FURTHER ENCOURAGEMENT FOR THE BEST USE OF SIMULATIONS

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ABSTRACT

Although over the last decade the world Merchant Fleet has become highly sophisticated and technically improved, economical, safe and reliable, human errors and accidents still happen. To minimize human and material losses in navigation, simulators (engine and navigation) are being increasingly applied, in the training of students as well as in the training of seamen. By simulator training the knowledge, experience and safety during work have been obtained, since this method enables simulation of certain failures and conditions without human or material losses.

In the 21st century maritime education and training are faced with both opportunities and challenges. STCW Convention requires institutions to adopt new approaches or make reforms in all the aspects concerned [1]. For an effective and high-quality education and training, the staff of maritime education and training instructors should establish further exchange and cooperation, joining hands in order to meet the required standards. *(The results presented in the paper have been derived from the scientific research project "Marine Power Plants Control in Faulty and Failure Conditions supported by the Ministry of Science, Education and Sports of the Republic of Croatia)*.

INTRODUCTION

Between theoretical-analytical approach to training for professional work, and real efficient professional work, there is an educational area that in modern education belongs to models and stimulations. Today, models and simulations are applied in industry, science and educations, as research or as educational techniques that reproduce actual events and processes under test conditions. Exactly this is happening in maritime technologies, where the object is to educate/prepare seamen, students and professors for complex working conditions. The whole range of simulators and methods of simulation already exist in this area and it's continuously developing. These way users can, in the real way, overcome vital objects/devices/equipment; but without adverse consequences of theirs possibly wrong decisions. There is a problem that occurs during models installations, and that is – their construction is never concluded; model's installation is a never-ending process. Models are constantly remodelled and replenished with new and fresh information. Researches in simulation's educational effects have shown that the more realistic replica is (of real tasks in real working

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environment), the more effective are simulations in passing the knowledge. Technological development brings in focus the managing of complex technological plants, and this managing demands expert, but mostly practical knowledge and skills.

How to efficiently educate young people, so they can become good and skilled maritime managers and ship masters - not only in maritime profession, but broader? There are growing demands for efficiency, and education is getting more expensive – does it offer a really good education for people who are getting ready for complex tasks? If we want that seamen, nautical engineers or marine engineers, are doing well in managing the ship, than they have to learn how to do it. This is accomplished by passing to them appropriate theoretical knowledge and possibility of work on range of simulators.

Power supply system planning, especially for a ship, is a very complex process that is constantly developing and upgrading. Complexity of the system is mirrored in colligation of production, distribution and consumption of electrical power on relatively "small" space (meaning the size) that is completely autonomous. In ship's power supply system, the generator is operating on its own transmission network. That means that with change of loading there is change of tension on terminals, generator, change in frequency, that is, change of rotor's rotation speed. Those parameters must be kept within given limits. So, it's necessary to continuously regulate terminal tension of synchronous generator by changing excitation current, and to regulate speed of rotation to keep it synchronous. This way we maintain constant frequency of induce tension. For those reasons, the subject of research is:

- How to regulate the load in ship's power electrical systems, to optimize the costs: The solution for this problem is formation of complex optimizing system for distribution of electrical power between consumers, according to sequence of electrical power sources (priority), to achieve the maximum effect;
- How to regulate the operation of synchronous propulsion engine and turbine;
- How to optimize the operation of synchronous generator;
- How to optimize the fuel consumption.

Different behaviours were analyzed on marine engineering simulator. Operation's analysis significantly influenced the input parameters of simulations models.

