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THE ANALYSIS OF NAVAL ELECTROMAGNETIC SYSTEMS USING SOFTWARE PROGRAMS

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Abstract: *Modernization strategy of the naval power system is based on the following: high efficiency, high flexibility with low emissions using combined systems consisting of multiple components and various generators. In order to simulate electro-energetic processes in the naval system and reduce fuel consumption, we built an application that performs the energy balance in each functioning regime of a ship by charging each consumer. The program also optimizes underway regimes, offering alternative changes in the system and thereby reducing electricity consumption on board. The optimization provided by the program will be made by passing the consumers in a particular type of operation in various modes so as the total energy consumption to be the lowest.*

Keywords: *power system, software program, maritime ship, underway and stationary regime*

1. INTRODUCTION

In order to optimize electricity consumption correlated with increased reliability of power systems aims in ships all equipment and facilities to be implemented on board must be updated along with marine propulsion development so as a greater efficiency and a reduced environmental impact to be achieved. [18, 6, 17, 14]

The aim is to develop and use digital tools to achieve combined energy production systems. [19,15] Developing component models at different levels of complexity, methods for their assembly into powerful software simulators, the use of such simulators to analyze both the dynamic and operational behavior while identifying limitations are very

important in developing the next generation of naval electro-energetic power systems [8, 21,16, 10, 5, 22, 9, 1].

The program starts with the specifications of a LPG (liquefied petroleum gas) carrier: Maersk LPG/NH3 Glory. The program can be used for any other type of vessel by introducing a new set of characteristic parameters, can achieve a theoretical calculation for a ship proposed for construction in any shipyard [11,20]. The program was developed using Microsoft Visual Studio C # 2008, Microsoft Excel and MathCAD 15. [2,3,4] The strengths of the proposed program: it can be applied to all categories of ships, requiring only the introduction of the manufacturing nominal parameters of the generator and consumers

(which can be found in the technical documentation of the vessel) [13,7], it includes a study mode according to experimental data measured onboard while underway, it takes into consideration weather conditions (humidity air salinity of sea and air) in the calculation of the power system losses, it also deals with time- damage of electrical consumers caused by harsh conditions on board usage (overload, mains transient), resulting in direct decreased efficiency of the generator [1,12] . The program was tested on board for the movement of the ship between two ports, leaving open the opportunity of using the program for the entire voyage. Weak points of the program: the format of the given parameters is not checked , bowing program on the premise that users are familiar with the way the program can be used; the program is not applicable to the short-circuit protection of NPS.

2. COMPONENTS OF THE PROGRAM

The program is a Windows-Form application built in C # (Fig.1). The menu bar contains seven submenus with functions to determine the energy balance in standard underway regimes and to select the consumers according to the type of vessel.

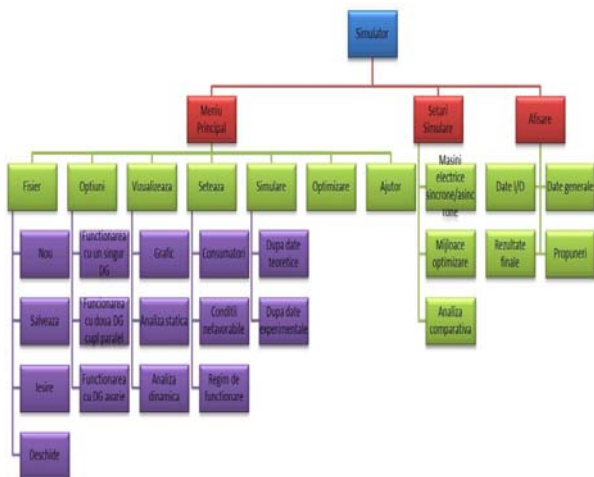


Figure 1. Block diagram of the program

3. MODEL SIMULATION

To exemplify the developed program usage, we present an optimization algorithm for a set of experimental values measured on board the reference carrier Maersk LPG/NH3 Glory. This simulation model comprises a

series of steps, as follows: select the “After experimental data” from the “Simulation” submenu of the menu. The selected option appears in the “Show data I/O” window of the display;

a) In the display window select the option “Show data”. Here the user can become familiar with the components and operating parameters of the power system on board (the main features of the diesel engine used for inducting the generator, the generator characteristics and high power electrical consumers features). Figure 2.

b) Access submenu “Options” from the menu. This sets the number of generators (connected to the board net). During this simulation the following underway regimes will be used: Underway regime at sea / at anchor - one DG, manoeuvre regime - 2DGs; stationary regime when loading or unloading - 2 DGs .

