CAPABILITIES OF LOCAL AND REMOTE MONITORING AND CONTROL OF EQUIPMENT USED IN MARINE SHIP INDUSTRY

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Abstract. This article presents two aspects regarding marine equipment control and monitoring. The first one is the issue of remote and local control in the maritime and land industry. The second is the economical and efficient use of redundant devices. This article describes the structure of remote control implemented on vessels. Paper presents an idea of control that combines remote and local control to provide optimal use of redundant devices with simultaneous increase of system reliability. The whole concept is shown on the built physical model with the control and operator panels. The control was implemented using freely programmable controller and HMI panel.

Keywords: maritime devices, redundancy, remote and local control, PLC

INTRODUCTION

With the continuous development of industry, the requirements concerning work efficiency and reliability of machine systems – and therefore their individual devices, located on marine vessels and land enterprises – have been raised. Implementing new solutions while constructing such systems also resulted in broadening the areas of automation. For economic reasons, one of the main aims in ship construction industry is the partial automation of marine vessels, it is exhibited by equipping specific marine vessel system with automated devices, which enable the steering and controlling the work of machines and devices (Śmierzchalski, 2006) from one location (Fig. 1).

Fig. 1. Central Navigation Console on Board of the Mayview Maersk Bridge.
Source: photo Robert Urbaniak

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The concept of remote control can be defined as the transmitting commands and instructions from a control unit to an actuator unit from a distance. The entire communication process may be carried with the use of wire systems (by means of such solutions as electrical cords, optical fibers), or wireless systems (by means of such solutions as acoustic, radio or infraredwaves). On board of marine vessels, due to their specifics, it is usual that wire systems are implemented, and the remote control is carried out by means of an operator's panel. Furthermore, there is also a possibility to control a device with the use of a panel located nearby the device (local control).
Local control is used mainly in the case of maintenance, inspection, replacement, or while repairing a specific device. In the case of land devices however, the remote control mainly refers to wireless signal transmitting technology (Klimkowska et al., 2016).
Due to marine vessel plating, wireless controlling on board vessels is difficult to implement. Plating is usually made with use of steel materials, which limit the spreading of electromagnetic waves as it in the case of a Faraday cage. However, in the case of large sailing vessels, which contain large and spacious interiors like engine rooms (Fig. 2), implementing controlling based on modified wi-fi networks or RF radio transmitter modules is possible.

Fig. 2. Mayview Engine Room.

Source: photo Robert Urbaniak

The following article describes the structure of a marine vessel remote control system. It also discusses the topic of redundant devices and control strategy, which use ensures effective and economic exploitation of devices.

REMOTE CONTROL AND MONITORING SYSTEM

The task of a remote control system installed on board a sailing vessel is to run the controlling logarithm indicated by the operator (navigator or mechanic), which directs to achieve the optimal parameters of a device's performance, and in turn, the whole system.
Such system manages not only individual machines, devices and installations, but complete systems – mechanic and electric (such as compressors, generators, pumps, relays, valves) (Polski Rejestr Statków, 2007).
Currently, in marine automation, the most common solution is a configuration of dispersed (decentralised) programmable systems of microprocessors – freely programmable controllers. The structure of an entire control system is hierarchical and multilevel (Fig. 3).