SHIP 'S POWER ELECTROENERGETIC SYSTEM

Ship electrical power system is considered to be a dynamic and complex system, because the power can't be stored. Simultaneously with production, there is a process of electrical power consumption. Parameter's quality is easily disturbed, and the measurements for power supply quality are:

- Frequency – constant, deviations are within strictly given limits. Basically, the frequency is 50 or 60 Hz. Frequency regulation is connected to the mechanical number of rotations of generator shaft, and in colligation with regulation of operating power;
- Tension (voltage) – it's not possible to maintain constant value of voltage in every part of electrical network. Electro-energetic system must be close to nominal value. This is accomplished with different devices and through correct dimensioning of electro-energetic system. Elevated voltage puts stress on isolation, and decreases the time-limit for system's components. Decreased voltage is causing larger power supply losses in the system;
- Availability- the electric power system must be design so that the consumers, in any given moment, can take the necessary amount of power - by quantity and by power. The aim for dimensioning of electro-energetic system is to achieve the optimal solution for higher level of safety supply, with minimum costs.

Above mentioned parameters for electrical power quality must be satisfied in range of possible propulsion states, and when some of elements are out of order because of failure or maintenance. Today, mainly the alternating current (AC) is used in ship's electro-energetic systems. Comparing AC to DC – AC has the bigger amount of available power, bigger production, distribution and exploitation rate of electrical power. But, there are also bigger losses in transmission because of reactive power transmission (because of limited lengths present in ship's electro-energetic systems, the losses are smaller compare to similar conditions on land). Larger losses are causing the skin effect; and there is a possibility of static and dynamic stability disturbances; with bigger power installation there is the increase in short circuit's power value, which is mirrored in equipment design, and so on.

Tendency is to manage the ship's power electro-energetic system like any other system. It isn't always possible to describe it with mathematical model like differential equations, so we try the intelligent managing structures and techniques that have significant success in managing of highly complex systems, as well as alterable systems. Intelligent systems are capable to perform some of the following functions: planning of operation on different levels; learning based on previous experiences; and identification of changes that are endangering the system's configuration, such as breakdowns. Based on mentioned functions, there was a development of different planning areas, expert systems, non-prominent systems, neuron grids, learning systems, failures diagnostic, hybrid systems, genetic algorithms, Petrie net's. This way, many systems could be made as highly resistant and tolerant to breakdowns, because there is an increase of reliability and availability of individual system and the ship's whole power supply. Namely, the aim of processes intelligent management is based on integration of existing knowledge and experience in management systems to achieve improvement of system's performances.

Electric generating plant's operation stability in great deal depends on loading size, propulsion conditions, system's technical-technological characteristics, and on the whole range of other conditions. During operation of ship's electric generating plant, there is a need for parallel generator operation on its own grid; so at the moment of big power consumers' connection, the maintenance of operation stability represents a significant problem. With growing level of automation of ship's power systems and demand for quick solution of problems; there is a tendency to improve the quality and safety power supply. It's difficult to learn during real events, so there are observances of appropriate mathematical models. This is much simpler and without adverse consequences on power plant. Research of ship's propulsion system dynamics as the only representative for complex, dynamic and technical systems is demanding application of the most effective modelling methods. In this work we used modelling with MATLAB-SIMULINK (power System Blockset).

The object of this work is to apply specified intelligent management system (genetic algorithm) to loading distribution, and to achieve the dimensioning of electrical safety equipment in high voltage electro energetic systems, that will ensure tolerance of breakdowns during operation.

Which elements to install, what size and type – to achieve the optimal effect – that is a very difficult optimization problem. The difficulty of finding the solution lays also in the fact that this is a combined optimization problem, where every one from a large number of combinations is made from a series of parameters in system operation. Along with that, the system is faced with a range of operational restrains. When solving the problem, we can achieve some good results from *adoptive research of solution sphere* technique. Genetic algorithm is especially efficient. During many generations the natural evolution is evolving in accordance to principles of natural selection, and by mimicking that process, the genetic algorithm is capable to "evolve" the problem solution.

Genetic algorithm is providing the independence in form of object functions. It is applicable to continuous or combined optimizations, and it's providing for stochastic approach in searching for optimum. This is totally in accordance with loading distribution optimization and optimization for electrical safety element location.

