Abstract

In this thesis,the dynamics, maneuvering, and navigation of surface andunderwater marine vehicles have been investigated. For surface marine vehicles (ships), long-range navigation condition under rough weather conditions is investigated. For underwater marine vehicles (Autonomous Underwater Vehicle (AUV)) the application considered is high-speed launch in horizontal orientation with station-keeping in bow-down orientation. The dynamics, navigation, and maneuvering characteristics for each one of the above conditions is different. However, total energy consumed during the voyage/ maneuver is one of the criteria for evaluating efficiency in both applications. Recently, several changes have been observed in the Earth's environment. This is also applicable to the ocean environment.Many service providers offer weather routing services with the availability of high-quality satellite data. Unfortunately, not much information is available in the public domain as to how much the recent change in the weather pattern has affected ship navigation. The purpose of this thesis is to fill this information gap. The influence of recent changes in the ocean environment on ship navigation is investigated in this thesis. The ECMWF weather data from 1992 to 2018(27 years) is analyzed. The statistical characteristics of this data are determined based on "summer" and "winter" zones as defined by international maritime regulations. For, ship navigation, six different worldwide commercial ship routes are selected covering all the ocean regions. The added resistance due to waves, wind, and the effort of keeping the ship on the desired course using autopilot in the rough ocean environment is included to find the fuel consumption andthe duration of each one of the voyages.The influence of recent changes in the weather conditions in the Southern Ocean, North Atlantic and North Pacific Ocean region has increased and affected ship's propulsive efficiency.

Similarly, the dynamics of an AUV, which can perform depth control maneuvers with pitch angles in the range of 90° is investigated in this thesis. Due to the unique operating condition of the AUV, Quaternion mathematics, 4 quadrant propeller open water characteristics, and PID controller for propeller revolution are incorporated in the maneuvering mathematical model for this purpose. A procedure for optimizing the gain coefficients for the PID controller is developed using the 7 DoF maneuvering mathematical model. Two different AUVs are evaluated in this work. Each one of the AUV designs has two design configurations, one positively buoyant and the other negatively buoyant. The design objective is, that the AUV shall travel as far away as possible from the parent vehicle using minimum energy and time. This study allows AUV to use a propeller for a low (nearly 0) speed in the forward and reverse directions. The methodology developed in the thesis can be used in the design and propeller revolution control system for certain categories of AUVs.

Keywords: Added resistance, AUV, depth control, ECMWF, ERA-interim, fuel consumption, great ellipse sailing, maneuvering, Quaternion, ship navigation, weather effects, four-quadrant propeller.