CONTROLLED PASSIVE SHIP STABILISER SYSTEM

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MECHANICAL

The biggest roll angles of a ship occur at resonance. The best way of reducing roll angle is to dampen the roll motion. One way of doing it is through using passive stabiliser tanks. This article describes this technique as applied to a fishing vessel.

A ship is equipped with two stabilising tanks. Damping relies on the natural flow of the water from one tank to the other. This article describes the Controlled Passive Stabiliser System, designed, manufactured, installed and commissioned successfully on shipping vessel of one of the leading fishing industries in South Africa, by Delcon Marine and Industrial.

Roll stabiliser tanks

A passive Roll Damping Tank system was designed by DMI in conjunction with Triton Naval Architects and installed on the Eagle Star, a fishing vessel belonging to Hout Bay Fishing Industries.

This specific tank consists of two sealed tanks that are connected via a water crossover duct between the bottoms and air pipes at the top, as shown in Figure 1. The air pipes at the top allow the tank to be controlled by means of valves in the air duct. The air pressure in the tanks changes effectively the damping of the tank.

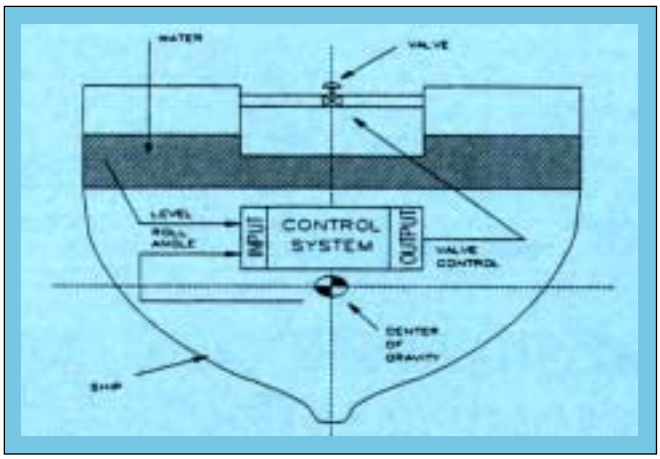

Figure 1.
Tank stabiliser system.

Stabilising is achieved by the ship roll moment and the water induced moment working in opposite directions. At the natural frequency, the moment will be 90∞ out of phase, exerting the maximum stabilisation moment against the righting moment of the ship.

Physically it would imply that the water is always on the upward moving side of the ship.

A means of controlling the water in the tanks is to put pneumatic valves in the air duct of the passive stabiliser tank (Figure 1). Precision control is clearly not possible (because of the compressibility of the air), but enough control is possible to restrict unwanted flow of water.

The basic principle in controlling the valves is to keep the water on the upwards moving ship's side (valves closed) as long as the specific period of roll demands, releasing the water only if a clear righting moment towards the other side is detected.

Motion of water that increases roll should thus be avoided by the control system. It should also cater for very long rolling periods such as in the stern (following seas).

System description

The functional layout of the system is shown in Figure 2. The interfacing between the Programmable Logic Controller (PLC) and the system parameters is shown and briefly described.

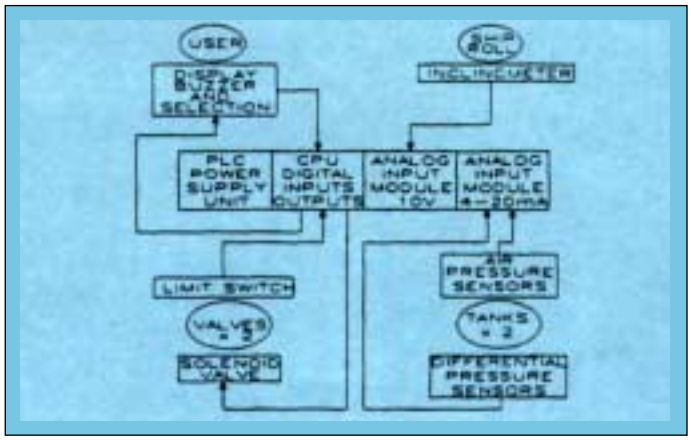

Figure 2.
System layout

The PLC is used to read system parameters such as roll angle and tank level, as well as giving control signals to the valves in the air ducts for opening and closing. The con-trol signal is generated by the software program situated in the Central Processing Unit (CPU) of the PLC.