SIMULATION'S MODELS

Different methods were analyzed in this work, with the object to achieve the optimum activity, motivation, interest and efficiency in students' work. Two groups of students (12 students in each group) were testing the change of loading in ship's power system [2]. With the help from instructor/ professor, students were trying to change the load (kW) in electro energetic system (power system). They were observing what is happening with generators in ship's power grid. One part of each group was trying to optimize the fuel consumption of diesel generator units, analyzing the ship's power grid when faced with short circuits in a part of power grid. The other section of student's group was trying to regulate the steam in turbine operations, and so on. Each group had different parameters for change; students were working on a simulator for a period of time – trying to reach the best solution for observed system. They were comparing and presenting results. Those results they considered as the best, students were submitting as input parameters for further mathematical modelling. This way we've achieved better motivation, team work and – the most important – logical thinking that is attributing to problem solving.

<u>WORK CONDITIONS ON THE ENGINE ROOM SIMULATOR</u>

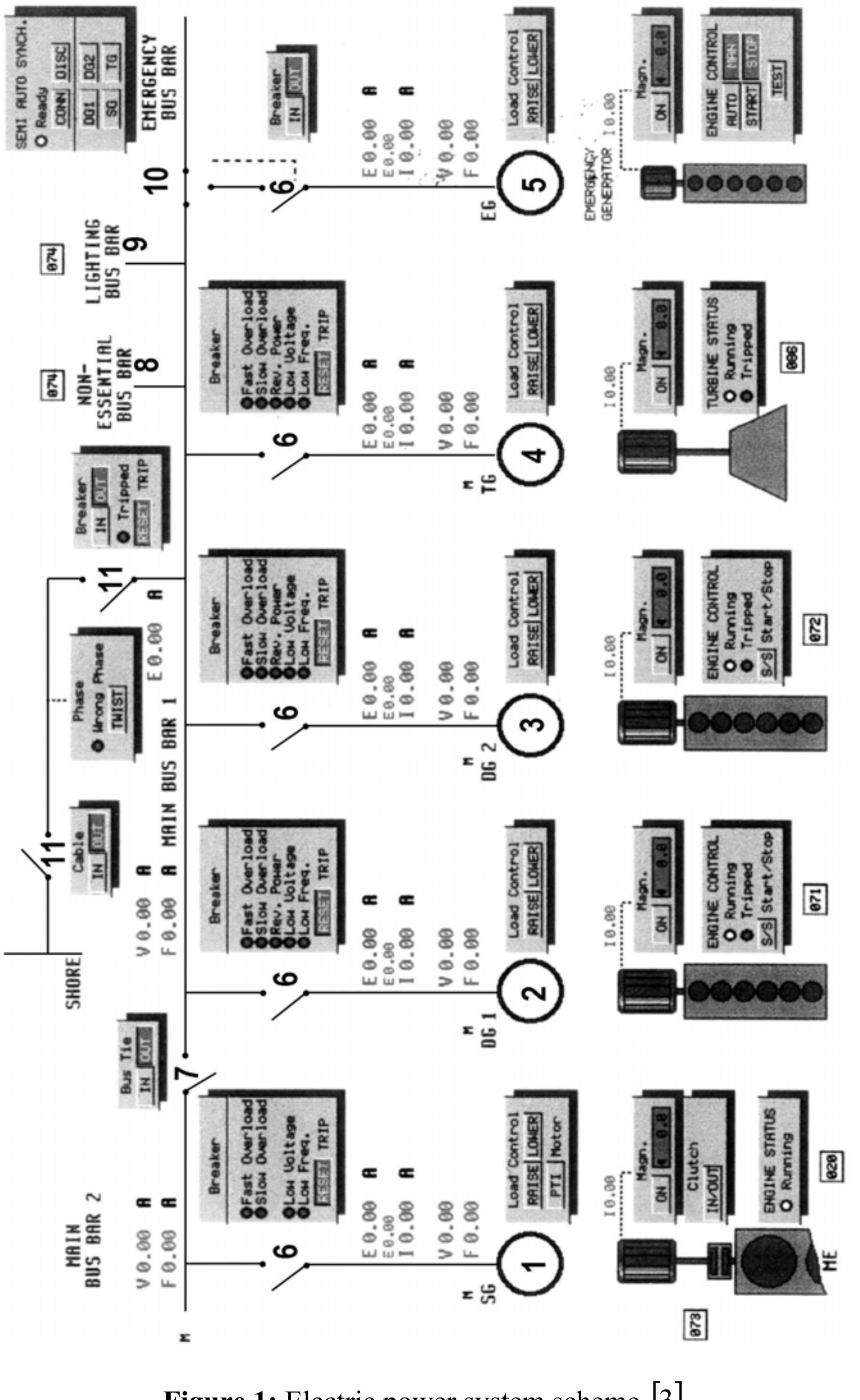


Figure 1: Electric power system scheme [3]

The works of the generator under equally distributed loading as well as condition which occur during stabilization of generator work are shown. Stopping of main engine (fuel oil supply cut off) and also the changing loading due reduced steam supply have been simulated (Figure 1.) The diagram (Figure 2.) shows the difference between an optimum and equal mode of loading. Within determined period (initial phase) the system works under an optimum mode of loading, where the priority on DG 1 takes over a greater part of loading, while DG 2 takes over the remaining loading. The optimum loading means the optimum operation regarding the fuel oil consumption, ship/s speed regarding generator characteristics. During subsequent period, Figure 2., the total electrical loading shall be divided into two equal parts (equally loaded generators). When simulating these processes, the values of voltage and main bus bar (1) frequency has not changed (slight deviations are shown by small oscillation). All parameters point at the system stability. It proves that the simulation of the system operation shall be necessary as to identify possible failures. In this way future marine engineers shall be trained for their jobs in the engine room and accordingly the crew shall be additionally educated, which all will contribute to the safety of navigation.
All simulations will be performed in Matlab and the model has been built with blocks [3] from the Power System Blackest. In this paper we didn't show the blocks from Power system Blackest but the results of the simulation are on the Figure 3.

