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Ships and marine technology — Guidelines for the design and manufacture of the hub cap with fins for a fixed-pitch marine propeller

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Foreword

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This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 8, *Ship design*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A hub cap with fins is an energy-saving device installed behind a propeller instead of a propeller hub cap. It rotates together with the propeller to increase the propulsion efficiency of the ship by decreasing the energy losses caused by hub vortex. To save energy and reduce underwater noise, propeller hub caps with fins are installed on a wide variety of ships.

Ships and marine technology — Guidelines for the design and manufacture of the hub cap with fins for a fixed-pitch marine propeller

1 Scope

This document provides general guidelines for design and manufacture of a hub vortex energy-saving device for a fixed-pitch marine propeller. This document can also apply to the design and manufacture of hub vortex energy-saving device for other types of marine propellers.

According to the specific geometrical shape of the propeller and other specifications, it is suggested that hub cap with fins is used in merchant ships.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
hub cap with fins
HCWF
device mounted behind a propeller that replaces the propeller hub cap which rotates with the propeller

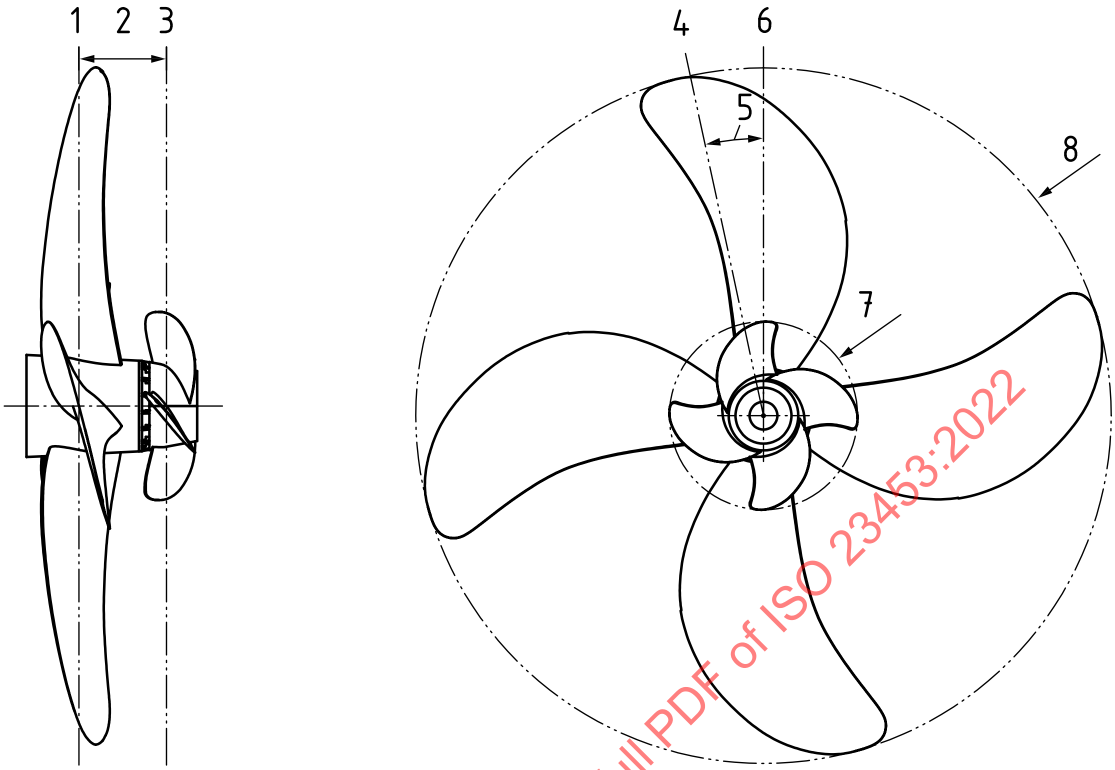
Note 1 to entry: The device saves energy by reducing the energy losses of propeller hub vortices. Figure 1 shows the sketch of a propeller and a HCWF geometry.

3.2
axial distance between propeller disc and hub cap with fins
L
axial distance from propeller disc to *hub cap with fins (HCWF)* (3.1) disc

Note 1 to entry: Figure 1 illustrates the axial distance between propeller and HCWF.

