WATER - From the Desert

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Libya is so dry that it is the only country in the world that does not have a river which is constantly filled with at least a certain amount of water. But under the Sahara desert at a depth of 300 to 2000 meters are huge water reservoirs in the Nubian sandstone. At the beginning of the 1980s the ambitious project "Great Mary-Made River" (CMMR) was started to bring the fossil freshwater to the densely populated coastal areas.

In the first phase, a network of aqueducts with a diameter of four meters is being built. This transports the water underground from the Tazerbo wells and Sarir reservoir in the south to the north-eastern coastal areas of Libya, namely Benghazi and Sirt. In the second phase, two million cubic meters of water are to be transported daily from the wells of the Fezzan region plus another further increase by 500,000 cubic meters. Additional phases are to provide another 1.68 million cubic meters of water from the Kufra region, the Gadammes region and Jiagboub. Given a daily water consumption of six million cubic meters the Libyan population can be supplied with water for over 50 years.

A Pipeline Management System Monitors Operations

In order to ensure that the GMMR project runs smoothly, computers monitor and control all aspects of the water supply, from groundwater monitoring and quantitative and qualitative condition detection to process control in treatment plants. Pipeline networks and distribution flows are managed and monitored as well and the system is also responsible for customer accounting. For the different stages of the project Siemens Water Technologies supplied and installed the power supply installations as well as the complete control and automation system for Phase 2. All the supplied automation systems and components are based on the Simatic family of products extended by the Sinaut family of products for Wide Area Network communication. Together with the Siemens SCADA (Supervisory Control And Data Acquisition) the combined system monitors and controls the installation involved in the transport of water. This includes 484 wells in three wellfields, each with associated balancing tank. Four pumping stations and five regulating stations as well as two Flow Control Stations and three outlet stations convey the water all the way up from the wellfields to the final consumer.

Perfected methods of measuring, costing and simulation ensure economically efficient transport and adapt the installations flexibly and easily to the operational necessities.

Each well in the Hasouna wellfields of Phase 2 is equipped with its own pump and is remote-controlled via a Simatic 57-300 automation station. The pumps force the water into the main pipeline, which is 4 meters in diameter and 700 km long. In the case of maximum utilization, approximately 2.5 million cubic meters of water flow through the pipe. Four pumping stations with main pumps and backup pumps ensure the necessary pressure in the pipeline. For correct and flexible operation of the pipeline, check valves have been installed in a number of different places. They block off specific areas in the event of a leak or maintenance work for example divert the water into another pipe. Flow-rate meters and pressure gauges monitor correct operation of the pipeline and upport leak detection and location. Depending on the pipeline profile, balancing tanks arid reservoirs (regulating stations) ensure the necessary pressure compensation. Redundant Simatic S5-155 H automation stations monitor the tanks and control the level of water in them. When necessary, the control system can be used to switch over to other tanks or initiate an emergency procedure in order to avoid complete drainage of the tanks, for example. Along the pipeline, so-called turnouts supply large cities and agriculturally cultivated areas with water. For this purpose. Simatic 57 systems control the pressure and the levels of the respective reservoirs and also measure the volume rate of flow.

All the automation and measuring devices communicate with the control system via a communication backbone system, i.e. over long distances. Data is transmitted by means of the station control system in order to monitor and control the widely distributed Sinaut ST7 process stations via optical fiber cables.

Water Management and Prognosis

Measured values relating to flow rate, pressure and filling levels are supplied by sensors fitted along the pipeline. All these values are collected in the main control center in Tripoli to calculate the most effective operating schedule for all the pumps and tanks in the supply system and the diverse water resources. From the data it receives, the automation system (SCADA) calculates corresponding valve and gate positions in the flow control stations and determines how many pumps have to be switched on in the wellfield area and in the different pressure stations. The greatest challenge is to cope with the changing demand of water taken from consumers for municipal or agricultural use.

On-Demand Operation by the Automation System

On-Demand operation (high level control) is performed within the Simatic S5-155H controllers. The automation system satisfies changing user flow demands, whilst avoiding wastage of water and avoiding overstress of any part of the system. To improve buffering action effectiveness, the total volume of water in the tank stations is adjusted based on the user flow rate.

When the user flow rate is high, the filling level in the storage tanks is reduced to provide available tank volumes to accommodate a possible rapid reduction in user flow rate. Conversely, when user flow rates are low, the total filling level in the storage tanks shall be increased to provide water to accommodate a possible sudden increase in user flow rate.

Based on this principle, the system calculates to the minute a 15 minutes average for common user demand. This average, derived from the actual turnout flow rates, is used as a basis upon which changes in consumer demand are detected. Using this average, the implemented high level control system (HLCS) responds to changes in consumer demand by calculating new target levels for the regulating and balancing tanks as well as new schedules for the flow control stations and pressure stations.

Coordination of running times and switching rates is used as an additionally criteria for optimization. Technical and operational restrictions such as the frequency of pump switching as well as minimum and maximum filling levels determine the general framework for optimization of the whole process.

Planned Demand Schedule Calculation (Three-day plan) by Simulation

In order to avoid a complete loss of important plant items (i.e. control centers in the wellfield or along the pipeline) in case of communication problems between these centers and the main control centre in Tripoli, a Pipeline Simulation System (PSS) is also fed with the plant data. In addition to pipes and tanks, the system also takes account of pumps and pumping stations, gate valves, feed-in sections and turnouts. Via its interface to the overall control system (SCADA), it obtains all the current values online and automatically.

The simulator makes use of a quasistationary model which is based on the pressure and flow-rate relationships of all important pipe segments and dynamically illustrates the filling levels of the tanks. On the basis of a priority list and the availabilities of the individual pumps, as well as of the filling level of the balancing tanks and forecast consumption for the next three days, the simulation system draws up a list of control stipulations for the overall control system, the so-called three-day plan.

This three-day plan incorporates all necessary plant schedules, for example start and stopping times for pumps or adjustment instructions for flow control valves in advance for the next three days. In the event of discrepancies between the forecast demand and the capacities of the pipeline system, the PSS sounds the alarm in good time so that the operator can take appropriate countermeasures or revise the forecast. After validation and approval of these calculated values by the operator, the three-day plan is distributed to the different pipeline control centres in the wellfields and along the pipeline, for use by the high level control system as the expected demand flow in the event that communications with the main control centre in Tripoli fails. In this case on-demand control for the respective control centre is inhibited and three-day plan operation is used as default production schedule.

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