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OPTIMIZATION OF MARINE POWER SYSTEMS

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Abstract: *Automated integrated systems assures supervision and command of a machine, of navigation integrated systems and loading, unloading and observation of the load. Automated systems for machines and mechanisms are used for signalization and indication, for controlling the propulsion installations, for distribution and energy command depending of the role on ship (essential and nonessential), etc. The running of electric sources needs the use of automated voltage regulation, automated synchronized schemes and distribution of load. Automated systems for navigation are used for autopilots, for supervising of hull stress, for active roll stabilizers, for anti-collision system and route, etc. Specific for naval integrated automation systems is the use of two computers – one for operation and one for standby – the two of them operating in tandem. Given the optimum level of optimization of a ship, it depends on many factors, from which the most important are the ones related to economic efficiency. Safety and reliability increase in installation operating, aggregates and measuring and control equipment, real time processing of large volumes of information required making programs.In order to achieve an optimization of electrical systems and energy consumption onboard a ship we made a program with the help of: Microsoft Visual Studio C# 2010 Express Edition for the assembly of data; MathCAD for numerical calculation and Microsoft Excell collect experimental data and plotting graphs representing some practical results.*
Keywords: *optimization, automated systems, integrated systems*

Introduction

In the actual evolution level reached by the civilization, no other means of transportation, in addition to ships, can't assure the volume of traffic across seas and oceans of the annual billions of tons of goods between international trade circuit.

The size of a ship power system depends on the type and the interdependence between it and propulsion plants (autonomous, with energy recovery of the propulsion system, combined with the propulsion system). It is therefore recommended a breakdown of a ship power system into subsystems for automatic management and optimization. [1,2,3,4] The main objective of decomposition N.P.S. count to ensure the balance of the generated and consumed power in each section in order to function economically and advantageous. When designing power plants it is provided the parallel operation of generators on a system or two of bars, which are divided into sections coupled together. The second objective is that each subsystem participates in maintaining constant frequency, resulting in a decentralized automatic adjustment of the power quality index. Achieving this objective is ensured by the decomposition of the adjustment of the frequency and power. Dynamic optimization of each subsystem operation is achieved through the full criteria. Solving optimization problems for marine power system must take into account its special features: meeting the needs of the ship by the electricity, transmission lines, distribution panels for electricity converters; requiring a permanent balance between production and consumption, because energy is not stored on board; changes in the operating mode of consumers may disturb the others; because of the complexity of the system and its components, quantities adjusted number is high, resulting in interference between some of the adjusting circuits. Economic optimization refers to investment, operating cost, maintenance and ship repair, equipment, fuel costs and subsistence of crew.

The complexity of optimization problems in N.P.S. arise from its cybernetic character. Mathematical modeling allows solving these types of problems. Between input and output parameters of a component of a naval power system
may establish dependency relations which allow to determine how some variation is depending on the other. These dependencies represent the operating characteristics of the element. The features are divided into static and dynamic regimes corresponding to stationary or dynamic operation.

Optimizing parameters of economy are: fuel consumption, electricity consumption, transportation routes, etc.

In the study of optimizing the operating modes of the N.P.S., mathematical models derived from relations that take into account the above requirements are presented as a form of systems of nonlinear equations. The large number of equations and the variables, taking into account the restrictions that need to be respected, lead to perform a high volume of arithmetic operations for determining the optimal solutions.

The problems in N.P.S. showing a certain degree of indeterminacy and the number of variants to be considered is high, determining optimal solution involves the use of complex mathematical methods based on mathematical programming (linear, nonlinear, dynamic). In the use of these methods, the use of computers is essential.

Naval power system produces, converts and distributes electricity. Naval Power Plant (N.P.P.) has the possibility of transforming voltage and division of power system using transformers in separate portions and high voltage use without worsening the reliability and safety. The tendency to keep weight and stress and costs in reasonable limits, as you increase the power of the plant is accompanied by increased nominal voltage. In the use of naval power voltage of 440V, lighting network will be supplied by eliminating the step-down transformer connections to the power plant. Transportation of electricity onboard has short lines and is always linked to the loss of tension, because transport lines have active and reactive resistance, and therefore it allows us to have losses of 5-10% from the nominal value.