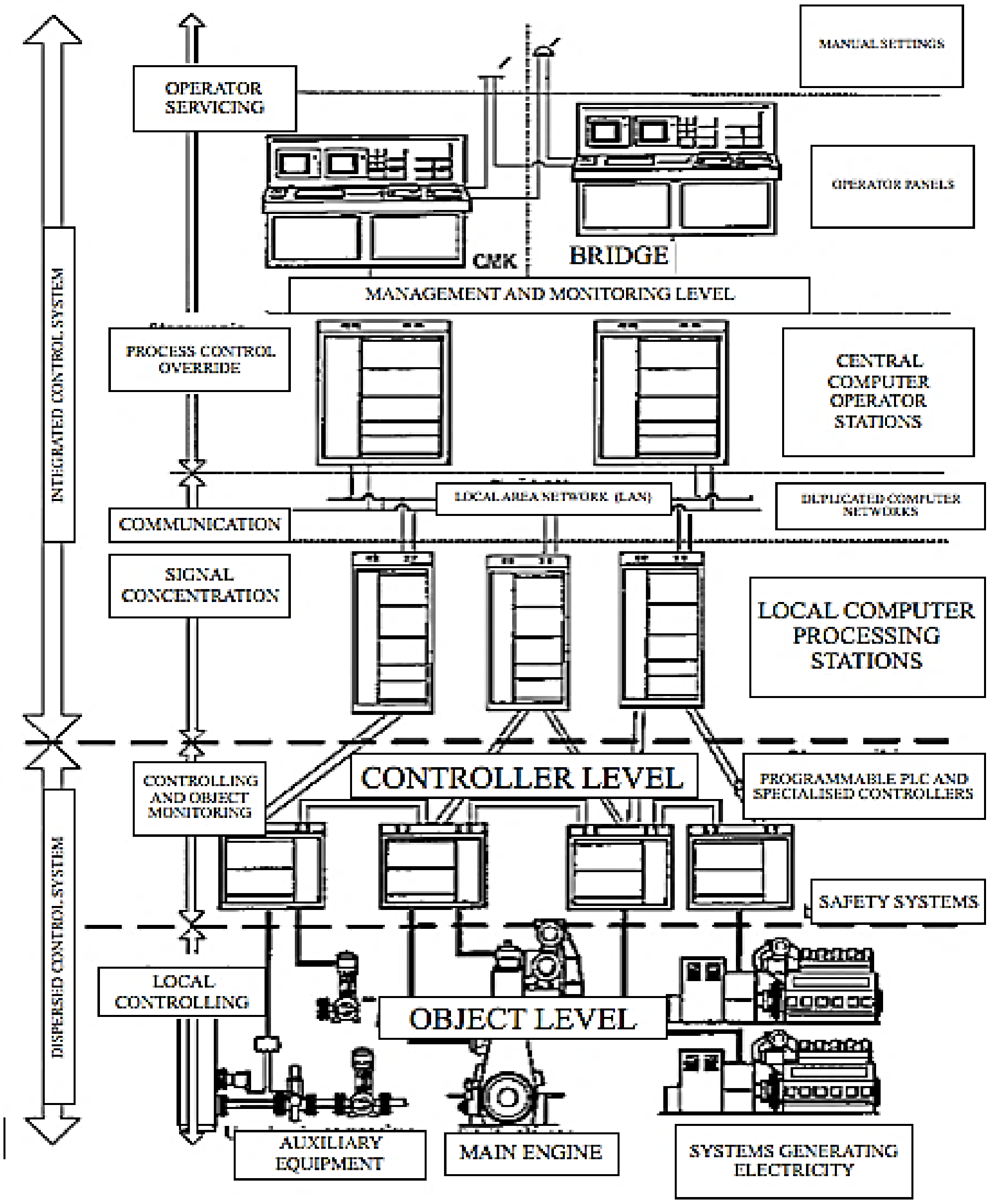

Fig. 3. Structure of a Remote Control System on Board a Marine Vessel.
Source: Śmierzchalski, 2006

Its construction is of three main levels connected by means of a communication network. The levels are:

- management,
- controller,
- objects.

In this article, the control structure is discussed with the example of pumps, which are a proper example of redundant marine vessel devices, due to their extensive use. It needs to be noted though that in the case of some devices, such as adjustable electric drivers, implementing additional specialised controllers – which will not be discussed in this article – is necessary (Śmierzchalski, 2006).

The lowest rank in the structure of remote control is held by the object level with measuring sensors. In this case these are pump systems (pumps with electric engines and additional equipment), as well as such equipment as pressure switches and thermostats. This level enables local control, however, it is often limited to running and shutting down the device by means of switches located on a local panel located in close proximity to the controlled object.

The next level consists of freely programmable controllers (Programmable Logic Controllers – PLC), which are at the decisive hierarchy. The algorithms and controlling sequences included in a PLC controller are run in the sequence: measuring sensor – programmable controller – device/executive object.
The next of the levels of control hierarchy are the local computer processing stations, which are communicated with the programmable controllers by means of transmitting interface (such as serial transmission: RS-232, RS-422, RS-485). This level is responsible for the analysis and processing of data received directly from the controllers, as well as information which is received by them. It is often the case that in constructing such a system the aim is the redundancy, or doubling of the processing stations in order to increase the safety and reliability of the system.
The highest level, namely the management and monitoring level consists of central computers. It is from here that signals of higher decision rank, such as set points, parameters and work modes are transmitted. The central units are usually two computers connected with the network by means of a mainframe (such as a CAN or Profibus). Together with operator panels they co-operate in a „master-slave" system (in such, one of the computers is the leading one, while the other is the secondary one). Depending on the assignment, construction and type of the marine vessel, the location of the panels and computers may vary. However, they are most often located in the engine control room (ECR), where the operator has the possibility to fully influence input in the system, or on the bridge in the wheelhouse, where there is only a possibility to influence the parameters directly connected with such a post. The central units are communicated with local processor stations by means of a Local Area Network (LAN). Furthermore, in the automation of marine vessels, satellite links are implemented in order to transmit technical system parameters to a central managing office.
The computer system is managed by an operating system, whose architecture is usually based on three layers:

- the first layer: designed based on numerous subprograms controlling objects by means of controllers. It does not cover the running of the operator's orders, but completes tasks based on information received from measuring sensors, with the consideration of the state of the controlled device.
- the second layer: created at the level of local processor stations. It runs the subprograms that consider the operator's orders and the current state of the object.
- the third layer: signalising alarm states, emergency states, anomalies, faults in the system, and gathering data on the state of the object. It provides a possibility to remote control with a possibility to change values and parameters. (depending on level of access) (Śmierzchalski, 2006).