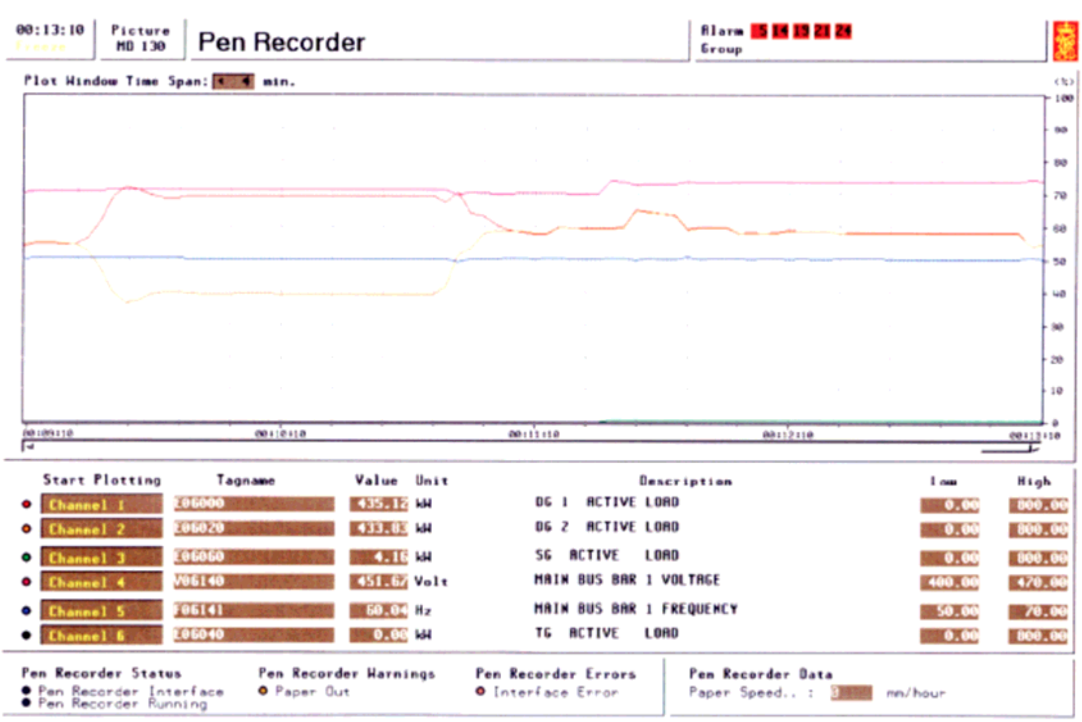


Figure 2: Diagram of loading of electrical energy generator – pass over from optimum to equal loading

<u>MATLAB</u>
Whatever the objective of our work-an algorithm, analysis, graph, report, or software simulation-MATLAB has quality tools. The flexible, interactive MATLAB language and companion toolboxes provide engineers, scientists, mathematicians, and educators with an environment for technical computing applications.

Simulink is a program package developed in Matlab surrounding, that is allowing modelling, simulation and analysis of system's different dynamic conditions. It supports linear and non-linear systems; modelled in continuous, but also in discreet time.

The characteristic of this simulation is use of graphical interface and "click-and-drag" operations with a mouse, to draw models in form of a block diagram. Simulink contains a rich library of input data generators, output variables' displays, linear and non-linear system's components and connectors.
After the modelling of a system, there could be different types of simulations. (Simulink-menu, or with commands that are entered in Matlab's command mode). By using the oscilloscope or other blocks for display of variables, the system's variables could be visible even during the simulation. Also, simulation's parameters could be changed (duration, source frequency...) with simultaneously monitoring of the results. Simulation's results could be stored for subsequently processing and visualization.

After the complete displayed of a block, and after all characteristics have been adjusted to mach the appropriate system, it's time for simulation performance. Firstly, duration time for simulation is selected. It begins with selection of Start function. During the simulation it's preferable to hold open the oscilloscope's display, to monitor the output variable. After the simulation's end, some of the output variables that were generated by the system could be additionally analyzed, processed and graphically displayed [5].

