ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XV, NR. 1, 2008, ISSN 1453 - 7397

Gheorghe Samoilescu

Control Engineering Embraces Instrumentation and Alarm Systems Of Navy

Control engineering can be applied not only to propelling and auxiliary machinery but also to electrical installations, refrigeration, cargo handling (especially in tankers) and deck machinery, e.g. Windlass control. Opinion still vary on such matters as the relative merits of pneumatic versus electronic system and whether the control center should be in the engine room or adjacent to the navigating bridge. Arguments against the exclusion of the engineer officer from close contact with the machinery are countered by the fact that electronic systems are based on changes other than those of human response. Automated ships (UMS) operate closer to prescribed standards and therefore operate with greater efficiency. The closer control of machinery operating conditions (cooling water temperatures and pressures), permits machinery to be run at its optimum design conditions, making for fuel economy and reduced maintenance.

Keywords: *control engineering, embraces instrumentation, alarm system, navy*

1. Basic requirements and planning the system

If a ship's engine room is to operate unmanned for specific periods, certain requirements must be met. Firstly, control of engine speed and direction (or propeller pitch) must be made available at the bridge. In order to avoid placing any additional workload on the bridge watchkeeper, who is concerned essentially with what is happening outside the ship, the engine remote control system should carry out instructions signaled by the bridge watchkeeper at a simple telegraph type control. No demands for engineering skill should be placed on the bridge personnel. The application of starting air, then fuel and the subsequent rate of acceleration to demanded speed should be functions of the control system rather than of the operator.

Having removed the need for engineers to respond to possible telegraph orders at any time, the next important step is to provide automatic control of main engine services such as cooling water, lubricating oil, fuel and air systems. These functions are carried out by means of automatic controllers and control valves, which maintain system pressures, temperatures etc. at predetermined values despite load changes. The response rate, stability and accuracy of these control loops are dependent not only on the quality of the components but more important, on the matching of the dynamic characteristics of the control system to the requirements of the particular service.

The third requirement for unattended machinery operation is the provision of an alarm system to monitor all the important operating conditions. These include temperatures and pressures of the fuel, air, lubrication and cooling systems for the main engines and generators, tank level alarms and many others such as bearing temperatures of equipment capable of carrying out these tasks, and some typical systems will be described later

The most important feature of an unattended machinery complex is the fire alarm system, in which sensors are placed around the engine room and associated spaces in order to detect combustion at the earliest practicable time

Finally, it is necessary to provide for the continuity of electrical power for essential services in the event of failure of the duty generating equipment. In its simplest form, this may be limited to starting the emergency generator to provide power for essential lighting, but other services such as steering motors, machinery and fire alarm systems may also be provided with emergency power

These are the five keystones of an automated machinery space, upon which all classification societies agree-remote engine control, automatic control of engine room services, a machinery alarm system, and fire alarm system and emergency electrical power.

Planning of the automation system, by which is meant the total complex of remote and automatic controls and plant instrumentation must take account of several basic parameters:the intended service of the ship, the intended manning arrangements, the type of propelling machinery, ship maintenance policy, classification society and notation required, ship resale value.

The above list of "design inputs" is by no means complete, but represents the major factors, which should influence the design of the automation system.

Experience has shown that where there has been some failure to achieve all that was expected it is largely due to lack of planning. Successful planning involves integrating and coordinating the system, as a whole and this cannot be achieved if sections are in different hands. Haphazard methods by independent concerns have resulted in conflicting and unworkable systems. For example, sensors have been used at the instigation of one interested party and without consultation with, for example, the supplier of the computer or the data-logger only to find later that the output is incompatible.

It is also essential the control engineer should have practical knowledge and experience of the plant to be controlled and that the plant supplier should concur regarding facilities for accommodating and positioning the sensors.

