The influence of surface waves on the added resistance of merchant ships

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Background

• In the early days of power prediction the main focus was the resistance a ship experienced in still water conditions.

• Predicting the power needed to achieve the designed service speed in the actual conditions experienced on the intended route quickly became an issue once towing tank testing was established as a reliable way to get the still water resistance.

• Since there was little consistency in studies on the subject, designers used prescriptive percentage additions to the calculated still water resistance based on experience, e.g. +25% for North Atlantic trades, +15% for coastal operations.

• These additions varied widely between different towing tank institutions ranging from 0-30% for North Atlantic.

• Several studies, both full scale[1] and model scale[2] were conducted in the 1920’s to try and highlight important phenomena causing added resistance.

• Since then several approaches to developing a reliable prediction algorithm has been made. The most notable are:

  • Maruo[3], who showed that the added resistance from individual wave components could be superimposed to get the total added resistance in an irregular sea.

  • Gerritsma & Beukelman[4], who managed to derive the added resistance from radiated energy methods which meant not having to solve hydrodynamic boundary conditions as with methods based on hull pressure.

  • Faltinsen et. al[5] who presented a versatile method widely used today.

Causes of added resistance in rough seas

• Unfavourable shifts in buoyancy forces causing heaving and pitching. This absorbs energy both from the waves themselves but also from the ships momentum causing speed loss.

• Reflection of incident waves at the bow

• Disturbances of the flow around the hull causing boundary layer distortion and poor propeller performance

• Poor power plant performance in unsteady running conditions

• Increased aerodynamic resistance in strong head on winds

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Aims

• To assess the different methods of predicting added resistance and identify strengths and weaknesses.

• To Study the influence of the bow shape both above and beneath the waterline on the flow features associated with added resistance.

• From this study identify key areas of the forebody where design improvements could be made.

Methodology

• The problem can be split up into several individual studies of the different aspects mentioned and the most suitable approach must be chosen for each one. Possible approaches include:

  • CFD analysis (e.g. numerical towing tank)

  • Custom potential flow approach

  • Energy methods

  • Towing tank experiments

  • Others, yet to be conceived

References


2. Kent J.L., Experiments on merchant ship models in waves (First series), Transactions of the Institution of Naval Architects 1944


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