If the emergency generator is the only one connected to the network, it is considered that the ship operates in an emergency regime. Further on, a study on the startup behavior of generators and large consumers is performed. This particular step aims to analyze the transient process of starting the generator with all the steps that are involved (starting the diesel engine, generator excitation and coupling to the network).

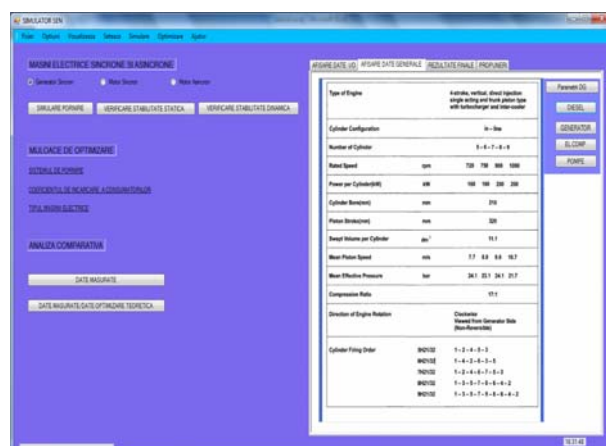


Figure 2. General data display

c) From “Settings simulation” of the parent window select the option ”Synchronous Generator”, then click “Start simulation”. A new window with two modules will open: “The rated parameters of the chosen electric generator” and “The rated parameters of the chosen electric engine”;



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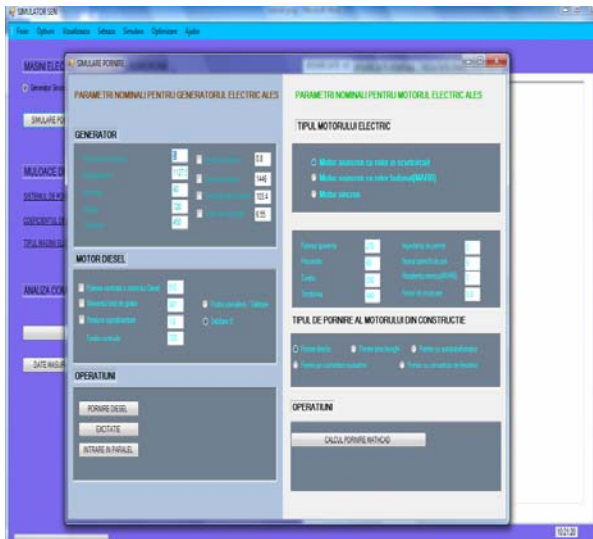


Figure 3. DG starting simulation

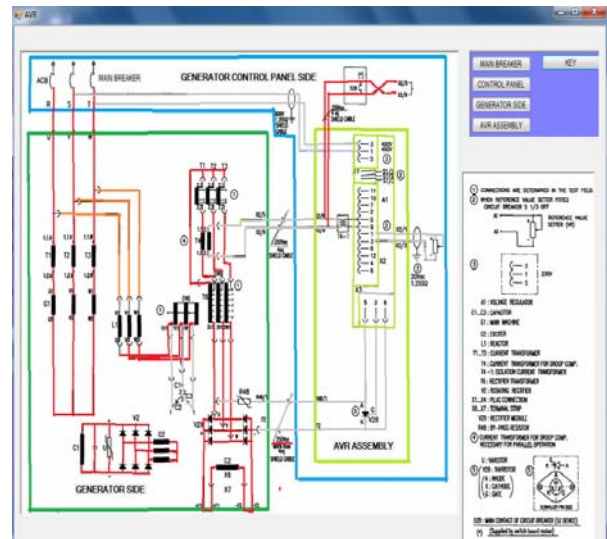


Figure 4. Generator excitation scheme

We will only work with the first module introducing the generator's features (apparent power, active power, frequency, speed and type of electric machinery, voltage to bars, power factor, power generator, excitation current, and voltage excitation).

d) In the "Diesel" section special features needed to run the engine are filled in (diesel engine rated power, total yaw moment, boost pressure, rated speed); select the "Position rack / cutting" to ensure engine start and its operation at rated parameters.

e) In the "Operations" section we will simulate the startup, excitation and parallel coupling for the parameters already introduced. Push the "Start Diesel Engine". A text box with the message "Engine started successfully" will appear.

