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EXPERIMENTAL AND NUMERICAL APPROACH TO MODELLING THE HYDROACOUSTIC PHENOMENA FOR FLOW WITH CAVITATION AROUND THE SHIP PROPELLER

One of the main components of the hydroacoustic signature of the vessel-generated noise is the propeller noise, especially in a cavitating state. The effects of cavitation have been thoroughly studied and are well known to have an undesirable influence on the propeller's operating conditions. On top of that, cavitation significantly increases the overall noise level generated by the vessel; moreover, it can be very destructive. Thus, the hydroacoustic approach to modern ship propeller and hull design consists in reducing average noise level generated by the propulsion system and minimizing the influence of cavitation. For this purpose a range of advanced simulations and model tests in specialized facilities are required, where these phenomena can be efficiently captured and adequate numerical, experimental and signal processing methods can be applied. The design is finally verified during the full scale sea trials.

The dissertation presents the results of experimental research and computational analyses simulating the operating propeller of ship propeller in cavitation conditions. The numerical results are compared with the results of corresponding experimental analyses carried out in the medium size cavitation tunnel of Ship Design and Research Centre (CTO S.A.) as well as the results of corresponding full scale trials. The benchmark propeller from the „NAWIGATOR XXI" research vessel is the object of model test and numerical analysis. The object of analysis is a four-bladed, left-handed controllable pitch propeller (CPP) identified as CP469. The scale factor of the propeller is 10. The water parameters (density, viscosity) for model and full scale correspond exactly to the parameters in the cavitation tunnel tests and sea trials respectively. The numerical analyses was carried out using the unsteady Reynolds-Averaged Navier-Stokes (RANS) flow computational model. Simulations were performed in the non-uniform velocity field ("A" field) at inlet to the computational domain. When a stabilized value of the torque factor was obtained, the calculations were extended by the cavitation model available in the Star CCM + numerical software. Pressure fluctuations at four points (above each blade) were also monitored during the calculations. The calculations were completed when the oscillating pressure fluctuations stabilized for min. 2s. Than it was post-processed with the Fourier Transform (FFT) and results of one-third octave spectrum in the frequency domain were obtained. The pressure levels were compared with the results of the experiment research in the cavitation tunnel and with the results of measurements from the sea trials carried out under the AQUO project. The noise level comparison was possible by normalizing the sound pressure level (SPL) to a distance of 1 m from the source and frequency of 1 Hz. The correlation between all results have been thoroughly analysed and commented.

Keywords: CFD, Hydroacoustics, Cavitation, Propeller