Analysis of low-speed manoeuvring capabilities

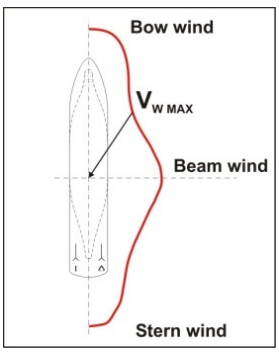
Dimensioning of thruster powers for low speed manoeuvres

In early design stage, calculation tools are used to quantify the low speed manoeuvring capabilities of ships. The capability is expressed in a number of determinative scenarios. The user is able to see whether the ship's capability is sufficient or whether for example more or less thruster power should be used to achieve a certain desired performance.

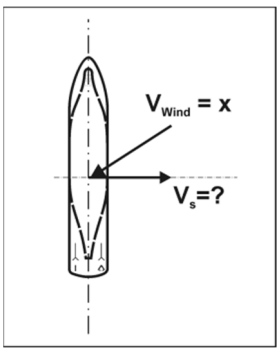
Cruise vessel engaged in harbour manoeuvres

Calculated scenarios

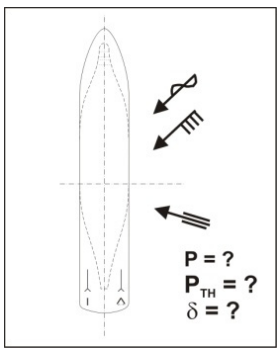
Typically quasi-stationary manoeuvres are calculated. If the performance is calculated and the performance is compared to the performance of a reference ship, the naval architect can obtain a good impression of the low speed manoeuvring capability of the ship. Time domain simulations are not carried out in this early stage of design. The target is to calculate low speed manoeuvring capabilities and calculate the characteristics of the ship in a meaningful way. At the moment 5 different scenarios are possible:



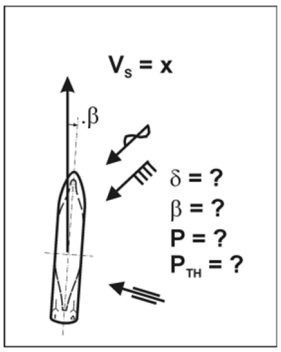
What is the maximum possible wind velocity (coming from all directions) in which the ship can maintain position? What is the most critical wind direction, and which actuator is the limiting factor?



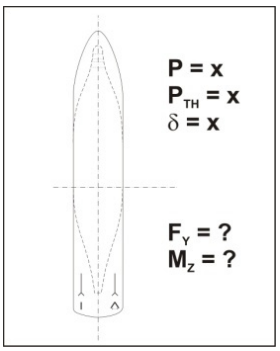
What is the maximum sideways velocity given a certain wind velocity and direction?



Given certain environmental conditions, what is the necessary power setting to maintain this position?



Given certain environment and desired ship's forward speed, what is the resulting power settings and drift angle for sailing at low speed?



Given certain power settings of thrusters and propellers, what is the force that the ship can generate?

Validation

The software modules that calculate all forces are validated against numerous model tests on ships. Data for the measurement of the performance of the actuators (propeller, thrusters and rudders) is coming from model tests as well. The resulting software is validated against a number of available full scale measurements.

Computational approach

The used software basis itself on the equilibrium of a number of forces:

- Wind forces
- Forces generated by:
  - main propellers
  - azimuthing thrusters
  - bow and stern thrusters
  - podded propulsors
  - rudders
- Interaction forces (the effects of pressure fields induced on the hull) are taken into account
- Forces due to a speed of the vessel (forces on the vessel due to a forward speed, drift angle or current

The effect of shallow water is taken into account. The effects occurring near a quay are not taken into account.

Having established all these forces, the software is calculating an equilibrium position. As there are (usually) many actuators and only three equations of motions considered, this equilibrium is 'overdetermined'. This requires that other aspects are looked at as well, being a minimum use of the total power. Furthermore, the software assumes certain preferred settings with respect to the angles of azimuthing thrusters or rudders.

Accuracy

The software is typically used in an early design stage, and gives an impression. The data used is based on model tests of previous vessels. It is possible to increase the accuracy by for example supplying data from wind tunnel measurements.

MARIN has found it very useful to make calculations for two vessels; a reference vessel, with known characteristics to the owner, and the 'new design'. From the relative comparison of the two ships a clear and good impression is obtained on the low speed manoeuvring performance of the vessel and the effectiveness of thrusters.

For more information contact MARIN:
Ir. F. Quadvlieg
T +31 317 49 34 23
E ships@marin.nl