Optimization of the operating regimes of generators and transformers N.P.S. is based on the number of task and involves running and loading them so that losses to be minimal.

Physical and functional integration of the electricity system and automation system, optimal allocation and power control for all subsystems are important for optimizing electricity consumption [5,6].

Analysis methods and optimization of energy consumption with the support control system and power management.

Under an initiative of I.R.I.S. (Integrated Intelligent Reconfigurable Systems) made by ASDL (Aerospace Systems Design Laboratory) at the Institute of Aerospace Technologies of Georgia, USA, is aimed to change the architecture and structure of the ship through increased automation for reducing operating costs. I.E.P. (Integrated Engineering Plant) integrates modular power systems, mechanical, electronic and resource allocation in a computer intelligent control and monitoring system and that represents implementation for IRIS platform concept [7]

I.R.I.S. allows the system to diagnose the current state of the vessel and automatic reconfiguration of resources on board when malfunction occurs. With the use of sensors, the intelligent fault detection technologies in combination with advanced networking solutions, the situation may evaluate the ship situation at any time, can suggest solutions and decisions can be made. All these activities will get a ship self-monitoring, self-assessed and will auto-respond for optimizing all equipment on board. Self-monitoring and self-evaluation will enable continuous detection of all operations carried out on board so that all naval subsystems entries are detected automatically, it will react the most viable solutions and will forward the information to the decision maker that may be the central system or a human factor. [8]

The simulations were used PID regulations (Proportional Integral Derivative). Neural networks have been abandoned and was used a genetic algorithm to optimize the PID parameters state variables measurements in different operating conditions of NPS and the route of the ship [9,10]. Based on a traditional PID controller, the ability of the vessel to follow a given route is optimized by a genetic algorithm. The ultimate goal is to develop a general simulation for all operations running on a ship. A chromosome with three genes was selected as PID parameter, which is checked and tested before. There were created other chromosomes and genes baseline of each chromosome were selected randomly as real numbers in the range 0-1. Each chromosome corresponds to a given regime, for a given situation – change direction, change speed, operating parameters change of the plant. Each chromosome has a quality indicator with a given optimization criteria in a certain period of time. Top two chromosomes of the current generation are transferred unchanged to the next generation. Of the remaining chromosomes occurs a selection resulting with the highest quality level chromosome and the procedure is repeated until it provides a new population is exposed to a selection and after which it determines how to route optimization, the functioning of an installation.

Any optimization problem must consider two requirements: reliability and efficiency.

Three important requirements that must meet on marine electrical systems: to have as few components as possible; to be automated; to ensure the safety of ships.

Reducing the number of elements of any electrical installation from S.E.E.N. and its automation leads to embedding multiple functions into a single element.

In a complex electrical system, like the naval system, with the requirement to minimize the risk of failure is supervised the quality of materials, used electric schemes, staff employment and electrical equipment components. [11,12]

Within marine power systems optimization, it aims to find the best technical solutions in order to achieve a S.E.E.N. at a low price, high performance with low failure rate as with a running time of the equipment as long as possible [13,14]. The first stage of optimization is performed during the design phase, where the foundations of electrical equipment used and their automation, continue to step to achieve S.E.E.N. and the exploitation of them. All these steps are aimed at enhancing the life of installations, reducing the risk factor and, not least, to take account of physical and moral degradation of equipment over time.

Failure or degradation theory was developed from the need to reduce the number of alarms due to the occurrence of a malfunction in the operation of electrical and automation, and increase operational life of the functioning. A current issue is the lifespan evaluation of the equipment and aggregates based on the concept of decay. Through automation and use of electronic programs is intended to diminish flaws, but degradation systems can't be removed.

