H∞ Control of Thruster for AUV

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ABSTRACT

Precise automatic control of an autonomous underwater vehicle during maneuvering and dynamic positioning requires accurate control of the thrusters. In this paper, we present the design for an H∞ controller. Laboratory experiments and simulations of step and sinusoidal responses are used to demonstrate the effectiveness of the design.

KEY WORDS: Marine Thruster, Thrust Control, H∞ control, ROV

NOMENCLATURE

$\Delta \eta$ : Flux coefficient
$\rho$ : Water density
$\Omega$ : Prop angular velocity

1. INTRODUCTION

Remotely operated vehicles (ROV) are widely used for important scientific and industrial tasks such as automatic docking and station keeping; precise surveying, inspection, sample gathering, and manipulation. Exact automatic position control is required to carry out these tasks. However, it seems that the accuracy of present-day position control is inadequate because the control system of dynamically positioned marine vehicles typically ignores thruster dynamics completely.

This paper focuses exclusively on the dynamics of electrically actuated thrusters typically employed on dynamically positioned vehicles, and on the thrust control of marine thrusters. A nonlinear mathematical model (Whitcomb and Yoeger, 1995) of a thruster was constructed using the results of experiments (Bachmayer et al., 1997) carried out to determine the thruster dynamics. An H∞ controller (Nakamura et al. 1997) combined with feedforward control was designed and simulations and experiments on thrust control were executed. The successful control by H∞ controller is shown.

2. TROV THRUSTER AND EXPERIMENTAL METHOD

The TROV (Thruster for ROV) direct-drive tunnel thruster and experimental set-up are shown in Photo 1 and Fig. 1. The thruster has a DC-brushless motor which generates the torque proportionately with the motor drive current. The thruster is a unique direct-drive design in which the magnet-ring rotor of the motor is directly attached to the tips of a four-bladed propeller – the propeller thus forms the center-part of the motor rotor. The current limit of the amplifier is 20 Amps at a supply voltage of 220V.

The 6-component loadcell measures the thruster reaction force and torque. The ambient axial fluid velocity is measured by 10 MHz acoustic doppler flow meters and the prop rotation velocity is calculated from the output of the prop position sensor. To control and monitor the experiments we utilized a PC and all data were logged at 1 KHz.