

Propeller pressure pulses influence on an underwater noise emission of the NAWIGATOR XXI vessel

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Introduction

Achieve QUIeter Oceans by shipping noise footprint reduction (AQUO) is a collaborative research project supported by the European Commission in the scope of the 7th framework program, Grant Agreement N° 314227. The main goal of AQUO project is to provide to policy makers practical guidelines regarding underwater noise issues, acceptable by shipyards and ship owners. One of the intermediate goals is to perform a series of measurements related to underwater noise propagation by the moving vessel NAWIGATOR XXI.



Figure 1: Navigator XXI during measurements

This paper focuses on chosen measurements results analysis performed by Ship Design and Research Centre (CTO S.A.) on the “NAWIGATOR XII” vessel.

Navigator XXI

One of the aims of the measurements campaign was to identify pressure pulses coming from the m/v NAWIGATOR XXI propeller and, at the same time, to measure other important parameters such as power, hull vibration levels, underwater noise, video observation, etc. Therefore all measurements had to be performed simultaneously with one common time stamp (DGPS time).

Full results of the measurement campaign were presented in [1]. In this article only chosen measurements results of NAWIGATOR XXI were described. Figure 2 presents the available locations of the pressure transducers that can be mounted on the vessel's hull. The pressure pulses were measured at 5 locations during the sea trials (pressure flanges 4, 5, 6, 7 and 8) as a voltage and recalculated with scale factor 10 to (pressures [kPa]).

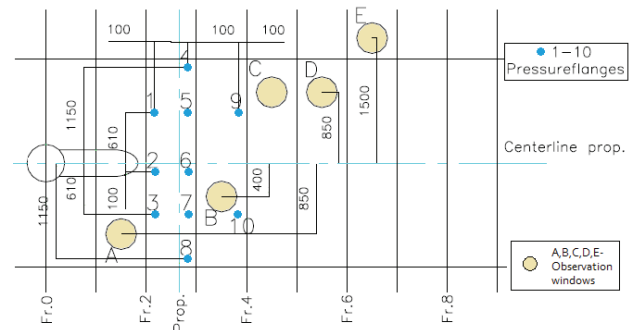


Figure 2: Navigator XXI - available locations of the pressure transducers

In Table 1 the characteristics of the propeller are listed.

Table 1: Navigator XXI- propeller characteristics

| Propeller | | |
|---|---------------------------------------|----------------------|
| Number of propellers: 1. | Model: ABB Zamech type P680/4-RPS5000 | |
| Power (kW): -- | RPM: 240 | Number of blades: 4. |
| Type: <input type="checkbox"/> Fix <input checked="" type="checkbox"/> Controllable | | |
| Location from aft perpendicular (m): 3 | | |
| Inception speed (m/s): -- | | |

The propeller arrangement is shown in the Figure 2.

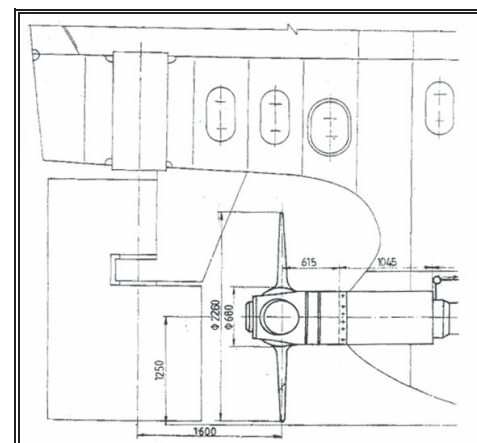


Figure 2: Navigator XXI – propeller arrangement

Pressure pulses measurements

The pressure pulses measurements were performed in accordance with the description presented below. Measurements conditions during the experiment are listed below:

- Pitch 79% / Rev 860 rpm (Gear Rd: 3.75)
- Speed 11,8 kn / Power 686 kW
- ship loading conditions during tests (aft and fore draft): 3,2 / 2,85 m;
- wind: 4,5 m/s, 315° (NNW);
- sea state: 2;
- sea depth: ~24 m;
- sea temperature: 19 °C;
- air temperature: 20 °C;
- non nearby ship traffic;
- only the equipment necessary for normal ship's functioning was operational;

In the Figure 3 the dynamic pressure pulses obtained on the "Navigator XXI" are presented. The measurement was conducted in the propeller plane with the sensor mounted on the flange N° 6. Note: the "m" next to the y axis values on the graph indicates 10^{-3} .

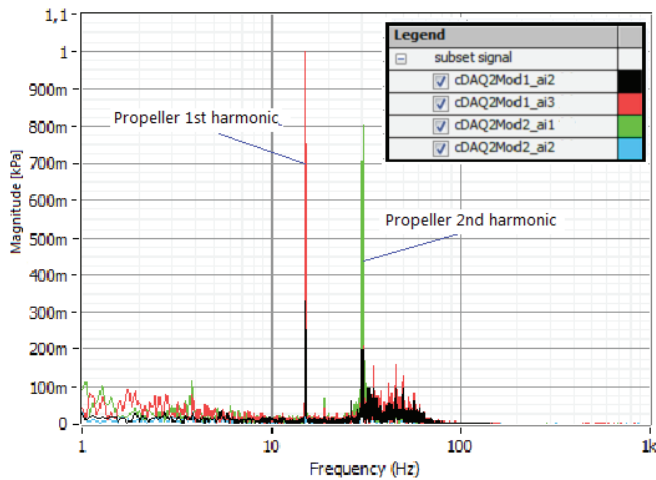


Figure 3: Navigator XXI- pressure pulses

One can observe two pressure pulses peaks corresponding to ~15,3 Hz (propeller 1st harmonic) and ~30,6 Hz (propeller 2nd harmonic).