Viability represents a function of the remaining lifespan of a system [15,16]. Viability function is:

$$p_{(v_{ramas})} = W_{(v,k} = W_{(v-k)} = -e^{-\frac{1}{v-k}} \quad (3.1)$$

v - lifespan;
k - lifespan used;
e - Euler's number.

The viable function argument v remained is equal with v-k where v-k is measured in temporal steps or time quants. Given that the modeling natural phenomena, and therefore energy naval systems can be done only in temporal steps. [G5] The lifespan of S.E.E.N. is determined strictly by the maximum entropy value and therefore it is necessary to consider that the assessment of the risk factor by entropy value is a good idea.

Because we are constantly evolving and this is done irreversible in the increasing value of entropy and realize that all has a beginning has an end - the end of the evolution of any equipment or object occurs when reaching maximum entropy, entropy is written:

$$S = -p \ln p \quad (3.2)$$

S - entropy;
p - the probability of the state of the system studied.

Using a natural logarithm leads to a mathematical property that simplifies formulas and calculations. Viability and entropy allows to achieve a mathematical model for solving optimization naval electrical installations which materialized in the concept of entropy theory in model systems and entropic graphs. [17]

The technique risk is defined by the relation:

$$F_{(t)} = 1 - R_{(t)} \quad (3.3)$$

F (t) - technical risk (probability of the system to work less than the time prescribed);

R (t) - reliability function

Considering the reality that we have to report to an electric system lifespan, the remaining risk can be assessed by function viability complementation so that we can write:

$$r = (v-k) = 1 - W(v-k) = 1 - e^{-\frac{1}{v-k}} \quad (3.4)$$

They are not equal:

$$F_{(t)} > (v-k) > S \quad (3.5)$$

r-risk

A lower risk means benefits for electrical installations because it reduces wiring costs by avoiding the oversizing of wiring andreductance decrease in the design stage of the entire SEEN, as well as a guarantee for a longer period and on the other hand decreases the purchase price in CEN products [18].

In order to optimize the electrical part of any ship must take into account:

-maintainability;
-maintenance;
-security;
-failure.

All this is achieved through a reliable and maintainability management, based on quality.

Quality management includes inspection, and quality assurance. Maintenance includes all technical and organizational measures for testing, maintenance and repair of electrical circuits and facilities to maintain them in working order. Maintenance performed on S.E.E.N. is preventive - periodic interventions that include inspection, testing, maintenance, overhaul and repairs, and corrective type - safety assurance security interventions to eliminate states of emergency and restore electrical system operating at rated capacity and help ensure equipment technical and human factors, plus the necessary conditions to achieve continuous supply of electricity efficiency of the ship.

Any electrical installation is composed of electronic circuits, this elements (resistors, coils, capacitors) connected by conductors, so a number of elements available functional groups to achieve SEEN. This system, during the service in different regimes (march, maneuver, stationary etc.), can support elements malfunctions.

Analysis of S.E.E.N. operation can be theoretically and practically, according to the possible states of the component systems (operating, idle, in standby, defect).

Optimize types

In judging the effectiveness of different decisions, the possible criteria should be used to measure the performance of the activities pursued. It is suggested to follow the steps: determining efficiency criteria; selecting a set of possible alternatives; determining a model to be used and the values of process parameters; determining an alternative that optimizes the criteria set out above. All questions, diagrams, installations, technical processes become every day more and more complicated and therefore it is necessary to make an abstraction and simplification of reality in a model. The coordinating or deciding person should adopt a strategy and take a decision on collecting quantitative and qualitative information. The decision maker must identify the most relevant factors for any problem that he aims to solve. Abstraction and simplification are necessary steps in solving any problems.

The first step in building a model is determining the factors and variables that the decision maker considers important. They can be classified into five categories: decision variables - including all the requirements they want implemented, including costs; external variables - including all requirements due to factors which are independent of the will maker; restrictions - includes all requirements due to international regulations, the resources and their evolution during the activities, legislative limitations etc; Performance measures - including quantitative and qualitative requirements that we want to achieve the goal or purpose; intermediate variables - variables are used to bind exogenous decision and performance measures. [13, 14, 16]

Optimization methods have wide applicability in almost any activity in which they are processed numerical information: science, engineering, mathematics, economics, trade, etc.

