UNITED STATES EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C.

THRUST DEDUCTION

BY H. M. WEITBRECHT, DR. ENG., CHARLOTTENBURG

EXPERIMENTAL MODEL BASIN
ERECTED 1898
BUREAU OF
CONSTRUCTION AND REPAIR
NAVY DEPARTMENT

RESTRICTED

SEPTEMBER 1940

TRANSLATION 62

THRUST DEDUCTION

(VOM SOG)

by

H.M. Weitbrecht, Dr. Eng., Charlottenburg

(Schiffbau, Schiffahrt, und Hafenbau, June 1, 1938)

Translated by M.C. Roemer

U.S. Experimental Model Basin
Navy Yard, Washington, D.C.

September 1940 Translation 62

THRUST DEDUCTION

By thrust deduction (German: Sog = Suction) is understood the change in the resistance of a ship due to the influence of the working propeller. There are numerous empirical numbers for determining it. However, it is not yet possible to predict it for a given ship form and propeller loading.

To establish a basis for calculation, experiments have for some time been in progress in the Preussische Versuchsanstalt für Wasser-, Erd-, und Schiffbau. These have the following objects in view:

1. Investigation of the negative pressure field of an open-water propeller;

2. Nature of the pressure field on the wetted surfaces of completely immersed bodies of revolution of varying degrees of fineness forward of the propeller;

3. Nature of the pressure field on the wetted surface of ship forms with various degrees of fineness forward of the propellers.

1. The pressure is measured forward of the open-water propeller on the propeller shaft at various distances from the plane of the propeller. From point to point near the plane of the propeller the pressure varies greatly, depending upon the velocity of inflow, propeller loading, RPM, blade area, blade section and pitch.

At a sufficient distance forward of the propeller, the impact pressures become more and more equal and the pressure soon becomes quite uniform, depending only upon the velocity of inflow and propeller loading. At a distance of about five times the propeller diameter forward of the plane of the propeller, the negative pressure is only about 0.5 per cent of the negative pressure directly in front of the plane of the propeller i.e., the thrust deduction effect is nearly zero. In order to express the phenomena mathematically, the water acted upon by the propeller can be thought of as composed of individual streamlines. Each streamline must comply with Bernoulli's law, according to which the sum of the static and dynamic pressures is constant.

It was possible to make a uniform compilation of the confusing multitude of pressure tests only by plotting the increases in velocity in place of the pressures to which they corresponded. It appeared that the ratio of the velocity increase at a point, to the velocity increase across the propeller disc, decreases (with good approximation) in accordance with the same empirical law along the propeller shaft at all inflow velocities and under all loads. This law apparently does not coincide with the physical law which can be derived by considering the propeller as a sink of given capacity.

2. Bodies of revolution are now introduced into the negative pressure field forward of the propeller, having the same axis as the propeller, and the pressure changes measured at various speeds and with the propeller operating under various loads along the surfaces of the bodies. The purpose here is,

(a) to determine the change in resistance of the bodies of revolution from the measured pressure changes,

(b) to find a law for the pressure changes as functions of the fineness of the body of revolution.

Problem (a) was solved as soon as the pressure was measured not only along the body, but also in the cleavage plane between the propeller boss and the body of revolution. The pressure at this point is much less dependent upon the propeller load than upon the RPM and the thickness of the cleavage plane. If the plane of cleavage is thin, forces may arise in it due to centrifugal action, which will have a strong influence on the total result. However, these centrifugal forces must be clearly differentiated from the effects of the negative pressure field of the propeller itself.

For the solution of problem (b), we must await the outcome of further tests.

3. No systematic pressure measurements along the sides of model ships with the propeller operating have been carried out as yet. From the thrust deduction factors of single-screw and multiple-screw vessels derived from experience and comparison with the wake effect on bodies of revolution, however, it may be seen that the thrust deduction on a ship's hull is materially greater than that on a body of revolution.

In the case of single-screw vessels, large areas of the shell plating lie within the zone of the unbalanced pressure field of the propeller. It would lead to erroneous conclusions in this case simply to take a mean angle of incidence of the blade sections for the mean wake factor. Therefore the calculation will have to be carried out in sections, taking into account the true angles of incidence of the blade sections and the resultant negative pressures.

In fine twin-screw vessels (for instance destroyers) the propeller is so far from the hull in axial direction that a direct suction is hardly conceivable. The fact that in such cases there is nevertheless a strong suction indicates that the water rising under the bottom in the direction of the buttock lines is markedly deflected by the propellers. Rough calculation, based on the law of momentum, of the volume of water passing through the propeller per second indicates forces of such a high order of magnitude as to account for the increase in the resistance of the ship directly determined by test.

Regarding the effect of inclination of the axes of propellers into the direction of flow, several papers have appeared in recent years, all of which state that an inclination of 10 degrees into the flow of water causes no material differences in comparison with zero inclination. Additional tests will be required to show whether interference with the flow of water to the propeller, due to the hull form, produces entirely different conditions.

Unfortunately continuation of the tests and their availability for the needs of shipbuilding are at present greatly retarded by the serious shortage of personnel and the requirements of current problems.