f) Click "Excitation" from the "Start Simulation". A new form opens. It contains the excitation of the generator. In the new window a set of buttons that separate parts of the excitation scheme appears. After pressing each of the 5 buttons, the AVR window will look like in Figure 4.

g) Close "AVR" window and click "Join in parallel" from the "Start Simulation". A new form containing in parallel connection of the main generators opens.

h) Close all windows except the parent window. Select the option "Induction motor" from the section "Synchronous and induction electric machineries" in the parent window, then click "Start Simulation". A new window will appear ("Start Simulation").

i) We will apply the necessary settings to simulate the induction motor start in the following sections: electric engine type, original engine starting mode, operations. For this simulation, we consider the default option "Rotor fault induction motor", specific to the electric motor of the reference vessel. In this section there are also the main parameters of the electric motor: active power, apparent power, frequency, speed work, voltage, impedance startup, number of pole pairs, the rotor resistance, load factor. For this simulation, we will work with default values specific to the electric motor of the reference vessel. We will fill in the "Rotor Resistance"

and “Choke start” only if the engine is a coil winding rotor one. Otherwise we will fill in the indicated fields with zero. In the section “Original engine starting mode” the following options are available: direct start, star start/triangle, autotransformer start, start with features given by the rheostat, frequency converter start.

j) In the “Operations” section with the settings given above, click ”MathCAD Starting Calculus”. A new form will open [Figure 5].

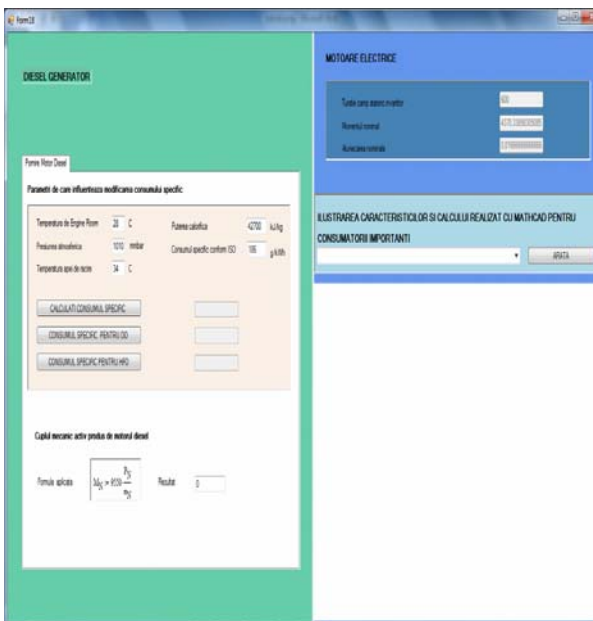


Figure 5. MathCAD Starting Calculus for the analyzed Electric motor

In the section “Illustration of MathCAD characteristics and calculus for major consumers” calculations are available for the following consumers: 270kW Compressor Motor, Deep Well Pump Motor, Booster Pump Motor, Water Pump Spray Motor, Fire and General Service Pump Motor Bilge, Ballast Pump Motor, Fire Pump Emergency generators Motor. We continue with the generators stability study. To do this, click “Check static and dynamic stability”. A form that contains a number of options to illustrate the different types of system stability will appear. Press the button “Show complete MathCAD calculus” to illustrate the generator stability calculation considered in the current simulation, and then press the four buttons. Compare the result with the three already shown systems [Figure 6].

