

Predicting the Inception of Ventilation

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OVERVIEW

Propeller ventilation is when surface air is drawn into the propeller disk. This can occur when a propeller does not remain submerged dynamically during motions or statically at light draft.

This report introduces a method to predict the inception of ventilation, which was derived from a publication from staff at Shanghai Jiao Tong University, China. The published method has been revised to make it suitable for general use.

PREDICTION METHOD

The inception of ventilation correlates to thrust loading. Greater thrust means more suction side “vacuum”, which in turn, means a greater likelihood of ventilation.

In the referenced publication, the prediction of the inception of ventilation relied on the relationship between pitch, RPM and advance velocity as a measure of thrust loading. The implementation of the method herein converts the relationship so that a limiting “critical” speed of advance, V_{A-CRIT} , is used as the indicator of ventilation. Non-ventilating performance is maintained when $V_A > V_{A-CRIT}$.

VARIABLES

D = diameter [ft; m]
G = gravitational constant [32.2 ft/s²; 9.81 m/s²]
H = hub immersion below WL [ft; m]
n = shaft speed [revs/s]
P = pitch [ft; m]
R = radius [ft; m]
V = ship speed [ft/s; m/s]
w = wake fraction

FORMULA

K = tip speed parameter

$$K = \frac{G}{n^2 D}$$

V_A = speed of advance [ft/s; m/s]

$$V_A = V(1 - w)$$

V_{A-CRIT} = critical speed of advance [ft/s; m/s]

$$V_{A-CRIT} = Pn \left[1 - \frac{0.416 \frac{H}{R} - 0.004}{0.854 + 0.34e^{(-6.1K)}} \right]$$

RANGE OF APPLICABILITY

The prediction method is suitable for the following ranges of parameters.

H/R = 1.0 to 1.5
K = 0.05 to 0.44

EXAMPLE

This example checks if ventilation is predicted to occur if the propeller tip should reach the surface during a particular operating condition.

D = 2.50 ft
G = 32.2 ft/s²
H = 1.25 ft
n = 13.0 revs/s (shaft speed)
P = 2.50 ft
R = 1.25 ft
V = 20.3 ft/s (12 kts)
w = 0.06

$H/R = 1.0$

$K = 0.076$

$V_A = 19.1 \text{ ft/s}$

$V_{A-CRIT} = 20.0 \text{ ft/s}$

Conclusion: V_A is less than V_{A-CRIT} , so ventilation is predicted to occur.

REFERENCES

Wang Guogiang, et al., "Propeller Air Ventilation and Performance of Ventilated Propeller", SHL Shanghai Jiao Tong University, China

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