Drive & Control
profile

Bosch Rexroth's global effort is key to Panama Canal expansion

Bosch Rexroth teams from multiple countries collaborated to expand one of the world's largest locks

Since June 2016, the expansion of the Panama Canal, as well as the new construction of two locks with water saving function have been completed. Now, ships with lengths up to 366 m and widths up to 49 m are able to pass through this shortened connection between the Far East and commercial ports along the North American shoreline, including the eastern seaboard and Gulf of Mexico.

A Global Task

The recent expansion of the Panama Canal was an enormous task—one that required the resources of project partners around the world. Bosch Rexroth, with previous experience in Panama Canal upgrades and a global leader in drive and control technology, was contracted by Hyundai to supply the hydraulic systems for the project.

A monumental feat of engineering and collaboration, the canal's expansion included installing valves for the filling and emptying lock chamber system and establishing a system of water-saving basins and corresponding valves to control the water flow. Two main players for this project were Bosch Rexroth and South Korean manufacturer Hyundai Samho Heavy Industries. Hyundai equipped and installed culvert,

Challenge:

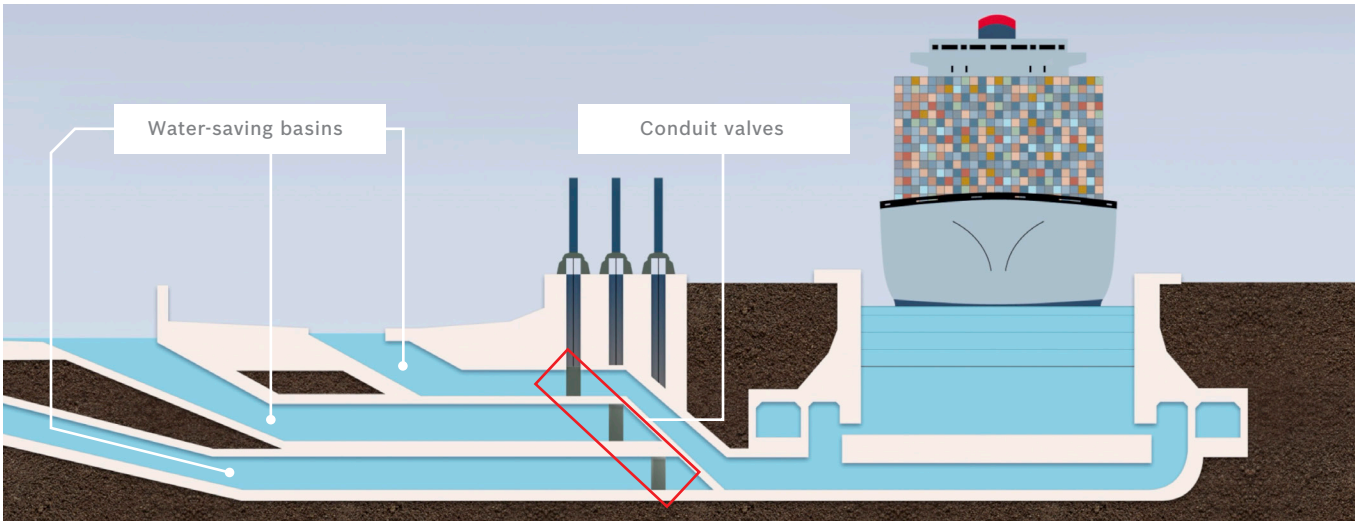
Expand the Panama Canal to allow for today's larger ships to pass through with the highest degree of availability for all locks.

Solution:

Develop systems using hydraulic cylinders, power units and controls to operate the valves that regulate the water.

Results:

- 158 complete systems developed (including six (6) spare units)
- 22 km of interconnected piping
- Built-in redundancy contributes to 99.9% lock availability
- Largest construction site in the world at the time



The new locks have three lock chambers each. Each lock chamber is connected to three water-saving basins to reutilize the water employed in a lockage from the Gatun Lake.

conduit and equalization valves and appurtenant structures, while Bosch Rexroth supplied and built all operating machinery for the valves. This machinery includes custom-designed hydraulic power units with full redundancy, hydraulic cylinders and comprehensive electronic control systems with sensors and backups, contributing to 99.9 percent reliability in all operating circumstances.

The sheer scope of the project created huge technical and time demands. Manufacturing 158 complete systems of hydraulic cylinders, power units and controls required a synchronized effort from Bosch Rexroth workshops in the U.S., China, South Korea, Germany and the Netherlands. Bosch Rexroth's ability to pull together resources from around the world, along with its history with the Panama Canal, made it a great partner for this world-class project.

The Right Experience

Rexroth was chosen as system supplier for the valve drives and related control technology based on a number of factors. First, the company has decades of experience in civil and hydraulic engineering, including large engineering projects in Europe, South America and China. Secondly, Bosch Rexroth has a rich history with the Panama Canal.