CONTROL OF REDUNDANT DEVICES

Due to the specifics of marine environment, marine vessel devices are mounted in excess (in most cases they are doubled). This generates additional costs, however, it improves the level of safety, and implementing appropriate control strategies allows to increase the reliability of a given system (Liberacki, 2010).
Among marine vessels' redundant devices that have found to be of extensive use are pumps, which constitute as an element of pump systems in various installations among which are such as, bilge, cooling, ballast, fuel, and lubrication oil installations. The illustration below presents a concept of controlling two pumps (Fig. 4) which assumes the possibility of both – local control (by means of a local panel) and remote control (by means of an operator panel), a possibility to choose an operation mode in the case of remote control, parameters monitoring, work and alarm signalisation (Baocheng and Zhaoqiang, 2017).

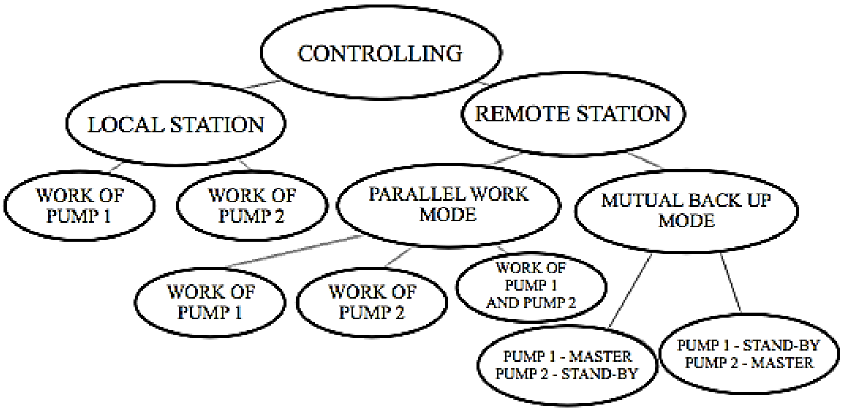

Fig. 4. The Concept of Controlling Marine Vessel's Redundant Pumps.

Tasks carried out by the system:
1. From the local station (local panel)
- possibility to run and shut down each of pumps,
- choice of control mode: remote or local,
- signalising work mode of each of pumps,
- return to setting and work mode in case of black out and subsequent power return.

2. From the remote station (operator's panel)
- choice of work mode in case of remote control: „mutual backing up” or „parallel work”,
- choice of pump to work as the leading device (master) and the pump to remain as secondary (slave) in „mutual backing up” work mode,
- initiating work of a pumps depending on the fluid pressure within the installation in the „parallel work” mode,
- pressure value signalisation while in „parallel work” mode,
- signalisation of work mode state of both pumps in every type of work mode,
- alarming in case of a critical failure of pump 1 and/or pump 2 in every work mode,
- alarming in case of low or very low pressure failure in „parallel work” mode,
- return to setting and work mode in case of black out and subsequent power return.

RESEARCH STAND

In order to present the differences between local and remote control, and to verify the assumed concept of controlling redundant devices, a physical model simulating the work of two pumps was constructed and programmed. It contained both, a local panel and an operator's panel (Fig. 5).

The completed model was of a simplified version, with the assumption of the existence of a local control from a control panel located near the controlled object, and a remote control from one operator's panel (Liangkuan, 2017).The program was completed on a programmable logic controller SIMATIC S7-200, CPU 222, while a HMI Pro- face GP 260 panel was chosen as the operator's panel.

All elements of the system have been communicated with each other by means of appropriate connection cords (Fig. 6).

The system carries out a control algorithm described in the previous section of this article. Additionally, there is a possibility of physically simulating (by means of a switch) a critical failure of both, pump 1 and 2 and observing the response of the system to the event in every type of work mode. A simulation of low, very low, or even non-existent fluid pressure failure within the installation was designed, by means of a switch setting percentage pressure value on one of the screens of the operator's panel during the parallel work mode. This allows to observe the response of the system to the failure. As a whole, it allows to familiarise oneself with the concept of partial automation marine vessel systems and to verify the set concept of controlling redundant pumps with the simulation of the most frequently occurring failures, and monitoring the work of objects (Fu-zhen et al., 2017).