Using optimization is based on focus and attention on a single objective designed to quantify the performance and quality of decision on an issue that would require determining the values of a large number of interrelated variables. This objective is maximized or minimized subject to restrictions that limit the choice of decision variables. If one aspect of the problem can be identified and characterized by an object (eg profit in a business) then the optimization can provide an appropriate framework for such an analysis. Optimization should be viewed as a design and analysis tool, not as a leading principle to the correct the solution in a philosophically way.

Formulating the problem always involves finding a balance between building a complex sufficient model for describing efficiently the problem-solving and ease it.

In order to optimize the composition of installation from SEEN equipment it is using technical systems which assures automated function so that the change of a parameter is followed by a program change deployment of that process, based on a logical decision - cyber complex automation systems. The systems have the ability to determine optimal adjustment operation of all SEEN components, the functioning program of each plant and equipment, dynamic qualities to achieve optimum parameters imposed to achieve performance on electrical and mechanical energy saving. Technical systems that make these modifications are a combination of complex automated facilities with electronic computers and they take logical decisions that are optimal adaptation SEEN components to changes in external conditions (average temperature, humidity, air, oil and salt content in the air, operation of equipment in a tilted position, vibration and shaking dynamic operation regimes), the change of certain internal conditions (regime march to power thruster operation less, etc.) and stabilization operations or disturbance compensation and adjustment after hours or tracking. [19]

Automated systems implemented in SEEN structure must fulfill the following functions:

- Adjustment and command control (measurements and associated signaling) with which we obtain information on the conduct of the operation system related to the equipment;
- Protection designed to interrupt or commuting operation of an installation, circuit or aggregate in case of fault, overload, short circuit or improper operating parameters (under voltage, over current, reverse current, reverse power, under and over frequency, etc.);
- Automatic drive which is based on information available to the automation device (any automated system has automated installation and automation device –elements in between which there are two routes of communication, one direct and one plant control device opposite the receiving device or control signals on the real values of the monitored quantities).

Computerized management system S.E.E.N., represents a set of equipment, computer programs and operating procedures in order to manage, supervision and ensure their functioning. We analyze two types of management and surveillance systems, as follows:

- Centralized control systems for process management and monitoring of operation SEEN

They perform the following functions:

a) measures and records after a preset computer program all electrical and mechanical parameters;
b) performs the comparison of the measured values with the permissible limit values and in the event of inconsistency signal optically and acoustically;
c) process the data collected from the system.

In the Figure 3.1 [19], the computer with the process interface is forming the process computer. The process interface has as basic elements a multiplex (supervised signal inputs of the computer) and analog to numeric converters for which the computer is connected to the management, supervision and ensuring the functioning of all circuits, systems and aggregates from SEEN composition.

