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Title: World's largest FRP Composite Mitre Gate

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Presentation of this paper will be given as part of the SHORT COURSE: Miter Gates, Rolling Gates and Operational Machinery Process Design.

This presentation will participants on overview of the state of the art in miter gate machinery and controls and will promote discussion of the benefits of specific design features. It will help participants decide which features are most appropriate to fit the unique characteristics of their sites.

Abstract

This presentation will draw heavily on the Working Group 138 report, Mechanical and Electrical Engineering Lessons Learned from Navigation Structures. Four different types of linkages are commonly used to drive miter gates. Three of these linkages are closely related and consist of a sector gear and sector arm with a strut connecting the sector arm to the gate. These three linkages are referred to as the Panama Canal, Ohio River, and Modified Ohio River linkages. The original Panama Locks used the Panama Canal linkage. The fourth type of linkage is the direct connected cylinder. The direct connected cylinder consists of a hydraulic cylinder with its shell (or body) supported in the miter gate machinery recess by a trunnion and cardanic ring assembly (or gimbal) and its rod connected directly to the miter gate with a spherical bearing type clevis. The direct connected cylinder has become the most common type of miter gate drive for new construction and retrofits. This is because of a cost advantage in the fabrication, installation, and maintenance of these systems. The Panama Canal and related linkages offered some advantages that should be considered. One is that the linkage can be electrically or hydraulically driven. Another advantage is that the geometry of the linkages inherently decelerates the motion of the gate as it approaches fully open or closed. This advantage is useful when the motion of the gate is controlled by the input of a human operator. Also, shock absorption can be incorporated into the strut. Miter gates are now often controlled by electronic control systems with varying degrees of automation. The control of drives with direct connected cylinders can be programmed to automatically decelerate the gate as it approaches opened or closed position. The direct connected cylinder can also be a linear mechanical actuator within certain stroke and gate size limitations.

Advances in hydraulic power systems for miter gates have allowed for increased reliability and maintainability through mechanical linear actuators, compact hydraulic drive units and self-contained hydraulic units that can be quickly and easily exchanged for maintenance with a spare.

The linear mechanical electric actuator is a completely encapsulated, electro-mechanical drive unit, consisting of a drive motor, screw drive with bearings, housing, and the extendable and retractable piston rod as the external power transmission element. Mechanical linear actuators are an advancement of the mechanical drive systems traditionally used on navigation structures. The motor is designed to operate in two directions which then retracts the piston or extends the piston. The piston assembly connects to the gate similar to a direct connected hydraulic drive.

Compact drives are environmentally isolated systems in order to minimize the effects of humidity and contamination of fluid. No fluid changes are required during the life of the unit. Outdoor units are equipped with an overpressure tank, where the fluid level can expand in the existing free space by compression of the air. This is done to absorb the pendulum volume of the hydraulic system and also the volume change due to temperature changes. The hydraulic compact units are driven by variable speed motors for adapting the speed of cylinders to the respective operational specifications. With variable speed motors, robust constant flow pumps and simple on/off valve techniques for compact units can be applied. In addition to the position sensing of the piston rod, further process parameters such as operation pressure, oil temperature, oil level and filter contamination are monitored by remote control so that disturbances and faults can be detected.

A self-contained hydraulic drive system combines a hydraulic power unit with a hydraulic cylinder to form a self-contained actuator that is completely sealed and submersible. Instead of directional valves, the drive unit utilizes a bi-rotational gear pump mounted inside a sealed reservoir that is driven by a submersible and reversible electric motor. The speed and direction of each actuator is controlled by a variable frequency drive (VFD) which controls the speed and direction of the electric motor. The gear pump is a simple, rugged, positive displacement design. Gear pumps have a high tolerance for fluid contamination, good overall efficiency, and are relatively quiet. Speed and direction control of an actuator is provided by driving a reversible gear pump with a variable speed electric motor, which makes them ideal for self-contained type power units. Gear pumps are generally restricted to less than 24 MPa (3,500psi) service. Sealed reservoirs are primarily used for the power unit of a self-contained actuator. This consists of a power unit attached directly to the hydraulic cylinder it operates. These actuators can be configured in many different ways by changing the design (shape) of the reservoir and where and how it is attached to the cylinder. The direct connected miter gate actuators recently installed on several locks have long slender reservoirs, made from square structural tubing, bolted to brackets on the side of the cylinder.