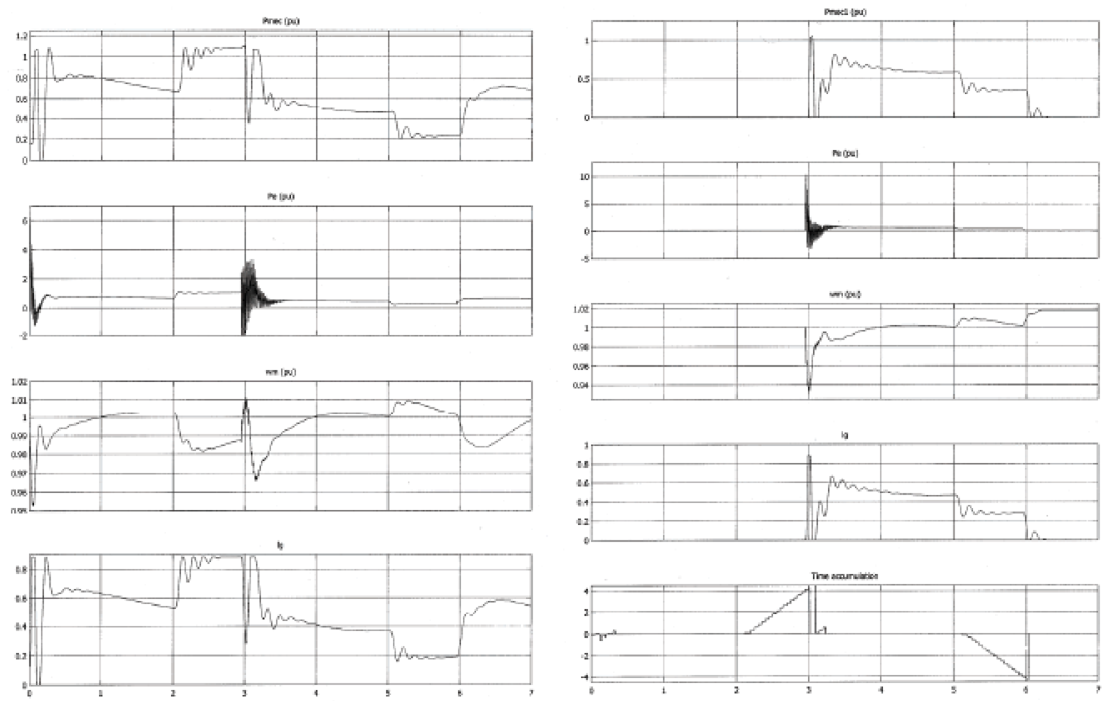


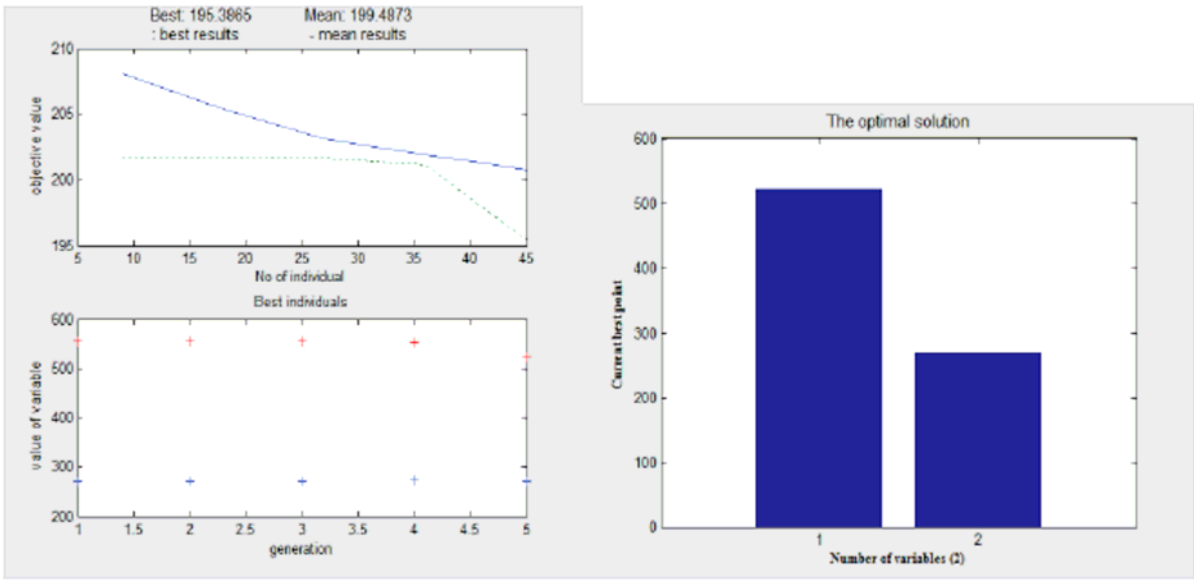
Figure 3: Simulation model in Simulink – results are graphically shown on a) SG1 b) SG2
a) Mechanical power b) Electric power c) Number of rotations d) Fuel valve e) Time of loading accumulation

GENETIC ALGORITHM

The genetic algorithm is a heuristic method of optimization, which is based on mimicking the natural evolution with search for the best individual, which is best adjusted to environment conditions [6]. Through the natural selection, the individuals are singled out – those who'll survive and create an offspring. This way, the population is advancing and adjusting itself to the environment. Genetic algorithms are imitating the natural evolution, in a way that the optimizing process represents the living environment for individuals (units) – process's input data. Each unit represents a combination of input parameters that are suitably coded. Through the selection in genetic algorithm, the units are picked up according to its genetic material: units with quality genes remain, namely –they are showing better results. The population is advancing through the genetic algorithm; it's offering better solutions for optimizing problem. Process of selection, reproduction and manipulation of genes materials is constantly repeating - until it reaches the condition for stopping the genetic algorithm. Initial population of units is created at the time of initiating the genetic algorithm. Genetic algorithm is executed until the condition for stopping is met. Condition for stopping depends on the problem and on conditions in which the problem is solving. When implementing the genetic algorithm, the main problem is correct choice of chromosome's representing and means of decoding to obtain the input data for function "good", and also the setting of this function.