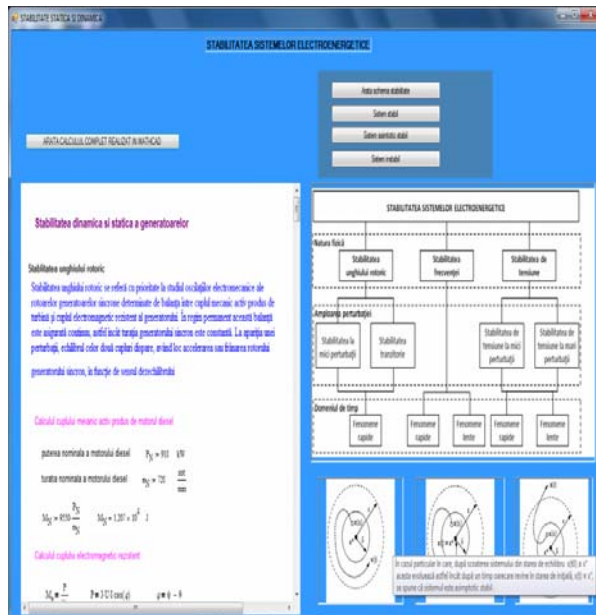


Figure 6. Comparing MathCAD calculus with illustrated systems

We will do three tests, the first for the underway regime, the second for the manoeuvre regime, and the third one for loading and unloading arrangements regime. Underway regime analysis – we use consumers that work continuously. We set up the main distribution panel like in figure 7. We obtain a power consumption of 507.44 kW. Therefore it is only necessary to connect one generator (507.44 kW represents 56% of the power generator of 910 kW). Manoeuvre regime analysis - we use consumers that work continuously. We will also add the consumers used in manoeuvring: bow winches, stern winches, and other deck installations that can be required. The necessary power will be 763.04 kW which is more than 75% of the power generator. We will also add automatic mode consumers and get a 906.64 kW power. So, for this particular regime we will have two generators connected in parallel for the network.



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Figure 7. Main distribution panel for underway regime

Loading and unloading arrangements regime analysis – we have the following configuration of the main panel, Figure 8:



Figure 8. Main panel for loading / unloading regime

We obtain a total of 1206.96 kW power consumption, having two generators connected in parallel.

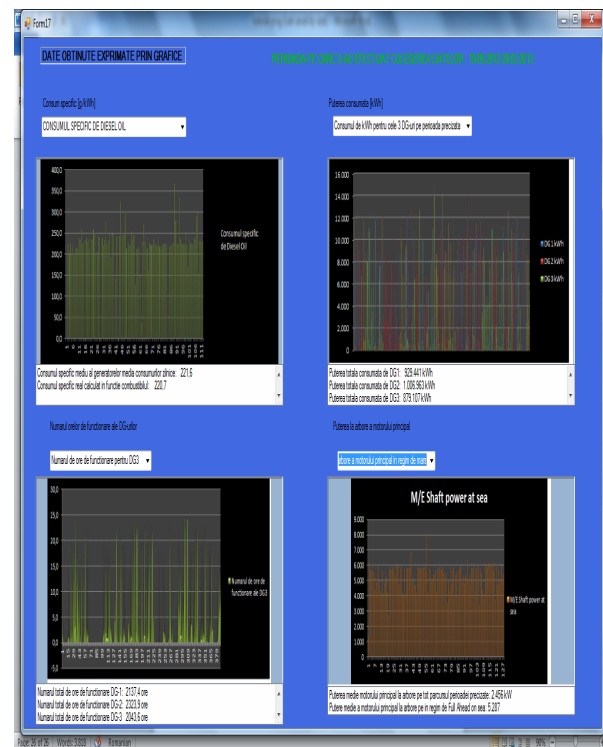


Figure 9. Statistics for considered ranges and regimes

Display the final data – we can observe all steps of this simulation. From the Display Mode window conclusions and proposals of the analyzed ship power system are accessed.



Figure 10 . Final results of the simulation

4. CONCLUSIONS

The program will do the initial analysis of the existing energy system and then will optimize each regime and seek alternatives for reducing electricity consumption thus lowering fuel consumption of internal combustion engines. The optimization made by the program allows the passage of consumers from a given running curve on another due to regime and charge changes, therefore, considering the calculated energy balance, the total power consumption to be the lowest. It also allows choosing the best alternative for the consumers as to achieve better system reliability and to launch windows illustrating energy balance for standard regimes. Particular regimes could be created as needed by selecting the consumers. Physical and functional integration of the power system and automation system, optimal allocation and power control for all subsystems are important criteria in optimizing power consumption. The aim was to use methods of analysis and optimization of energy consumption so as to realize the analysis of dynamic behavior of the equipment with the support control and energy management. In order to optimize electricity consumption in correlation with the increased reliability of power systems all equipment and

facilities that are to be implemented on board so as to achieve greater efficiency and reduced environmental impact. The control and management of electricity consumption are integral parts of achieving naval power system monitoring functionality of the system. The efficiency of electricity consumption has been charted. It has also been made a selection of marine equipment focusing on low power consumption, high efficiency and low pollution. The quality of power supply is determined by the following factors: the operational safety of the plant, power quality at the point of separation between the consumer and the supplier, the electromagnetic compatibility of systems with the works.

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