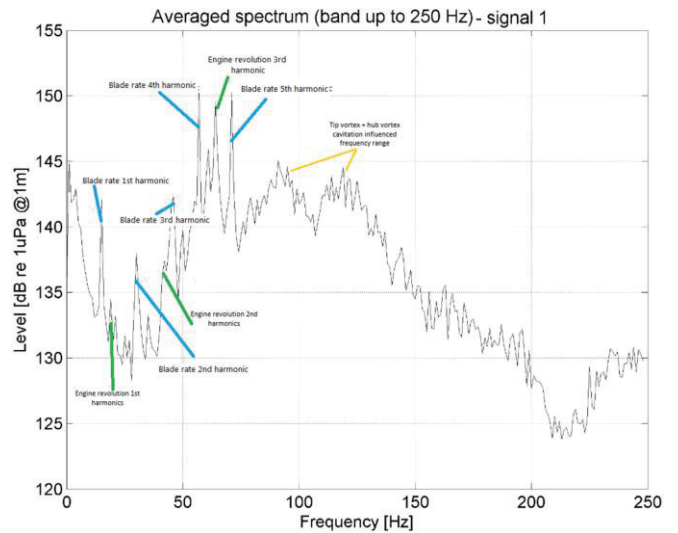


Figure 4: Navigator XXI- example of identification of underwater noise sources for the frequency range from 0 to 250 Hz

In underwater noise measurement spectrum one can observe discrete peaks coming from propeller influence together with middle frequency noise coming from propeller cavitation.

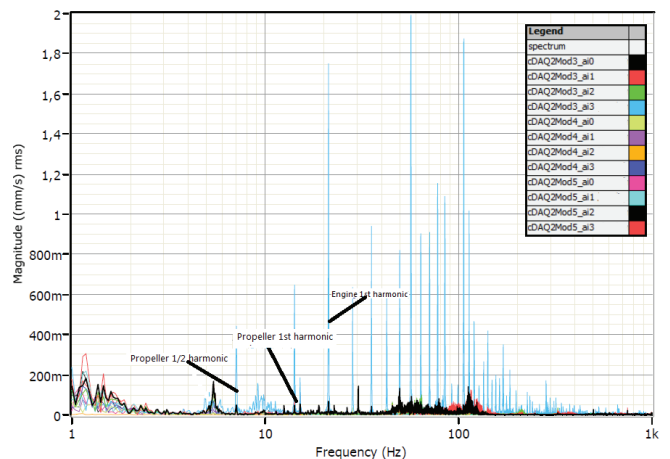


Figure 5: Navigator XXI- example of identification of vibration measurements

In addition to these analysis one can observe vibration measurements results taken simultaneously with previous measurements. Measurement points cDAQ2Mod3_ai0, _ai1 and _ai2 are located over the propeller plane in aft part of the vessel. One can see that propeller influence on the vibration of the hull is very low.

"NAWIGATOR XXI" is equipped with unique feature which enables cavitation phenomenon observation. Five glass windows are fitted in the vessel's hull – directly above propeller. Therefore one can record cavitation effects of the propeller (Figure 6).

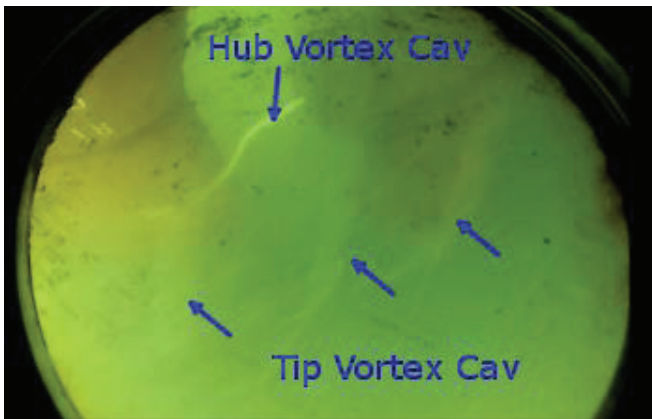


Figure 6: Navigator XXI- example of cavitation observation

One can distinguish two kinds of cavitation – hub vortex and tip vortex cavitation.

Summary

Results of presented above measurements were a part of a large measurements campaign performed on a Navigator XII vessel for the purpose of AQUO Project. Simultaneous measurements of underwater noise, vibration, pressure pulses and other parameters had been used as an input for establishment and validation of the “European URN Standard Measurement Method Proposal” [1]. Very important was also a possibility to correlate video recordings of the propeller with recorded measurements data.

Acknowledgement

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Literature

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