A procedure, which has been advocated for ensuring success, is that the ship-owner should, at the outset, state in broad terms what he requires. The shipbuilder should then prepare an outline specification to meet the owner's requirements and from this the control engineer can prepare a detailed specification. All three parties should then get together and agree the control specification. Hitherto there has been too little feedback information and experience from the ship but control engineers and ship-owners are now appreciating that this is important. If owners or builders have preferences for any particular make of component for any particular make of component; it is at the planning stage that agreement should be reached.

The owner will need to consider operational and economic issues to decide how far to go and what financial benefits he can expect from each section. For example, in a refrigerating plant, push-button starting from the control console may not be justified, as it is an infrequent operation, which can be performed manually, and so centralization can be confined to instrumentation and alarms. The essential factors for successful systems are: Reliability, Simplicity, Ease of operation and maintenance, Suitability for marine conditions, Facilities for servicing (especially in foreign ports).

Marine conditions involve ambient temperatures, humidity, vibration and saline atmospheres but also the physical conditions inevitable during construction, installation and trials. These apply to all parts of the system-sensors, instruments, consoles, computers, etc. Paint spraying, asbestos lagging, welding, staging and dirty surroundings can play havoc. Fitters and erectors have no respect for such equipment and many sensors have served as a footstep.

Systems must embody "fail safe" features and this aspect must be studied analytically in the planning stage. All possible sources of failure and their consequences must be covered. For example, if a fuel injection system is such that a spring is balanced by fluid pressure acting on a piston then loss of fluid may result in full fuel admission to the engine and a dangerous condition exists. The arrangements must ensure that failure of the controlling medium will result in either the speed remaining constant or that is reduced.

Fail-safe principles can be interpreted in different ways, such as complete stoppage of an operation or reverting to some other (safe) state. In suitable cases it can mean "fail-as-set", i.e. continue as at the time of failure, sometimes referred to as "failed-as-is". This essential that an alarm be operated to direct attention to the failure.

A vital part of planning procedure is planning the pre-commissioning trials and calibration. This must be considered and agreed by the builder at an early stage so that he can include it in his overall program and delivery date and, when the time comes, provide the essential facilities.

It is not unusual for a comprehensive system to include 300-400 control points widely distributed and each requiring individual checking for operation and possibly calibration. This is time consuming and can only be done when installation is complete and ship's services are available. It cannot be postponed until after the sea trails. A detailed test program and timetable, agreed by the shipbuilder is therefore essential. Whit all systems there is an initial period of teething troubles and these must be tracked down as far as possible before the sea trials. This applies particularly to closed-loop systems.

Simulators can be provided in some cases, which make possible to test the entire electronic equipment by providing similar responses to those anticipated under service conditions. They can form part of the permanent installation so that, for example, prior to arrival in port, the navigating officer can himself simulate operation of the engine telegraph.

2. Control system

The simple control loop has three elements, the measuring element, the comparator element and the controlling element. The loop may be effected pneumatically, electronically or hydraulically. In some instances the control loop will be a hybrid system perhaps utilizing electronic sensors, a pneumatic relay system and hydraulic or electric valve actuators. Each system has its strengths and weaknesses:

Pneumatics- require a source of clean dry air-can freeze in low temperature, exposed conditions, but equipment is well proven and widely used. Most engineers naturally favor pneumatic control, as it is effective and relatively easy to maintain. Nevertheless electronic systems can be equally reliable and in fact become indispensable for sophisticated systems especially those incorporating computers and data loggers. Pneumatic systems can give a speed of response sufficient for marine applications and have been used for example for fuel and lubricating -oil temperature recording, boiler control and in numerous other directions.

Electronics **-** good response speeds with little or no transmission losses over long distances, easily integrated with data logging system, require being intrinsically safe in hazardous zones. Advantages are low power consumption, reduced size and cost of components, high speed of response.

Hydraulics - require a power pack, may require accumulator for fail-safe action – compact and powerful and particularly beneficial in exposed conditions.

