

INFORMATION ON DOCTORAL DISSERTATION IN ENGINEERING

Title of the thesis:	<i>“Studying the effects of rudder cavitation on the ship rudder force”</i>
Speciality:	Science of navigation
Code:	9840106
PhD candidate:	Co Tan Anh Vu
Supervisors:	1. Assoc. Prof. Dr. Pham Ky Quang 2. Dr. Vu Van Duy
Training institution:	Vietnam Maritime University

1. Aim of thesis:

Studying the effects of rudder cavitation on the ship rudder force.

2. Objective and scope of thesis:

Objective of the study:

Studying the rudder cavitation and the effects of rudder cavitation on the ship rudder force.

Scope of the study:

- Clarifying the theory foundation for rudder cavitation, studying calculation and simulation for this fact, and verifying the results of study by experimental research. Basing on these to analyze the effects of the rudder cavitation on the rudder force;

- M/V TAN CANG FOUNDATION, 7040 DWT, equipped with a right hand propeller to be selected for experimental research.

3. Methodology of thesis:

In order to successfully solve the study purpose, the combination of theoretical research and practical research is applied as the following:

Theoretical research:

- Studying the theory foundation of cavitation in general and the rudder cavitation in particular;

- Studying the mathematical foundation based on calculating dynamical flow CFD in order to calculate and simulate the cavitation area. Hence, calculation and simulation in details for the M/V TAN CANG FOUNDATION rudder in cavitation shall be applied;

- Studying to build a research model by digital method and a simulating calculation process of the effects of partial cavitation occurring to the leading edge of rudder and cavitation at the trailing edge on the rudder force, corresponding with each combination of propeller resolution and rudder angle (n_i, α_i) when partial cavitation occurs. Afterwards, this detailed simulation is applied for the rudder of M/V TAN CANG FOUNDATION when cavitation is seen on the rudder.

Based on the achieved results, the effects of rudder cavitation on the rudder force is evaluated.

Experimental research:

Conducting research on the experimental system (applying rudder under the Froude congruent standard with M/V TAN CANG FOUNDATION rudder) and field surveys for M/V TAN CANG FOUNDATION in order to prove the simulating calculation results of the rudder cavitation and the effects of cavitation on the rudder force.

4. Scientific and practical significance of thesis:

Scientific significance:

- Systematizing the theoretical basis of ship rudder cavitation to provide a model of research. The results of study partially contribute to completion of theoretical basis concerning with the studied problems and to the science of navigation.

- Introducing a methodology on building a process of simulating calculation of the effects of rudder cavitation on rudder force in general. Under this methodology, the effects of cavitation on rudder force is evaluated and the solutions of minimizing the damages as well as the status of ship rudder cavitation under operational data are given.

Practical significance:

- Closely associating the specific theoretical foundations related to navigation science with practical navigation. Moreover, the thesis constructs the scientific basis for maritime experts when deploying ship control algorithms taking into account the impacts of rudder cavitation;

- Making contributions to the specialized science of navigation: building a partial system for experimental research on the ship rudder cavitation. Evaluating and proposing adequate solutions to the effects of rudder cavitation on the ship rudder force, especially when maneuvering.

5. New contributions of thesis:

5.1. Building a digital simulation algorithm of 2D and 3D problems for cavitation current model surrounding the ship rudder. Then, simulating calculation in details for the

rudder of M/V TAN CANG FOUNDATION by the Boundary Element Method (BEM), the 2D sequencing method and the CFD application with Fluent-Ansys program.

5.2. Introducing the characteristics of rudder cavitation, effecting the ship rudder force in operational conditions with the input data complex (n_i, α_i) . Also building the research model by digital method and the simulating calculation process of the partial cavitation effects on the leading edge on the rudder force corresponding to the input data complex (n_i, α_i) when the partial cavitation occurs, shown as below:

- Period (T) and oscillating frequency (f) of the rudder force for M/V TAN CANG FOUNDATION are $T = 0,091s$ and $f = 11Hz$;

- Oscillating amplitude (A) of the rudder force in the stage of starting the partial cavitation depends in the velocity of flow and the rudder angle. The formula for determining the oscillating amplitude of rudder force of M/V TAN CANG FOUNDATION has been built as follows: $A = 2 \frac{k}{L} R_{th}$;

- Predicting the rule of forces effecting on the ship rudder and proposing recommendations in order to diminish the effects of cavitation. Introducing the rule of variation for the rudder force over the time $R(t)$ when the effects of the partial cavitation at the leading edge of rudder exist. The results of simulated calculation are applied to the rudder of M/V TAN CANG FOUNDATION with the rudder angle $\alpha = 35^0$ and the speed of vessel $V = 7,5$ m/s.

5.3. Analyzing, evaluating and comparing the results of the experimental research with other concerned solutions. Moreover, studying on the field survey of M/V TAN CANG FOUNDATION could also prove the simulating calculation results of rudder cavitation as well as the effects of cavitation on the rudder force.

6. Construction of thesis:

The thesis consists of the following parts: Introduction; Content (*including 4 chapters*); Conclusion and Recommendations; List of published research projects related to the thesis; Reference; Appendix (*6 appendices*).

Hai Phong, May 09th, 2018

Supervisors

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