System Dynamics Simulation Model of the Marine Diesel Engine Start up System

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Keywords: System dynamics, Modelling, Asynchronous motor, Start up system and ship/s piston compressor.

Abstract. System dynamic simulating modelling is one of the most appropriate and successful scientific dynamics modelling methods of the complex, non-linear, natural, technical and organizational systems. Investigation of behavior dynamics of the ship/s propulsion system as one of the complex, dynamic, non-linear technical systems requires application of the most efficient modelling methods. Marine Diesel engine start up system, which it is consisted of ship/s piston compressor and its driving electric motor, i.e. in this case asynchronous motor, shall be presented in the System Dynamics modelling approach in POWERSIM simulation symbolic and language. System dynamic models are essentially continuous models since the realities have been demonstrated by a set of non-linear differential equation, i.e. “equations of conditions”, however they are at the same time discrete ones because their principle time interval calculation i.e. (discretisation) sampling “DT” is determined in full compliance with (Sampling Theorem) by Shannon and Koteljnikov.

Introduction

The System Dynamics Modelling is in essence special, i.e. “holistic” approach to the simulation of the dynamics behavior of natural, technical and organization systems, and it contains quantitative and qualitative Simulation Modelling of various natured realities. The concept of optimization in System Dynamics is based on belief that the manual and iterative procedure, i.e. optimization by the method “retry and error” can be successfully executed using heuristic optimization algorithm, with the help of digital computer, and in complete coordination with System Dynamics Simulation Methodology. This simulation model is small part of scientifically macro project called Intelligent Computer Simulation of the Model of Marine Processes.

System Dynamics Simulating System Models Ship/s Piston Compressor – Electric Motor

System Dynamics Models of the Ship/s Piston Compressor

Devices for air, gas or steam supply under high delivery pressures are called compressors. Compressors may be driven by electric motor or diesel engine. Air in the piston compressor is compressed by decreasing volume of the cylinder working space by means of a piston. Multi-stage compressors are used for obtaining high pressures and compression is performed at piston both sides, while for obtaining higher capacities of piston compressor one stage of compression have been performed with several cylinders. Accordingly, various combinations of multi-cylinder and multi-stage piston compressors have been achieved.

Basic equations of the piston compressor condition are:

\[
\frac{d\omega}{dt} = \frac{M_{\text{mem}} - M_{\text{kom}}}{M_t}
\]  

\[
M_{\text{kom}} = \frac{G W_k}{\omega}
\]  

(1)  

(2)
Air receiver capacity depends on whether the engine is reversing or non-reversing and thus the air receiver capacity for reversing engines shall be calculated for 12 starting and for non-reversing ones the capacity shall be calculated for 6 starting only.

At one starting air shall be supplied to the cylinder at 1/3 to 1/2 piston stroke, therefore the air receiver volume is approximately to equation 3.

On the basis of basic equations flow diagram, mental verbal and structural diagram of the piston compressor may be performed.

Mental-Verbal Model

When the ambient temperature is increasing, air receiver air mass, at various pressures is decreasing, resulting in negative sign of concerned cause-effect relations. When air receiver volume is increasing, air receiver air masses (quantity) are increasing too and observed CER (UPV) is positive. Where pressures are increasing (atmospheric, pressure at 15 bars, pressure at 30 bars), air masses in these points are increasing also and observed CER (UPV) is positive. Where air mass (quantity) is increasing at the atmospheric pressure condition as well as at 30 bars pressure, air receiver air quantity variation is increasing too and thus CER (UPV) shall be positive. When air quantity speed variation is increasing, air mass supply speed in the air receiver is increasing also and thus CER (UPV) shall be positive. When air mass (quantity) is increasing at the atmospheric pressure condition, air mass supply speed is reducing and thus observed CER (UPV) shall be
negative. When air mass supply speed is increasing, compressor moment shall increase too and thus CER (UPV) is positive.

![Figure 2. Structural diagram of ship’s piston compressor.](image)

**Graphical and Tabular Simulation Results**

Scenario of driving dynamics of the piston compressor driven by asynchronous motor includes I charging, I discharging, II charging and II discharging of the air receiver. Graphical simulation results:

![Figure 3. Angle speed, asynchronous motor slip and air mass condition in air receiver, air quantity speed variation and air consumption speed.](image)

![Figure 4. Stator and rotor linkage fluxes of asynchronous motor and load torque.](image)
Conclusion

System dynamics is such scientific methodology enabling the simulation of the most complex systems. The application of the system dynamic simulating modelling for various loadings when piston compressor is driven by an asynchronous motor demonstrates applicable methods of computing simulation, either for education of young engineers (training) or for designing of complex electrical mechanical systems and also enables quick and scientific method of investigation of complex systems to any technical specialist, to acquire additional technical knowledge about that very system. This essay deals with system, dynamic and qualitative (mental-verbal, structural and diagram-continuity) and qualitative (mathematical and computing) models of the complex non-linear system. It is evident from this essay that the global conclusion would be that ship/s piston compressor is a specific consumer which is mostly appropriate to be driven by a (robust) heavy duty asynchronous motor.

References