3.3
circumferential phase angle
ψ
angle between propeller generator line and hub cap with fins generator line

Note 1 to entry: Figure 1 shows the circumferential phase angle.



a) Side view b) Back view

Key

1 propeller disc
2 axial distance between propeller disc and HCWF disc, L
3 HCWF disc
4 generator line of HCWF fin
5 circumferential phase angle, ψ
6 generator line of propeller blade
7 diameter of HCWF, D_F
8 diameter of propeller, D

Figure 1 — Sketch of a propeller and a HCWF geometry

4 Guidelines for HCWF design and manufacture

4.1 Hydrodynamic performance and energy-saving effect evaluation

The hydrodynamic performance of a propeller with HCWF and its energy-saving effect should be evaluated by Computational Fluid Dynamics (CFD) methods or model tests. In the case where CFD is used, verification such as comparisons of model tests, full scale trials and monitoring, and other methods are essential.

4.2 Manufacture

4.2.1 The HCWF material should be the same as the propeller material and should comply with the relevant requirements of IACS UR W24[1].

4.2.2 It is recommended that the surface finish and dimensional tolerance conform to the relevant requirements of ISO 484-1[2] or ISO 484-2[3] as appropriate.

4.3 Tightness test

The inner chamber of the HCWF should be tested under hydrostatic or air pressure greater than 0,2 MPa for more than 30 min. During the test, the pressure should be maintained at more than 90 % of the given pressure and no leakage should occur from the chamber to ensure the tightness of HCWF during service life.

4.4 Accessibility

The HCWF should be easily accessible for installation and maintenance.

5 Hydrodynamic design procedure of HCWF

5.1 Applicability analysis

HCWF is suitable for the fixed pitch propeller, especially for the propeller with a high loading at root. If the load on the propeller root is small, the energy-saving effect of installed HCWF is also small. Applicability analysis is determined by the designer's experience.

5.2 Preliminary principle dimensions and main parameters

The following two parts of parameters should be selected at the beginning of design according to the experience of the designer:

a) the parameters about relative position relations between HCWF and propeller including axial distance and circumferential phase angle;

b) the geometry parameters of HCWF including diameter, number of fins, chord length of fins, thickness of fins, rake distribution and skew distribution.

5.3 Pitch and camber distribution

Pitch and camber distribution are two important geometric parameters that affect the energy-saving effect of HCWF. Pitch and camber distribution of HCWF are designed according to potential flow theory coupling with viscous flow theory, CFD or other adequate methods.

5.4 Verification with open water testing

The total propulsive efficiency of a vessel can be expressed by Formula (1):

$$\eta_d = \eta_0 \cdot \eta_h \cdot \eta_r = \eta_0 \cdot \frac{1-t}{1-w} \cdot \eta_r \tag{1}$$

where

η_0 is the open water efficiency of the propeller;

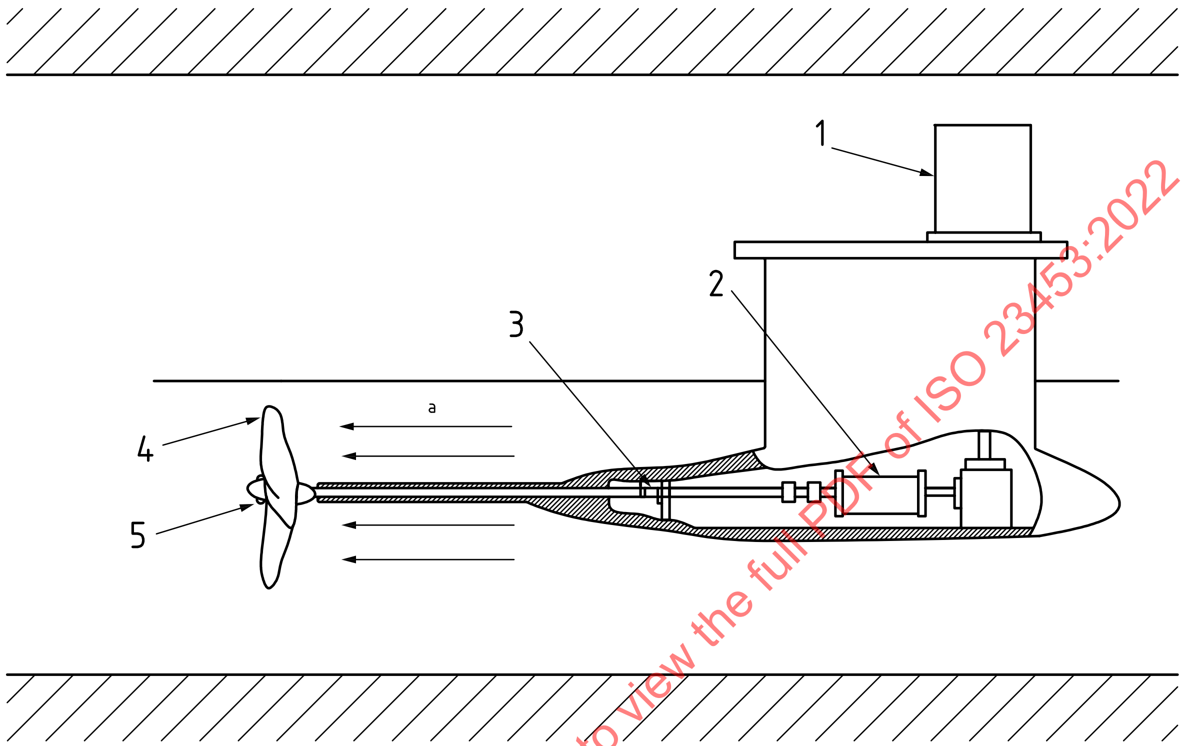
η_h is the hull efficiency, $\eta_h = \frac{1-t}{1-w}$;