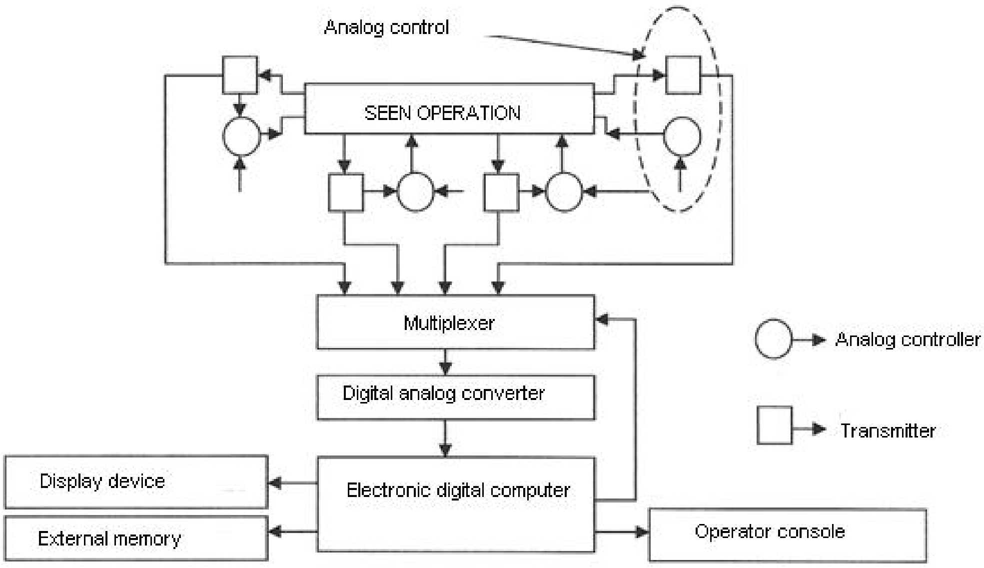

Fig.1 The process computer

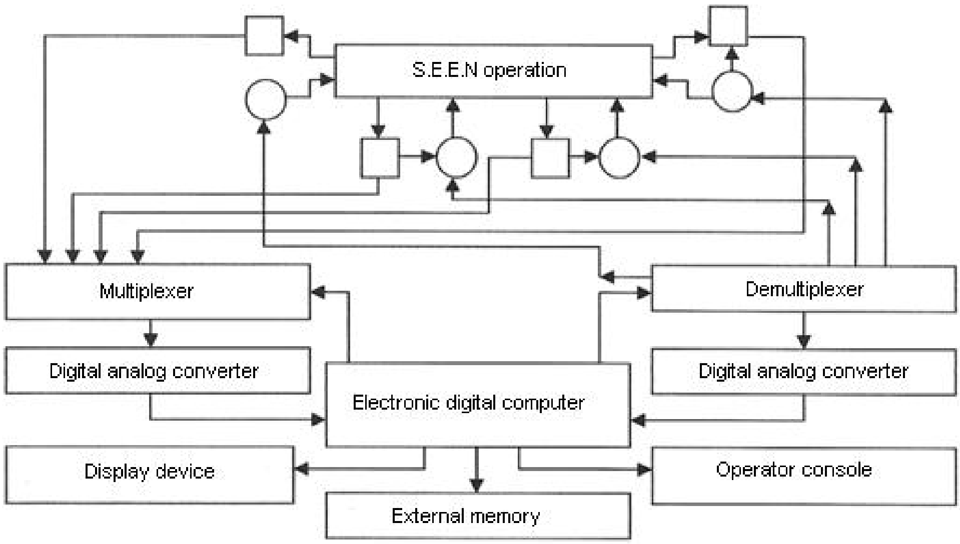

Fig. 2 Supervision System and numeric analog converter and demultiplier

All transducers and analog regulators for measuring and comparing parameters of the system are connected directly to the computer.
- supervision systems automatically ensures change in parameters and marine equipment devices and allows normal functioning optimally. Compared to previous the differences are in the interface process digital-to-analog converter and the demultiplier, they allow distributing signals from the computer to regulators - Figure.2. [19] Numerical computer used can provide solving the adjustment equations and transmitting to the signal control for execution element and comparison with the prescribed size resulting in the possibility that analog regulator to be missed in previous schemes.

CONCLUSIONS

Automated integrated systems assures supervision and command of a machine, of navigation integrated systems and loading, unloading and observation of the load. Automated systems for machines and mechanisms are used for signalization and indication, for controlling the propulsion installations, for distribution and energy command depending of the role on ship (essential and nonessential), etc. The running of electric sources needs the use of automated voltage regulation, automated synchronized schemes and distribution of load. Automated systems for navigation are used for autopilots, for supervising of hull stress, for active roll stabilizers, for anti-collision system and route, etc. Specific for naval integrated automation systems is the use of two computers – one for operation and one for standby – the two of them operating in tandem. Given the optimum level of optimization of a ship, it depends on many factors, from which the most important are the ones related to economic efficiency. Safety and reliability increase in installation operating, aggregates and measuring and control equipment, real time processing of large volumes of information required making programs.

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