Latest in Technologies for Navigational Locks

by

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ABSTRACT

The Panama ship lock extension has been a huge project not for only the civil engineering but also for hydraulic installations. The total installation of 6 locks together with water saving system has made it one of the biggest civil works in the field of navigational locks.

The water saving system of the locks of the Panama Canal extension makes it possible to save up to 60% of the water used during lockage of vessels. The water saving system consists of three basins built for every lock. In a normal lock system the water flow is always downstream with the lockage of a vessel. New Panama water saving system saves 60% of the water in the lock by using the water saving basins in three phases. The water saving process is an important improvement of the Panama Canal because the central Gatun lake gets most of its water from the rain fall and is also an important source for the water service in the Panama City.

The water flow to fill and empty the lock chambers, the water saving basins as well as the lock area between the rolling gates is realized through valves operated by hydraulic drive systems. The operating environments and the high demands on the reliability for the water saving system has setup high standards for the hydraulic system.

The hydraulic drive system of the 6 new locks consists of 152 special designed cylinders, each operated by a dedicated hydraulic power unit. Each hydraulic power unit can be operated locally. All lockage processes are operated by the machinery-control system (LMCS) and the lockage process can be operated automatically, semi-automatically as well as in manual mode with the LMCS. The hydraulic power units are equipped with a local control panels, which enables the manual operation at the power units.

The pipe work of the whole Panama expansion project consists of a length of about 22 km made of stainless steel. The oil used in the hydraulic system is an environmental friendly fluid to eliminate the impact to the environment during the overhaul of the hydraulic system.

Moreover, the challenge for the environmental aspects were taken into account during the design of the projects. Two main elements to ensure a long maintenance period and leak free operation of the cylinders were the quality of the piston rod surface and the sealing system of the hydraulic cylinder. The traditional way of making piston rod coating has been the chrome plating. Quite often the hard environment has set up a demand to have a stainless steel base material.

As an alternative there are new technologies in the market to avoid the expensive use of base material combined with the tight and crack free structure of the coating. The High Velocity Oxygen Fuel (HVOF) technology is used to produce coating on the piston rods especially on the large dimensions. By using the HVOF technology there is no need for the corrosion resistant base material and therefore the total cost for the appropriate corrosion resistance can be lowered. In addition, by using the HVOF technology it's possible to adjust the needed corrosion resistance according the operating environment by the different parameters of the HVOF process.

The other factor on the trouble free operation of the cylinder is the correct function of the tribological system at the piston rod. The piston rod is impacted on the abrasive materials as well as oxidation layer on the piston rod. To prevent the abrasive particles to enter in to the oil through piston rod and keep the oil inside the cylinder, the effective seal system is needed. The most common seal type used in the navigational locks is the chevron seal. However, the multiple amount of seals in the chevron package creates friction and is therefore uneconomic. The resent development in the field of seal material and construction makes it

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possible to introduce low friction solutions also for chevron seal. In addition, with the patented structure, the chevron seal design can be changed at the overhaul on the site without disassembly the cylinder.

There has been taken efforts also on the other type of actuators for the navigational locks. In the development work the hydraulic and also electro mechanical solutions have been realized. The latest development of the gate operating technologies let us introduce new features also on the field of information technology. It gives us an option to let the machinery communicate with the upper level control system i.e in case of maintenance needs.

The long hydraulic pipe works increase a risk of leakage in the navigational locks. Normally the risk has been minimized by setting high standards on the pipe work design and realizations. To avoid the field piping totally the self-contained actuators are needed. Self-contained actuators need only electrical energy and control signal. The movement is created in the actuator. There two types of self-contained actuator available for the ship locks.

The electro-mechanical actuators are presented for applications, where the need of force is adequate. The advantage of the electro-mechanical actuator is the easy installation, since no room for hydraulic power unit and no field piping are need. Unlike easily understood, the environmental protection has to be taken in to the consideration during the design of system also with electro-mechanical actuator. The lubrication system of the spindle consists of grease and it needs to be naturally leak free. Therefore, the sealing construction of also the electro-mechanical actuator has be taken well into the consideration. In addition, the electro-mechanical actuator is incapable to take impacts since the main operating element is a spindle. Therefore, the electro-mechanical solutions are used in the small roller gate systems.

Another type of self-contained actuator is an electro-hydraulic actuator. Like in electro-mechanical actuator it needs only electric power supply and the control signal. The electrical energy is transferred to movement by compact hydraulic unit located in the actuator. The electro-hydraulic actuator is suitable for high forces and applications, where impacts are expected from the moving elements like mitre-gates. The oil system of an electro-mechanical actuator is closed and the structure of the cylinder has normally three chambers, which enables the pendeling volume circulate inside the cylinder.

For the heavy sliding gate design there are normally a mechanical drive equipped with a gearbox. The redundancy is realized by a several electro-motors and gear box combinations. By using a closed loop hydraulic system with a direct drive concept, the operation and the redundancy can be realized easily and with a savings in the needed room and the weight of the total system. The direct drive can be also taking in to the consideration on the modernization projects, where an old mechanical drive need to be updated on the latest technological level.

The latest development in the information and sensor technology have made it possible to introduce new tools for the monitoring of the condition of the operating machinery in the ship locks. In the modern hydraulic system there are sensors detecting the characteristics of the system. The characteristics like temperature, vibrations, pressure level and pressure pulsations are detected and analyzed during the use of the system. The analysis provides a hydraulic health index for the new system and by monitoring this hydraulic health index, the need for the predictive maintenance operations can be planned in advance. By equipping the system with a remote access, the main operating characteristics can be easily checked without visiting the machinery.

Panama Canal Extension was the newest state of the art in 2009. The development in the technologies in the field of navigational lock has been progressed a lot since that time, especially in algorithms of sensing the hydraulic systems but also on the mechanical engineering of the components used in navigational locks. The further development of collecting and analyzing the data taken from the operating systems will make possible to design and build locks even more reliable by getting more online data from the sub systems operating parameter.