Optimizing rudders to minimize fuel consumption

Martin Hjorth Simonsen

[1]DTU Mathematics, Technical University of Denmark
[2]DTU Mechanical Engineering, Technical University of Denmark
[3]FORCE Technology

More than half of all transportation of goods is done by ship. The reason being this way of transportation is much more cost effective and less polluting than other means of long distance transportation. Even so great focus should be taken on minimizing the effect this form of shipping has on the environment. As a minimal reduction in emissions will result in a great relative reduction. Many measures of minimizing fuel consumption have already been taken, but many have yet to be explored.

The goal of this project has been to minimize the force affecting rudders by optimizing rudder specifications. More specifically by altering three main variables of the rudder, as the general profile of rudders have been greatly optimized by the flight industry. This was to be done so the ships maneuverability still meets the requirements presented by the UN organization IMO.

The project has been carried out in collaboration with FORCE Technology.
The manoeuvring and calculation of the force acting on the rudder has been done by simulations using the DENMark1 model, a simulation program developed by FORCE Technology. For the means of optimization the force has been calculated at maximum velocity only. An optimization method has been utilized to find the specifications of the rudder resulting in minimal force. Further analysis of the results have then been made to conclude in which extend these specifications may be altered, still giving a near minimal force acting on the rudder.

The tests have been done on two different kinds of rudders, one conventional type and one flap rudder. From their original specifications the force acting on the rudders could be minimized by approximately 40% for the conventional type rudder and approximately 55% for the flap rudder. The further analysis of the rudders with optimal specifications has shown that two out of three specifications may be altered together within certain bounds without significantly increasing the force acting on the rudder.

In conclusion there is with certainty room for optimization, but further research should be done in a greater variety of sailing conditions to obtain a larger perspective on exactly how much the force acting on the rudder can be minimized. The final program is though tuned to be able to find the optimal rudder specifications given other sailing conditions.