of the various models, while also taking account of the fluid pressure at the impeller inlet, efficiency, the space occupied by the pump, and the civil engineering measures that have to be implemented.

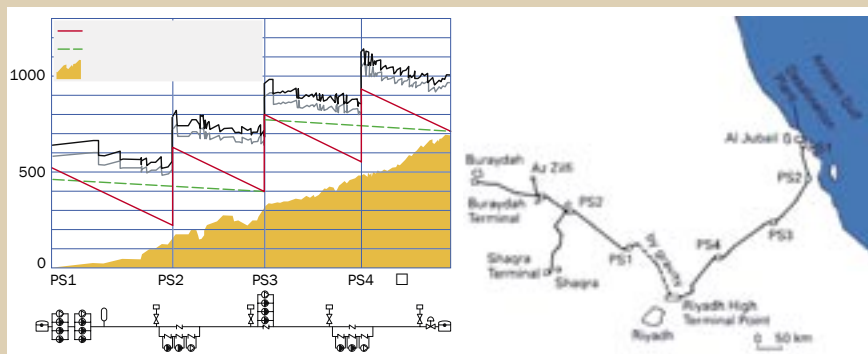
Lowest cost of ownership

The geodetic profile of the pipeline dictates the split of parallel pump units. With a variable speed solution, the pumps work at close to best efficiency over a wide operating range, while any throttling of the generated head is avoided. This option is the most cost-effective solution. In addition, the variable-speed arrangement reduces the loading of the pumps, especially during the plant start-up phase. Close cooperation between the pump manufacturer, client, and consultant is essential to find the optimal specifications for large water transport pumps for an individual project. The expertise of Sulzer Pumps engineers can help clients to reduce the risk of failure and to select pumps that can operate effectively while achieving the lowest possible overall cost of ownership for the water transport system. <<

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The skilful arrangement of pumps provides operational flexibility

The skilful arrangement of the pumps provides maximum flexibility for the operator, as illustrated by the example of a system that has to feed variable flows over a long distance with a slowly rising geodetic head with no high point. The design comprises 4 pumping stations, with booster and main pumps operating in parallel in station 1 and main pumps operating in series in stations 2 and 4. Pumping station 3 is equipped with main pumps of the same size as in station 1, also operating in parallel. This combination enables the number of different pump types to be reduced to 3, i.e., a booster pump, 2-stage back-to-back main pumps in stations 1 and 3, and single-stage double-flow pumps in stations 2 and 4. It is important to use the booster pump at the appropriate speed to fulfill the suction conditions of the plant and to provide sufficient suction head for the main pumps. The pumping stations 2 and 4 can be bypassed at low flowrates. The proposed concept can accommodate a wide variety of flows at low operating costs. <<



Water transport and supply system: Al Jubail-Riyadh, line C (Saudi Arabia).



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