Computing Simulation and Heuristic Optimization of the Marine Diesel Drive Generating

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Abstract. The aim of this paper is to show the efficiency of the System Dynamics Computer Simulation Modeling of the dynamics behavior of Marine Diesel-Drive Generating Set, as one of the most complex and non-linear marine technical systems. In this paper Marine Diesel-Drive Generating Set will be presented as a qualitative and quantitative system dynamics computer model with a special automation aspect provided by two UNIEG-PID-regulators (Electronics Universal PID Regulators). One of them will be used for diesel-motor speed (frequency) regulation and the other will be used for the synchronous electrical generator voltage regulation.

1 Introduction

The System Dynamics Computer Simulation Modeling Methodology is one of the most suitable and effective ways of dynamics modeling of complex non-linear, natural, technical and organization systems. Studying the dynamics behavior of Marine Electric Power Systems, as one of the more complex dynamic non-linear technical systems, requires the application of only the most effective modeling methods.

System dynamic modelling is as a matter of fact a special scientific approach i.e. "holistic approach" to the dynamics behaviour simulation of the natural, technical and organisational systems and therefore it includes qualitative and quantitative simulation modelling regarding varieties of various characters. This Computer Simulation Model of the Marine Diesel-Drive Synchronous Generating Set is very suitable education simulator software, especially for marine students and marine system engineers because it provides them with the means to conduct numerous simulations for various productive scenarios.

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2 Simulation model of the marine Diesel-drive generating set

The mathematical model of the Marine Diesel Motor with turbo compressor
The mathematical model or level equations of the diesel engine with turbo-compression are:

$$\frac{d^2\varphi}{dt^2} = \frac{1}{T_H^2}\left(-T_{DH}\frac{d\varphi}{dt} - K_{DH}\varphi + T_S\frac{d\chi}{dt} + K_S\chi - T_U\frac{d\alpha_D}{dt} - K_U\alpha_D\right) \quad (1)$$

Where:

φ = relative change of angular velocity,
χ = relative shift of the high-pressure fuel pump cogged shaft,
α_D = relative consumer load change,
T_H = time constant proportional to the moment of inertia,
T_{DH} = time constant opposite-proportional to the moment of inertia of the engine as the object of regulation,
K_{DH} = self regulating and amplification factor,
T_S = motor time constant of inertia,
K_S = motor amplification factor,
T_U = generator time constant of inertia and
K_U = load amplification factors.

System Dynamics mental-verbal simulation model of the Marine Diesel Motor with turbo compressor are presented at SCI 2004 (12).

3 Simulation of behavior dynamics of the marine Diesel-drive generating

The mixed scenario has been built into this computer simulation model of DDSGS:
l. - diesel engine starts at TIME= 0 (s) and KAPA= gears batten relative shift of high-pressure fuel pump is shifted (opened), and it is self-started in "idle-running" mode;
2. - synchro-generator starts with its self-exiting process at TIME= 20 (s);
3. - load impedance or resistance R_L and reactance X_L starts at TIME= 0 (s). The R_L=150 and X_L==0, which means that DDSGS is in the "idle-running" mode. At TIME= 40 (s), the R_L= 1 and X_L= 1 (nominal load); and
4. - stator short-circuit start at TIME = 70 (s) and R_L= 0 and X_L=0, which means that DDSGS is in the "short circuit" mode.
The authors had installed two automatic short-circuit protection switches also. One of them had taken out the u_f = rotor exciting voltage time reaction delay, which is .4 (s) and the other had taken out the KAPA= relative shift of the high-pressure fuel pump cogged shaft time reaction delay, which is 2 (s).
Results:

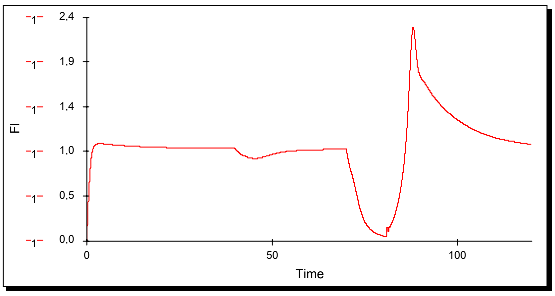

Fig. 1. FI- relative change of angular velocity,

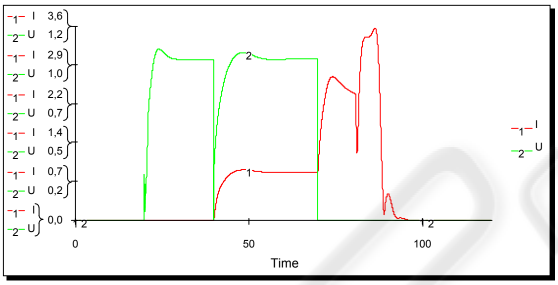

Fig. 2. I- stator current, U- stator voltage

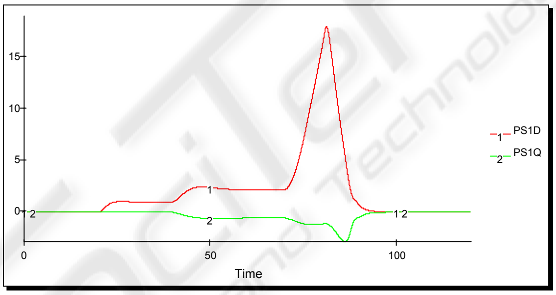

Fig. 3. PS1D- damping coil flux linkage in the d-axis, PS1Q- damping coil flux linkage in the q-axis

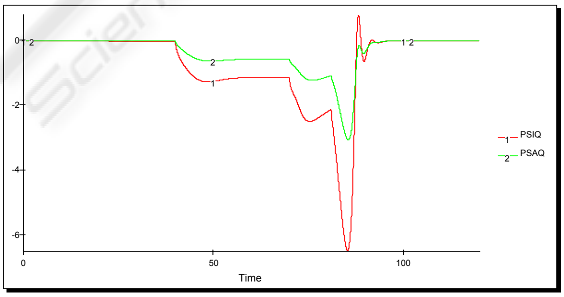

Fig. 4. PSIQ- stator flux linkage in the q-axis, PSAQ- stator mutual flux linkage in the q-axis

The dynamics behavior reaction to this mixed scenario, after the modeler had finished the process of "heuristic optimization" by parameters of two UNIREG-PID regulators ("retry and error" computer manual method), is the following set of time curves, where: FI= relative rate of angular velocity, U= u = stator effective voltage, I= stator effective current. Everyone acquainted with thermodynamics and electrodynamics machine sets recognizes the dynamically transient well-known behaviors of the Marine Diesel-Drive Synchronous Generating Set.

4 Conclusion

The application of System Dynamics Simulation Modeling Approach of the complex marine dynamic processes, which the authors, together with their graduate students, carried out at the Maritime Faculty University of Split - Croatia twelve years ago, revealed the following facts:

l. The System Dynamics Modeling Approach is a very suitable software education tool for marine students and engineers.
2. System Dynamics Computer Simulation Models of marine systems or processes are very effective and successfully implemented in simulation and training courses as part of the marine education process.

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