The system - roll stabilising tanks and controls, are shown in Figure 3.

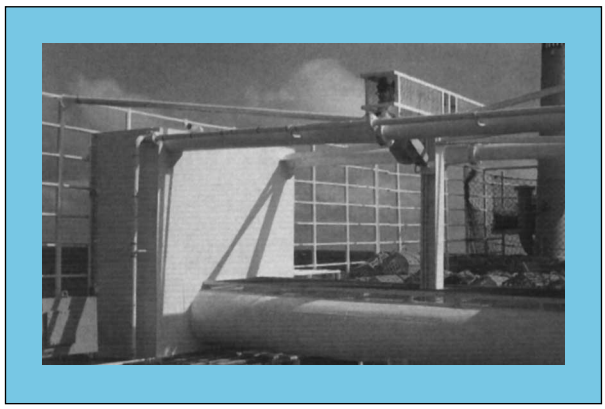

Figure 3.
Roll stabilising tanks and controls.

Mode of operation

The mode of operation, for example passive, controlled and closed mode of the tank stabiliser, is controlled by an operator making a selection at the bridge control unit. A four-position rotary switch controls the different modes of operation in this unit.

Selection display

The selection mode and error codes are displayed on the Bridge Control Unit and act as feedback to the operator. A buzzer will alert the operator should a failure occur.

Roll angle

Roll angle is measured by an Inclinometer Module, installed in the Officers' mess. It is measured as a ± 10 V analog value, representing ± 45∞ and is generated by the inclinometer module.

Tank level

The level of the sea water in the roll damp tanks is determined using differential pressure sensors installed in the tanks, with a signal of 4-20 mA. representing a level of 0-3 m.

Air pressure

The air pressure in the tanks, due to valve closure for safety purposes, is measured by pressure sensors situated in the tank. These generate analog values of 4-20mA, corresponding to pressure of -1 to 4 bar.

Valve position

To determine if opening and closing commands for the pneumatic valves in the air ducts are executed, valve position feedback is achieved by monitoring limit switches installed on the actuators. These are coupled to the axis of the valves, giving the feedback signal if the valves are in the closed or opened position.

Control valves

To obtain control over water motion by means of air pressure in the tanks, control valves situated in the air duct of the tank are opened/closed by the control system.

Modes of operation

Passive operation

The system works as designed without control valves. The action of the water is such that it will remain out of phase with the roll angle of the ship. Basically, the water will be moving to the one side while the ship starts to roll to the other side, thus damping the motion.

This mode of operation is used under normal loading conditions and high frequency seas

Valves closed operation

If the valves in the air duct are closed, the high air pressure in the tanks will restrict the water flow front the tank on one side to the tank to the other, thus reducing the effect of the natural flow of the water.

This mode of operation is used during heavy manoeuvering and was incorporated as a safety feature during design and testing.

Controlled operation

The controlled operation will phase the water so as to maximise stabilisation. It will open/close the control valves during long periods, thereby effectively reducing every individual roll motion of the ship.

This mode of operation is used when the ship is heavily loaded, as well as in heavy seas whenever the wave period is very low.

Conclusion

This article has described the simple yet effective passive stabiliser installed on the fishing vessel Eagle Star.

Resume

Lufuno Mphaphuli, PrEng, BSc (Eng) (Wits) MSABTACO, MSAIMC, MSAIEE, WK) also obtained a Certificate in Programme Management from Pretoria University, is Currently Director of Delcon Marine and Industrial (Pty) Ltd.