"We have worked with then Rexroth and now Bosch Rexroth since the early 1990's and they have been a suitable technical solution provider for applications on locks, locomotive hydraulics and PLC controls," said Jorge L. Quijano, CEO for the Panama Canal Authority (ACP). "They have provided ACP with robust technical

HYDRAULIC DRIVES

Culvert	Conduit	Equalization
66x hydraulic power unit with redundant PLC	74x hydraulic power unit with redundant PLC	18x hydraulic power unit with redundant PLC
P=75kW, Q=335l/min., p=120/180bar, tank volume 1325 l	P=56kW, Q=206l/min., p=145/180bar, tank volume 760 l	P=36kW, Q=130l/min., p=115bar, tank volume 570 l
66x cylinder 260/100/6650	74x cylinder 220/100/6150	18x cylinder 200/70/4150
Valve weight 31,500 kg	Valve weight 24,500 kg	Valve weight 12,100 kg

The hydraulic drives for all the valves are identical, but with different capacities for e-motors, pumps, valves and reservoirs. The differences are caused by three types of cylinders for the culvert, conduit and equalization valves. However, the software control system is the same for all the valves where the configuration parameters determine the type of valves.

Every drive cylinder is equipped with a position measurement system which allows for the exact recording of the valve positions

Hydraulic power units with stainless steel and flexible lines

solutions and effective project management. They have been there to support our challenging needs both on the Panamax and Neo Panama canal locks."

Bosch Rexroth and the Panama Canal

In 1992, Bosch Rexroth reached out to the Panama Canal engineers to explore how they could help upgrade the original mechanical lock machinery, in operation since 1914 when the canal first opened. Bosch Rexroth delivered a turnkey prototype project for rising stem valves, converting them from mechanical to hydraulic operating machinery. From there, Rexroth won a contract to convert all of the mitre gates from electromechanical to electrohydraulic, including computer controls and data acquisition. Based on these upgrades, canal engineers experienced the ease of control and reliability of an electrohydraulic solution, which resulted in Bosch Rexroth adding hydraulically operated systems.

Focusing on the Lock System

For the most recent project awarded in 2010, the attention turned to the canal's two identical lock systems, one at the Pacific site and another at the Atlantic site. Because the system uses large amounts of water, the new advanced lock technology was designed to save water. Both new locks have three chambers and each is connected to three water-saving basins. With this arrangement, it is by far the largest and most complex locks system in the world.

If a ship travels from the Atlantic Ocean into a new lock, tug boats will bring it into the lower lock chamber. As soon as the outer lock chamber gate closes, it fills with water from the basins through the valves by means of gravity. Then, main culvert valves even out the water levels of the middle and lower chambers. Once the level between the two chambers equalizes, the corresponding lock chamber gates open and the ship can be tugged into the middle chamber. After the gates close behind the vessel and the chamber is isolated from the previous chamber, the process repeats itself with the upper chamber.

Together, the three water-saving basins hold about 60 percent of the water volume to equalize each corresponding lock chamber. Therefore, only 40 percent of the water volume is lost by using the basins, saving water from the Gatun lake. When the ship reaches lake level, the outer gates open and it can continue its journey through the Gatun Lake in the direction of the Pacific Ocean.

Control block of a hydraulic power unit with pressure gauge

Time Challenges

Apart from the technical challenges of the project, time played a decisive role. Rexroth needed to develop 158 customer-specific power units and drive cylinders for the valve operation to regulate the water flow. These compensating valves control the inflow to the lock chambers and water-saving basins. After final completion of the hydraulic drives' design, the first partial delivery to the Panama construction sites had to be fulfilled by January 2013. This was only achieved because of Rexroth's global development and production capabilities. Engineering and project management took place in Germany, while the hydraulic cylinders were developed in the Netherlands. Rexroth's U.S. and South Korean plants manufactured the hydraulic power units and the cylinders were produced in China. Through all of the various locations and projects, everything had to conform to US-American Society of Mechanical Engineers (ASME) standards—a challenging, but routine task for Rexroth as an international supplier.

Redundancy is Key to 99.9 Percent Availability

The lock system's unique process and international service require as close to perfect equipment availability as possible to ensure the canal operates reliably. Because of this, all installations also require a redundant design. For emptying a basin, technically only two valves are required, but each basin has four. This means two valves could fail and the lock would still continue working without issues. The same redundancy exists for the culvert canal. Here, a total of 32 valves were installed per lock installation, with only half needed for operation, or eight valves per lock head. Valve maintenance doesn't influence operation, and even when maintenance is being conducted, the lock can remain operational. In addition, there are two rolling gates for each lock head, when only one is needed.

Every valve has a drive cylinder and related power unit, and each power unit has two motor pump units (one being redundant). Additionally, the PLC control technology, including the position sensoring system of the valves, is designed in a redundant manner. There are also two spare units for the culvert, conduit and equalization valves, so the complete scope of delivery comprises 158 drive units. This exhaustive redundancy contributes to a lock availability of 99.9 percent.

Global Flexibility

With a project of this size and scope, Bosch Rexroth's global resources were a key factor in completing the project successfully and within the time constraints. With several international Rexroth teams from Brazil, Chile, Germany, Mexico, the Netherlands and the U.S. working simultaneously on the two large installation sites, the units were installed quickly and efficiently. When the project was extended from its original October 2014 end date to June 2016, Bosch Rexroth had the resources and flexibility to adjust accordingly and even trained canal employees on maintenance and operation.

Do you have an application worthy of a case study?
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