Visualization of ship motion at the roll motion stabilization with active fin stabilizer

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Abstract

The aim of the paper is to present visualization of the ship motion. Detailed ship’s parameter (length, width, dip, etc.) and the sea conditions (the wind speed, height of a wave) must be inserted into a programme before simulation procedure. Subsequently, the library consisting of selected stabiliser and controller functions and the working options of the simulator (working with a fin or without it) must be chosen. The programme calculates the parameters of the mathematical model and parameters of the forced randomness. The simulation of the ship motion on the sea is performed by solving the differential equations using the Runge-Kutta method, at pre-assumed input data. As a result we can observe the simulated picture of the rolling ship at different planes and conditions (with a fin or without it). Resulted picture of the ship motion during the simulation process is interpreted by the graph.

1 Introduction

On the ship vessel, which moves after woven sea acts forces and moments\(^\text{1,2,3,4}\) generated by wind and acting on the vessel as a result of waving and the sea currents. As a consequence, the rolling of ship, and particularly the rolling motion are observed.

As an effect of these rolling motions some unprofitable occurrences can be observed:
- Making worse of work circumstances of shipping systems,
- Making worse of passengers transport and loads circumstances,
- Possibility of loss of transverse stability of the ship.

In order to enhance the generally understood safeties of shipping and improvement of manoeuvring of ship on the wave, one install different kind of stabilizers.

The aim of presented material is to show the possibility of simulation of dynamic system: ship - fin stabilizer with use of mathematical model with 4 degrees of freedom\(^\text{5,6}\) and visualization of process of roll motion stabilization. Base of simulation is mathematical model: ship - fin stabilizer.

2 Visualization of regulation system of steering with active fin stabilizer

Using the visualization methods as tools to obtain the final solutions of problem is necessary for analysis of work of ship-fin system from the following reasons:
- usage of visualization elements gives visual effect of activity.
- the effect of changes of the fin work parameters is evident at once - without deeper analysis received results.

At present time, in fin systems of suppression of roll motions universally practical are regulators of type PDD\(^2\) assuring very high efficiency of suppression of roll motions. After-mentioned we represent our proposed system of steering with active fin stabilizer form visualization process (Figure 1).

![Figure 1: Block diagram of steering system with active stabilizer of ship roll motions.](image)

In effect of investigations results that algorithm of simulation used in programme reflects the real movement of ship and can be used for testing of different kind of regulators to stabilize the roll motions, course of ship, manoeuvring tests.

![Figure 2: Schematical representation of simulation programme](image)

During visualization work out one accepted the assumption: assurance of general usage, and also maximum automatization of calculations and easy analysis.

### 3 Visualization of ship motion

Programme consists of three modules:
A) Introduction of data;
B) Simulation of ship motion
C) Visualization of data received as result of simulation
3.1 Introduction of data

This module serves for introductions of data necessary for simulation. These data are:
- Data of the ship (minimal length, width, dip etc.);
- Data about initial conditions (minimal longitudinal speed, course angle etc.);
- Data about extortion - regular/irregular, amplitude and period of waving;
- Data about noise;
- Data about regulator

![Figure 3: Set of the ship data](image-url)

![Figure 4: Initial conditions of ship parameters](image-url)
3.2 Simulation of the ship motion

Mathematical model of dynamics of the ship motion describes longitudinal swings, transverse swings, rolling motions and yawing, and are recorded in form of differential equations. On base of ship data and initial conditions (only in first step) the programme dissolves 16 of differential equations by Runge-Kutty method. Data are steered to regulator of roll motions, and from here to the active stabilizer of roll motions. In result of activity of stabilizer we receive a new initial data. And in following step, they determine the conditions to solve differential equations. Data received from solutions of these equations determine the base for generating of input data.
3.3 Visualization of data received as result of simulation

In order to avoid the excess of information programme makes possible the choice of output parameters (e.g. inclination of fin, angle of roll motion):

- A) graph on the monitor;
- B) image of moving ship;
- C) image of fin movement;
- D) saving of simulation results in text file;
- E) data from text file, which can be represented in real mode by means of DDE as graphs in any configuration.

![Simulation Interface](image)

Figure 7: Simulated ship motion on the sea

Figure 7 represents the image of the ship on the sea. This figure fully shows the realistic image of ship behaviour with fin stabilizer and without fin during simulation, and it gives to oneself then the possibility of more full introductions with problem of suppression of roll motions.

4. Conclusions

The visualization method of the ship motion on the sea was presented. Ship’s parameters and the sea conditions were inserted into a programme before simulation procedure was started. The simulation of the ship motion on the sea was performed by solving the differential equations using the Runge-Kutta method, at pre-assumed input data. As a result it was possible to observe the simulated picture of the rolling ship at different planes and sea conditions (with a fin or without it). The visualization method applied here can be helpful tool in solving the problem of suppression of the rolling motions of the ship. Furthermore, this
method can be used at early stage of ship design for simulation of different ship’s behaviour at the sea (circulation, zig-zag test, etc.)

References

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