3. Measurement of process conditions

The range of parameters to be measured in merchant ships includes temperatures, pressures, level, and speed of rotation, flow, electrical quantities and chemical qualities. Instrumentation used for remote information gathering purposes invariably converts the measured parameter to an electrical signal which may be used to indicate the measured value on a suitably calibrated scale, provide input information to a data logger or computer, initiate an alarm or provide a signal for process controller – fig. 1.

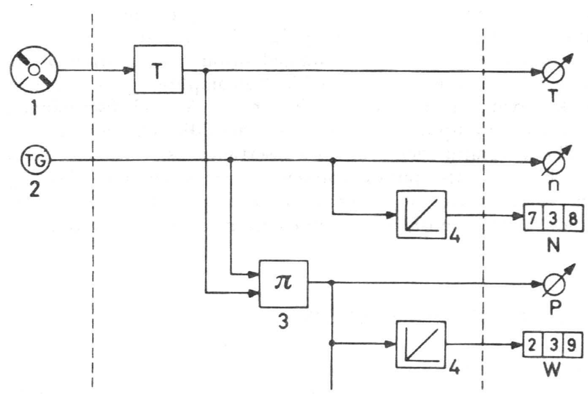

Figure 1. Torductor power meter

Where: 1Torque transducer, 2. Tacho-generator, 3. Multiplier 4. Integrator,
N.- Total number of revolutions, T-Torque, P - Shaft horsepower
n. - Rate of rotation, W.- Total power output

As stated earlier however the more favored means of providing process control information (as opposed to information display only) is to use a pneumatic system.

4. Sensors

Sensors play an essential role in all systems for transmitting information to control and other remote positions. The quantities necessary to sense include counting, fluid flow, humidity, liquid levels, noise, position, pressure, salinity, smoke density, speed, strain, temperature, viscosity, torque, power, etc.

The type of sensor must take into account the relative importance of the effect of its presence on the quantity to be measured, together with the extraneous effects by or on the sensor. For example: it should not effect the quantity to be measured, e.g. flow metering, the effect of ambient and adjacent temperatures should be either known or be capable of elimination, speed of response in respect to rapid changes, independence from magnetic fields, humidity, barometric pressure, local heat, independence from variations of electrical supplies (e.g. frequency and voltage) or be provided with means for compensating for variations, linearity, hysteresis, repeatability and zero-point drift are also important.

Sensors may be required to initiate mechanical operation, for example, such as the high forces required to operate cargo valves in tankers and for hatch closing and opening and as most sensors cannot provide the mechanical effort required this can be provided via transducers. The electrical or pneumatic signals obtained from them can in turn operate alarms, relays or instruments. Bourdon tubes, diaphragms and floats can provide sufficient power to operate instruments directly or can act as transducers.

5. Alarm systems and data loggers

The first step towards centralized control of marine machinery was simply to extend the conventional control and instrumentation facilities to a central control console, which was housed in a special control room. Consequently, the resulting consoles were very large and presented a great mass of information on gauges. In later installations and the wide spread use of microprocessors it became the practice to integrate the three basic instrumentation functions – alarm monitoring, display of data and recording – within one electronic system. Alarm scanning is the most important function performed by this type of equipment.

Scanning speeds vary between one and 400 channels per second for analogue parameters, and the accuracy of alarm comparison is generally within one per cent of the measurement range. An extremely complex machinery arrangement can be checked for mal function twice every second, and alarm thresholds can be set very close to normal operating conditions, so giving practically instantaneous response to potentially dangerous situations. The development of high –reliability alarm-scanning systems is an important accompaniment to the increasing use of multi-engines propulsion systems, higher b.m.e.p.'s and the growing practice of operating ships with unattended engine rooms.

Several types of equipment are employed in ships, and while the details of operation vary, the basic arrangements are similar. Such equipment may be regarded as comprising four sections; primary measurement, signal selection, signal processing and control of out-put units.

6. Boiler control systems. Controls for generators

Automatic control of boilers and turbines is a much more complex problem than that of diesels and does not lend itself to any precise directions. Nevertheless it offers the greatest scope for efficiency and economy in both manpower and fuel consumption.

