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Control design of ship robust active rolling stabilizer

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Abstract

Control design of the robust stabilizer for roll motion of ship is discussed. The ship is under pressure by waves. To design robust controller we use 2-Rikkati's method of optimization. It allows to design a control system with incomplete and inexact input signal information. Furthermore, we study the types of waves and design model of control object. The control design is shown to be suboptimal and it depends of boundary level of tolerance.

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1. Introduction

The marine transport has an important meaning for transport system of Russia: it's on the third place by turnover the goods after railway and pipeline transport. The basic imperfection of marine transport is natural factor dependence, influencing both safety of swimming, and economic effect of flight. One of those factors are waves and wind, defiant rolling. Rolling – it's harmful phenomenon as in itself, and because of those consequences by which it is followed. The harmful consequences are:

- worsening of ship habitability because of adverse physiological effect of rolling on a condition of people;
- violation of normal work of ship designs, mechanisms and devices because of vessel inclinations on nervousness and additional inertial loadings;

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- worsening of road and maneuverable performance of the ship because at the rolling the speed of the course and controllability can significantly decrease;
- security risk of swimming because of deck flood, possible capsizing of the ship.

Because of the main time exploitation, the ship navigates at storm conditions, necessary correct choice ship's elements, providing optimal type of rolling and the equipment special constructive devices – stabilizer for a ship stabilization ship with sea choppiness. As controlling device which help to damp sea choppiness. At this paper robust regulator for a control system of onboard wheels of the ship is developed to represent the wings of small lengthening acting from both boards of the vessel and supplied with the mechanisms providing their turn, move out and in. The model of control object is linear. Two-Riccati robust optimization and H_∞-theory path following is an issue of practical importance for control object.

2. Control object model

Ship has six degrees of freedom. At the time of moving on real windy choppiness ship rolling is complex dynamic process, which we can be considered like a set of vibrations for each degrees of freedom. At this paper is considering simplified model of control object – ship at rolling conditions representing rotary vibrations (fluctuations) around a longitudinal axis (the axis lying in the diametrical plane of the vessel), that is alternate list on the left and right board.

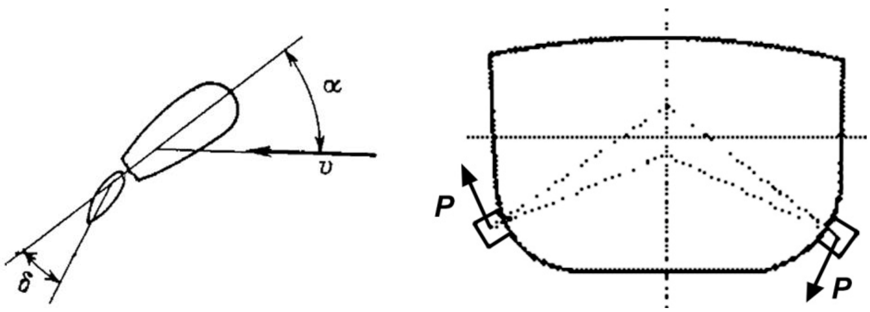

Fig. 1. Control signal.

The actuating mechanism by means of which counteraction to sea choppiness indignation will be carried out – decrease of list angle θ - are couple of cutting onboard operated wheels. Cutting onboard wheel consists of the main wheel and the flap re-laying in the same party, as the main wheel (Figure 1). Due to re-lay flap δ becomes change an attack angle α. On wheels arise a stabilizing moment opposite to sea choppiness revolting due to the carrying power arising on a wing, which it is proportional to a square of speed of the running stream. Because of it usually warships are equipped with onboard operated wheels. We are going to use traditional model of sea choppiness, using following simplifications:

- the steepness of waves is infinitely small;
- wave speed is small and their squares can be neglected.

We will take a special case of linear model, hoping that:

- waves are free and also move only under the influence of gravity and hydrodynamic forces caused by waves;
- plane motion (by the y-axis direction all parameters will be constant);
- free surface of liquid is boundless.

As a basic for the analysis we will take the so-called shortened equation of onboard rolling (not considering diffraction a component of the revolting moment)[1]:

$$\ddot{\theta} + 2\nu_\theta \dot{\theta} + \omega_\theta^2 \theta = x_\theta \omega_\theta \sin \omega_k t \tag{1}$$