GA is standard suitable for simulations of unanticipated processes, where few units (representing different types of competitors), are fighting for survival.

Functions "good" are used when developing GA – fitness function is representing quality price for individual unit. In the simplest form, the "good" function is equivalent to function f, which it optimizes. Higher quality means better chances of survival, creating the offspring through crossbreeding – so the "good" function doesn't represent any restrains (it can mean the selection in practice). The most difficult step is the definition of "good" function, because this function must truly mirror the problem it represents. During the genetic algorithm there is a selection process. It consists of preserving and passing of good attributes to the new population. Crossbreeding brings the exchange of genetic material between two units. Mutation is influencing one unit, and it is a random change of one or more genes. Genetic algorithm performs a large amount of operations, so it's possible to extract individual parts that could be executed independently. Specific equations for system's determination have been set, and entered parameters are based on simulations performed on Northcontrol simulator. On an example of three electric power sources (synchronous generators) and a certain group of consumer's genetic algorithms have been implemented through several calculation cycles. Figure 4: presents an optimal solution of our problem (optimization of expenses) where we discussed and analysed the problem of load regulation and regulation of generators work within the ship's electric power system.



a) b)

Figure 4: Simulation results GA: a) The result of each generation b) Optimal solution

CONTROL OF THE ELECTRICAL POWER SYSTEM

For safe control of ship's power system, it is necessary to understand the dynamic. The controlling system must be based on the following:

- Effectiveness – deliver power supply to all customers with minimum production costs and losses;
- Quality - ensuring the constant tension, frequency and wave form;

- Safety – this factor is variable in time, and it depends on power system resistance to disturbances;
- Reliability – probability of satisfactory performance during the set period (not depending on time).

Power system plant could be described with five propulsion states (Figure 5.)
Object of control safety contra-measures is the maintenance of normal propulsion state. The worsening of propulsion system brings reducing of control problem.

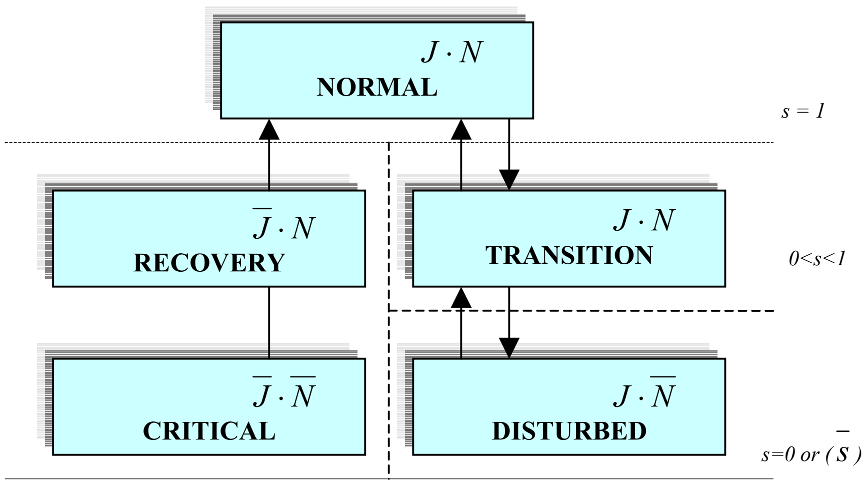
Power system stability is a capacity to maintain the balanced state - with original parameters, and after exposure to disturbances; and with variables of system state within the limits that ensure system's integrity.