Dealing first with steam raising, the efficiency of modern complicated high-efficiency steam and feed-water systems depends on the correct relationship and operation of a large number of independent controls. They are all inter-related and each variation of main engine load, sea temperature, etc. requires a different combination of values and optimum efficiency is rarely achieved without some form of automatic control.

In unattended machinery installations it is necessary to provide certain control facilities for the electrical generating plant. These may vary from simple load sharing and automating starting of the emergency generator, to a fully comprehensive system in which generators are started and stopped in accordance with variations in load demand.

Medium speed propulsion plants normally use all diesels generating plant. Turbine ships obviously use some of the high quality steam generated in the main boilers in condensing or backpressure turbo generators, with a diesel generator for harbor use. The usual arrangement on large-bore diesel propulsion systems is a turbo generator employing steam generated in a waste-heat boiler, plus diesel generator for maneuvering, port duty, and periods of high electrical demand.

Diesel generators the extent of automation can range from simple fault protection with automatic shutdown for lubricating oil failure, to fully automatic operation. For the latter case the functions to be carried out are: Preparation for engine startingStarting and stopping engines according to load demand.Synchronization of incoming sets with supply., Circuit breaker closure, Load sharing between alternators., Maintenance of supply frequency and voltage, Engine/alternator fault protection.

Preferential tripping of non-essential loads and restoration when sufficient power becomes available.

It is necessary to provide fault protection for lubricating-oil and cooling services, and in a fully automatic system these fault signals can be employed to start a stand-by machine, place it on line, and stop the defective set.

7. Automation on tankers

Automation and computers play an indispensable part in tanker operation, particularly in the super-tankers now in service. It is of vital importance, for instance, to take account of stresses raised in the hull due to bending moments resulting from unequal buoyancy. These may arise from ballasting or from different grades of oil or may occur during loading/discharging.

It will be apparent that with modern tankers a large number of valves are involved which must all be operated in a logical sequence. Not only is this important from considerations of hull stress, but also when a mixed cargo of different grades is involved. For protection against incorrect operation some valves require sequence interlocking. Trim and list must also be controlled. There is obviously a fertile field for centralized control and for computer operation.

It is essential if containers are to locate accurately in guides in ship's holds that the ship stays on an even keel during loading. Careful control is also necessary during unloading. Detection of the heel can be utilized to automatically control pumps and valves for the transfer of ballast between tanks. Systems have been developed for operating for lists greater than one degree.

A large number of ships have been fitted with computers which are programmed to carry out a great variety of tasks embracing satellite navigation, ship's housekeeping, crew wages, machinery surveillance, weather routing, cargo-loading calculation and ballasting, satellite communications, e-mail, etc. General-purpose industrial computers have also been employed or the single task of machinery alarm scanning and data logging.

Computers offer very important and unique benefits when they are applied with due regard to cost-effectiveness. Particular areas in which the computer may excel are the control of advanced steam generating plant, marine gas turbines, and performance monitoring of diesel engines.

Progress is now being made towards machinery component condition monitoring, which could result in diesel engines only being stripped down for repair of known defects, rather than on the present basis of hours run. If classification societies are prepared, in the fullness of time, to relax periodic survey requirements as a result of this development, then these systems will be widely fitted.

References

[1] Smith, D.W., *Marine Auxiliary machinery*, Butterworths.

[2] Watson, G.O., Marine Electrical Practice, Butterworths...

[3] Guide for Shipboard Centralized Control and Automation, American Bureau of Shipping

[4] Wilkinson, P.T.C., Fundamentals of Marine Control Engineering, Whitehall Press.

[5] Gray, D., Centralized and Automatic Control in Ships, Pergamon Press

[6] Jones, E.B., *Instrument technology*; Vol.3 Telemetering and Automatic Control Butterworths.

Address:

- Prof. PhD. Eng. Gheorghe Samoilescu, Naval Academy of Constanţa, Str.Fulgerului, Nr.1, 900218, Romania,samoilescugheorghe@yahoo.com