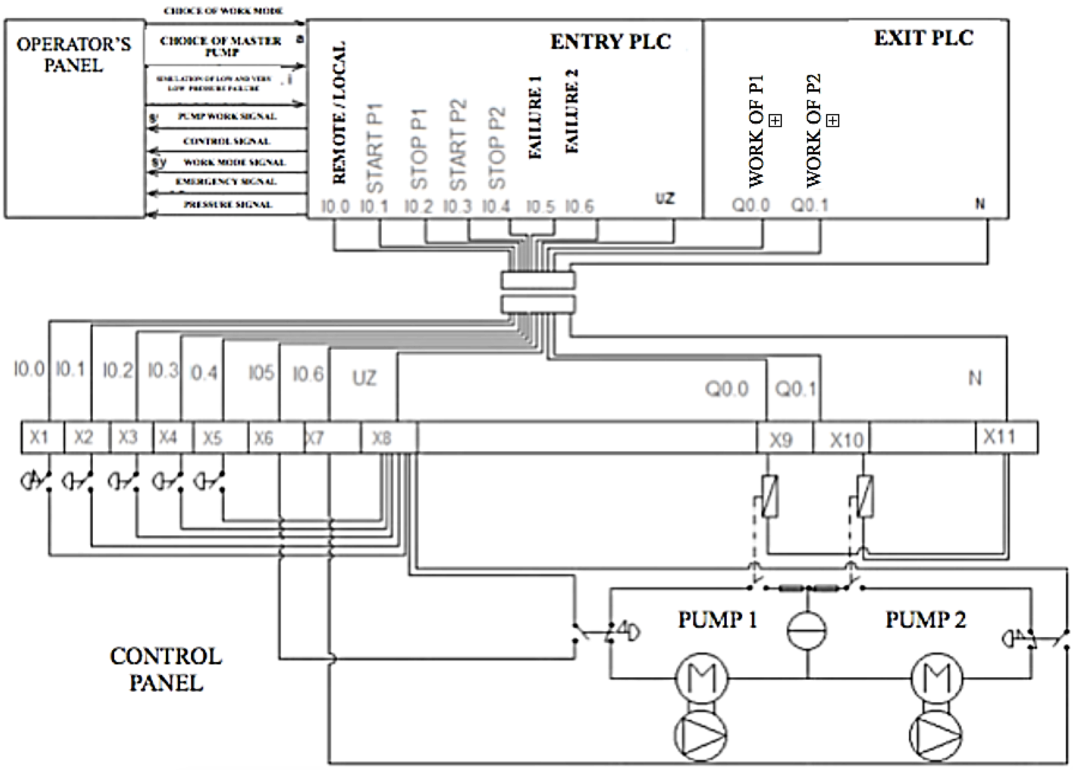

Fig. 5. Electric Diagram of the System

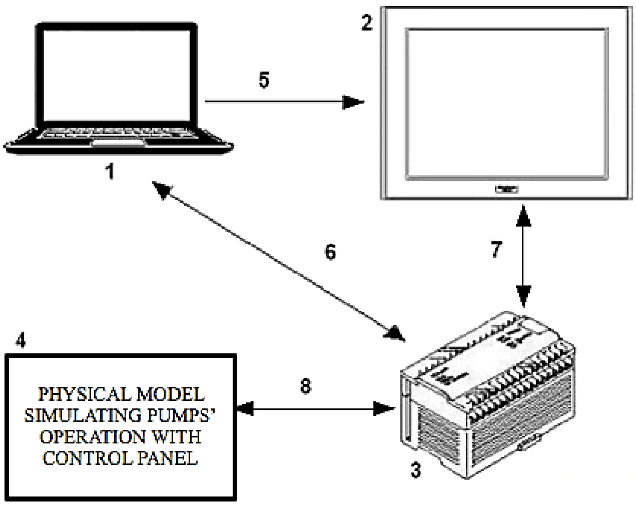

Fig. 6. Block Schematics Diagram of the Structure of the Whole System.
1 – computer with installed programming - used for controller programming and HMI panel programming. 2 – HMI Pro- face GP2600 Operator's panel. 3 – Siemens S7-200 CPU 222 programmable logic controller. 4 – physical model of pumps. 5 – HMI panel programming cord.
6 – PPI connection cord between the computer and the controller.
7 – connection cord between the controller and the panel.
8 – parallel LPT cord, for connecting the pump model with the controller

CONCLUSIONS

The current concept of complex marine vessel automation leads to the unmanned work of all devices, however, considering economic aspects, the most common solution is a partial automation of marine vessels.

In the case of redundant devices, among which are marine vessel pumps, partial automation allows effective and economic applying of these devices. Despite the fact that excessive installation of these devices allows to increase safety at the effect of increasing the financial costs, a well-designed and well-programmed controlling algorithm increases the use and reliability of both devices, decreasing the mortality of the whole system.

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