Experience With Direct Measurement of Steering Generated Propulsion Losses.

by
M.Blanke* and
J.C.Nørtoft Thomsen**

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*Servolaboratory, Technical University of Denmark
Bygn. 327 DTH, Dk 2800 Lyngby, Denmark

**EMRI Aps, Marielundvej 37 A
Dk 2730 Herlev, Denmark

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M. Blanke
Technical University of Denmark
Lyngby, Denmark

J. C. Nørtoft Thomsen
EMRI Aps.
Herlev, Denmark

ABSTRACT

The paper presents the results from five years of experience with direct measurement of propulsion losses related to autopilot and steering gear performance. More than ten ships of different types have been involved in this effort.

The paper shows how it has been possible to obtain statistical significant values of steering generated losses when different control equipments are installed. Measurement of very small fractions of speed and shaft power is shown to be possible, without using excessive periods of time for the experiments. Dedicated computing and motion monitoring equipment supplemented by ship installed instrumentation makes this possible.

Important results presented are values of speed and power consumption obtained when different autopilots and steering gears are used. Measured values of propulsion losses are further discussed in the paper referring to different steering devices. Extensive series of short time experiments, and results obtained over extended periods, show the principles of control equipment which should be used for achieving minimal values of steering generated losses. Among the possibilities, the analog steering gear is found to offer the greatest average improvement and selftuning autopilots based on a Kalman filter approach are significantly superior to conventional controllers in rough weather.

INTRODUCTION

More than a decade ago, Nomoto, Norrbin and others found that ship propulsion losses were closely related to the performance of the ships steering equipment. The relation found was simple, the better the equipment, the smaller the propulsion losses. Due to technology, the steering equipment at that time was constructed with little consideration to the finer aspects of control theory. Many autopilots as example were of simple proportional-integral (PI) type. And all steering gear remote control systems were of the three state (Bang-bang) type. As a result rather stable limit cycling was commonly encountered in autopilot steering systems. Due to the action of the autopilots integrator the average course was correct, and most navigators were satisfied by this fact.

Ship speed, however, dropped slightly in the continued zig-zag manoeuvre, which was forced upon the vessel by the early autopilot equipment. On most ships the limit cycle,which was introduced by the steering equipment itself,had magnitudes of rudder angle from 3 to 10

degrees, even in fine weather.

During the past five years, considerable effort has been devoted the development of better performing steering equipment which does not suffer from introducing extraneous speed losses. In order to achieve this, new control methods have been introduced in steering gear servo loops and in autopilots.

Among the most promising results can be mentioned analog control of the steering gear and adaptive control in the autopilot controller.

When introducing such new equipment,assessment of the magnitude of possible improvements in propulsion efficiency and economy is of the utmost importance.

Based on a range of seatrials with the purpose of evaluating the performance of different automatic steering systems, this problem is addressed in the paper.

Specific attention is given to the measurement of the changes in speed and fuel consumption associated with using different types of control equipment. Conclusive sea trial results are further presented. They show how direct measurement of speed loss is indeed possible, and how these results clearly indicate the types of control equipment which should be preferred.

The paper is separated in three main sections.

First, elements of the fundamental ship speed and propulsion characteristics are reviewed, and the properties of external disturbancies and the influence of shallow water effects on ship resistance are discussed. Based on this an experimental procedure for measuring the tiny propulsion losses is outlined. Propulsion losses are then related to different categories of steering equipment. Principal schematics show the installations actually tested. The last section presents major results from extensive series of sea trials.