System integrity is practically preserved if the rest of the system is complete (integral), without further failings of production units or consumers; with exclusion of the disconnected elements in the grid; and with object to achieve isolation or deliberate disconnection of elements to preserve propulsion for the remaining part of the system.

Power system is a multi-variable and non-linear regulation system, with constant changing of propulsion state. The consumption and machinery participation is also constantly changing, and that brings about the change in network's parameters. When the power system is exposed to disturbances, the stability of system depends on initial propulsion state and on the nature of that disturbance.

When analyzing the power system's stability, we emphasize the sudden and significant changes – short circuits, and also the smaller and common changes, like the change of loading (connection and disconnection of major consumers, or changes of referent quantities in regulation systems).

That is the reason why is distant simulation learning technology – on board and ashore - is one of the three components of a strategy for better located maritime education and training in the work processes on board. The other two are: experiential learning on board and teaching (training) in the classroom or on the simulators.



1.System's integrity is in danger
s = system's safety level
J = algebra limitation of equivalence

2. Preservation of system's integrity
JN = algebra limitation of non-equations
- = negation

Figure 5: The propulsion states

CONCLUSION

With simulators, specific behaviours in certain situations can be taught much better than on „real“ ships. High safety standards of ship operation require appropriate crew training and competence assessment for subsequent certification. This is the reason of simulating certain damages effects by computers and by means of a simulator. The introduction of the simulator as a teaching aid to was very successful according to feedback from both the students and the instructors. The provision of this educational tool, in conjunction with the optimisation techniques, will help to accelerate the understanding of engines, engine room, propulsion plant and another part of system through an interactive learning process.

Today, we try to go a step further with simulation models, that is – we try to create the Interactive simulation system (VR-i3D or 3D/VR). Those systems are representing the combination of sets and program support, for creation of different applications that are enabling the consumer to interact with virtual environment. *Scol* components of VR system are receiving input signals from the user's operated device, and through multiple sensor outputs, the illusion of virtual word is created. This way we created the image of virtual ship with simulation of dynamic behaviour of ship's power supply system. The objective is to train personnel and verify characteristic of prevised devices and equipment.

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BIOGRAPHY

Maja Krčum was born in Split, Croatia (on March 1958.). She graduates from the Faculty of Electrical, Mechanical Engineering and Naval Architecture, University of Split on March 1981. She received a graduate degree (M Sc.) at the Faculty of Electrical Engineering, University of Zagreb in 1996. Her master's thesis was entitled "Simulation on Model of Shipboard Electrical System". In 1997. she was appointed Head of Department, also working as a tutor and counsellor. Now, she is quality manager at the Faculty. She was participated in a number of both national and international conferences where her papers and lectures were generally acknowledged as an active and valuable contribution towards the development of her profession. Her primary interest lies in the field of shipboard propulsion systems, with a special emphasis on electrical propulsion and its numerous applications (simulation methods). She is also a member of several national and international societies (e.g. IEEE, ELMAR, KOREMA…)

Anita Gudelj was born in Split, Croatia (1970). She received her B.S. degree in mathematics and computer science (1993) from University of Split, Faculty of Mathematics. Since 1995 she is a lecture at the Maritime Faculty University of Split. Also, she received the M.Sc degree in information science from Faculty of Organization and Informatics, Varaždin, Croatia (2000). Her postgraduate research was "Design and Implementation of Temporal Database". Now, her primary research interest is database design. But, together with some other staff member of Faculty, she currently works with Matlab and simulator. Her research work also includes simulations, genetic algorithm and their implementations on ships.

Predrag Krčum was born in Mostar, Bosna and Hercegovina (1953.). He graduates from the Faculty of Electrical, Mechanical Engineering and Naval Architecture, University of Split (1982.). He worked as expert assistant in PTT – Split, as director of manufactory “Obuća” –Split, and since 2005. He is a lecture at the University Centre for Polytechnic Study – Split. His primary research interest lies in the field of automatic control of hydraulics and pneumatics propulsion and also in some system for education students.