t is the thrust deduction;

w is the wake fraction;

η_r is the relative rotational efficiency.

HCWF is generally considered to improve the efficiency of the propeller. Therefore, this energy-saving effect can be verified by model test or numerical calculation method. In the case of model test, the energy-saving effect can be verified by using the reverse propeller open-water test method as shown in Figure 2, or other methods.



Key

1 motor

2 torque sensor

3 thrust sensor

4 propeller

5 HCWF

[a] Flow direction.

Figure 2 — Reverse propeller open-water test set up (Reverse POT)

Model tests can be carried out in a cavitation tunnel, circulating water channel and towing tank. The test should be performed on a propeller with HCWF and a propeller with a conventional cap, respectively.

In order to compare the performance of the propeller hydrodynamic when HCWF is installed and when HCWF is not installed, three parameters are defined as shown in Formula (2), Formula (3) and Formula (4).

$$K_{t,\delta} = \frac{K_{t,HCWF\_R}}{K_{t,0\_R}} \quad (2)$$

$$K_{q,\delta} = \frac{K_{q,HCWF\_R}}{K_{q,0\_R}} \quad (3)$$

$$\eta_{\delta} = \frac{\eta_{HCWF\_R}}{\eta_{0\_R}} \quad (4)$$

where

$K_{t,0\_R}$, $K_{q,0\_R}$ and η_{0_R} represent the measured thrust coefficient, torque coefficient and efficiency of the propeller with a conventional cap by the reverse propeller open-water test (POT), respectively;

$K_{t,HCWF\_R}$, $K_{q,HCWF\_R}$ and η_{HCWF_R} represent the measured thrust coefficient, torque coefficient and efficiency of the propeller with HCWF by the reverse POT, respectively.

Then, $K_{t,\delta}$ and $K_{q,\delta}$ eta_delta is applied to correct the open water performance of the propeller obtained from the normal open water test or another method (such as CFD method). This is done to obtain the open water characteristics of the propeller with the HCWF under the same advance coefficient J_0 by following Formula (5), Formula (6), Formula (7), and Formula (8):

$$K_{t,0\_HCWF} = K_{t,\delta} \cdot K_{t,0} \quad (5)$$

$$K_{q,0\_HCWF} = K_{q,\delta} \cdot K_{q,0} \quad (6)$$

$$\eta_{0\_HCWF} = \eta_{\delta} \cdot \eta_{0} \quad (7)$$

$$J_0 = \frac{V_0}{n_D} \quad (8)$$

where

$K_{t,0}$, $K_{q,0}$ and η_0 represent the thrust coefficient, torque coefficient and efficiency of the propeller with a conventional cap, respectively;

$K_{t,0\_HCWF}$, $K_{q,0\_HCWF}$ and η_{0_HCWF} represent the corrected open water thrust coefficient, torque coefficient and efficiency of the propeller with HCWF, respectively;

J_0, V_0 and n_D represent the advance coefficient, the velocity of flow and the rotation speed of propeller model, respectively.

The power performance of propeller with HCWF can be predicted by replacing the open water performance of the propeller with that of the HCWF corrected open water performance[4] and keeping the same self-propulsion coefficients as with the conventional propeller cap.

5.5 Verification using full-scale tests

The energy-saving effect of HCWF can also be verified using full-scale tests.

6 Strength check of HCWF

6.1 Strength check method of HCWF

The strength of the HCWF can be checked by reference to the propeller specification of the classification society. In addition, numerical calculation methods, such as CFD and finite element method, can also be used to check the strength.

