

INFORMATION ON ENGINEERING DOCTORAL THESIS

Thesis title: **Researching, manufacturing the rotary shaft torque measurement device and analyzing the torsional vibration on marine diesel engine propulsion**

Speciality: Dynamic- Mechanic Engineering

Code: 9520116

Ph.D Candidate: Hoang Van Si

Supervisors: 1. Associate Pro.SciDr. DoDucLuu
2. Dr. Le Van Vang

Training Institution: Viet Nam Maritime University

1. Aim of thesis:

Researching, manufacturing the modern device to measure the torque of the rotary shaft and to analyze the torsional vibration on marine diesel engine propulsion in Vietnam.

2. Study objective and scope of thesis:

Research objective:

Torque and torsional vibration on main propulsion shaft-lines using diesel marine engines (DME) including:

- DME 2 stroke, low speed, high power, driven directly fix pitch propeller.
- DME 4stroke, high/medium speed, medium and small power, driven indirectly fix pitch propeller or controllable pitch propeller via clutch gear box.

Research scope:

- Researching the measurement methods torque signal, choose the non-contact strain type on the face of the rotary shaft to apply for.
- Researching calculation and simulation the torque of real marine diesel engine propulsion.
- Researching extract sample error in measurement period, noise filter in transfer process the torque signal from real time to frequency by Fast Fourier Transfer (FFT).
- Researching, manufacturing the torque signal measurement device to determine stress in engine speed range $n_{min} \div n_{max}$ for 12 first orders (DME 2 stroke) and for 25 first orders (DME 4 stroke).
- Researching the testing and commissioning at the marine engine dynamic lab room to inspect the accuracy of manufactured device.
- Researching the experiment at the shaft-line of the marine diesel engine propulsion in the real ship.

3. Methodology of thesis:

Using analytics modelization methods and statistics methods, internal combustion engine fundamentals, technical vibration, digital signal processing with electric technology - modern communication, Matlab, LabView software and industrial hardware of National Instruments (NI, USA). Combined between theoretical method and experiment one.

Theoretical research: Analyzing to choose the method for measuring torsional signal on the rotary shaft of the marine diesel engine; Processing the measured torsional signal in the real time and frequency domain; Predicting extracted sample error and noise while measuring, processing torsional signal; Simulink for measuring and processing the torsional signal with extracted sample error and noise.

Experimental research: Researching, manufacturing the measurement device system and analyzing the torsional vibration on marine diesel engine propulsion; Researching, experimenting for measuring the torque signals and analyzing the torsional vibration on the real shaft-line of marine diesel engine propulsion. Collecting, comparing, analyzing and estimating experiment results.

4. Scientific and practical significance of thesis:

Scientific significance:

- Analyzing and estimating the class rule requirements from International Association of Classification Societies (IACS) about calculating and measuring torque, stress and forbidden speed range also for the rotary shaft-line of the marine diesel engine propulsion;
- Building the theoretical foundation about sample extract rate. Establishing mathematical foundation for sample extract error in a working cycle of 2 stroke and 4 stroke marine diesel engines;
- Setting up scientific and modern technology foundation for measuring torque and analyzing torsional vibration. Decoding the manufacture technology and interiorizing industrial product with high quality is indispensable to manufacture the relative devices;
- Applying successfully hardware technology and LabView software of National Instruments in manufacturing the torque measurement device and analyzing torsional vibration.

Practical significance:

- The torque measurement device and torsional vibration analyze software had made from thesis is a foundation to research, develop the measurement methods, supervise and diagnose the technical status of marine diesel engine by oscillating on the shaft-line.
- Using torque measured results and analyzing torsional vibration to verify with calculated sheet; to estimate recent technical status of marine diesel engine propulsion;
- The torque measurement device and analyzing torsional vibration will be perfected to serve shipbuilding industry, to operate and exploit the marine diesel engine propulsion, concretely use to testing and commissioning for sea trial, to estimate the technical status of diesel marine engine (DME) and to supervise the real power of diesel main engine propulsion;

5. Achieved results and new contributions of thesis

Achieved results:

- The first time in Vietnam, manufactured successfully the torque measurement device and analyzing torsional vibration with 02 channels: one for measuring the micro-strain on the torsional surface of the rotary shaft by strain gauge and one for measuring the working cycle phase of diesel engine by optical sensor, NI technology (Data acquisition - DAQ, LabView software with other support toolkits), all of them has compact dimension, modern, portable and easy using.
- Researching the affection of sample extract error to the analyzed result of Fast Fourier Transfer (FFT) for torsional signal, the researched results had shown out spectrum error is very big if the quantity of extracted sample are not correct with a working cycle of marine

diesel engine. And demonstrating the system need one more channel to measure the working speed phase of DME is necessary in measuring torque and analyzing torsional vibration on MDE's shaft-line.

- Establishing mathematical foundation and virtual instruments models (VI) programed in LabView for measuring and processing micro-strain data and speed phase into the spectrum characteristics according to the Rules and Regulations for the Survey and Construction of steel ships (Correlative with QCVN 21:2015/BGTVT required).
- The measuring device had been testing, calibrating many times at dynamic engine lab-room of the science research and marine technology belongs Vietnam Maritime University and also on real coastguard ship (built at Hong Ha Shipyard, 2016-2017) while testing and commissioning for sea trial. They are important documents not only use in manufacturing the measurement device but also got meaning to develop monitoring and diagnosing torque/torsional vibration and the technical status of DME's propulsion.
- Results for digital simulation about the torque/torsional vibration on the rotary shaft-line of main diesel engine propulsion (2 stroke engine and 4 stroke one) were be programmed and displayed. Results simulated on DME- MAN B&W 6S46MC of ship series 34000 DWT shown in science reports are be of the list of research works relative to the thesis.
- In the research period, there are 09 science research works which had reported on the famous, reputable specialized journals and science conferences in the International and Vietnam.

New contributions:

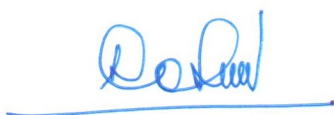
- Putting forward the science foundation and technology for manufacturing (hardware and software) based on the strain gauge and optical sensor; data acquisition (DAQ) with wireless of NI and Labview background software.
- Building successfully the software identifies with the peripheral device, manages the measurement process, treats the measurement data, displays and saves the micro-strain (torque signal) data in real-time domain and analyzing torsional vibration on marine diesel engine propulsion in spectrum domain.
- Integrating successfully between m-file program in MatLab into Code Mathscript program in LabView to draw short time in program code in LabView while build the software of the measuring device, especially in processing complex digital signal using strong mathematical tool of MatLab.

6. Construction of thesis

This engineering doctoral thesis (including 121 pages without appendix) consists of the following parts: Introduction; Contents (Including 4 chapters); Conclusions and Recommendations; List of published research projects related to the thesis (10 scientific studies); References (56 refers) and Appendix (including 04 appendices).

Hai Phong, Date 17th April 2019

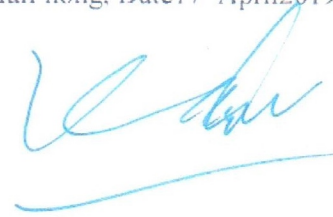
SUPERVISORS Ph. D Candidate



Asso Pro. Sci Dr. Do Duc Luu



Dr. Le Van Vang



M Eng. Hoang Van Si