PIAQUO

A Practical Implementation of AQUO

UNDERWATER NOISE IMPACT REDUCTION OF THE MARITIME TRAFFIC AND REAL-TIME ADAPTATION TO ECOSYSTEMS

Propeller design by optimisation

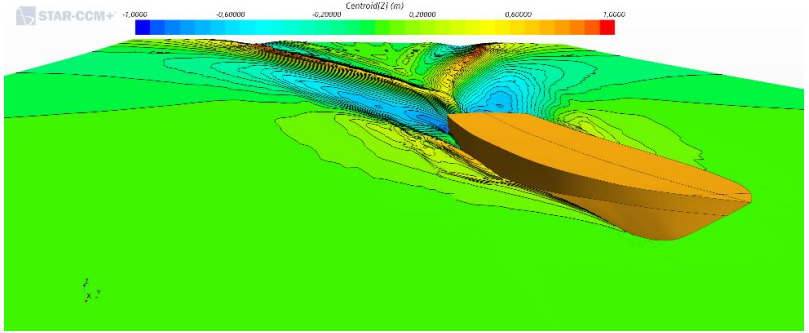
Ship characteristics

Primero VII

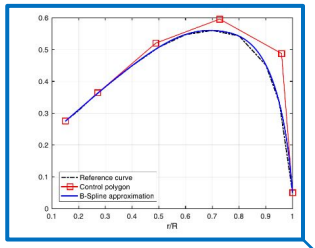
LOA = 27.60 m
LBP = 23.40 m
Bmax = 6.82 m
D = 2.17 m
Δ_1 = 76.5 t (full load)
Δ_2 = 64.5 t (intermediate*)
Δ_3 = 46.0 t (light)

*50% consumables and 250 (over 350) passengers: most common condition, used as design condition

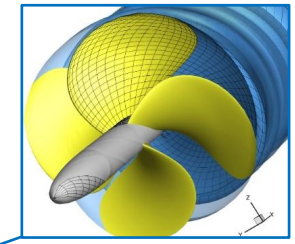
Missing information (e.g. resistance, trim, propulsive coefficients) have been estimated by CFD computations.



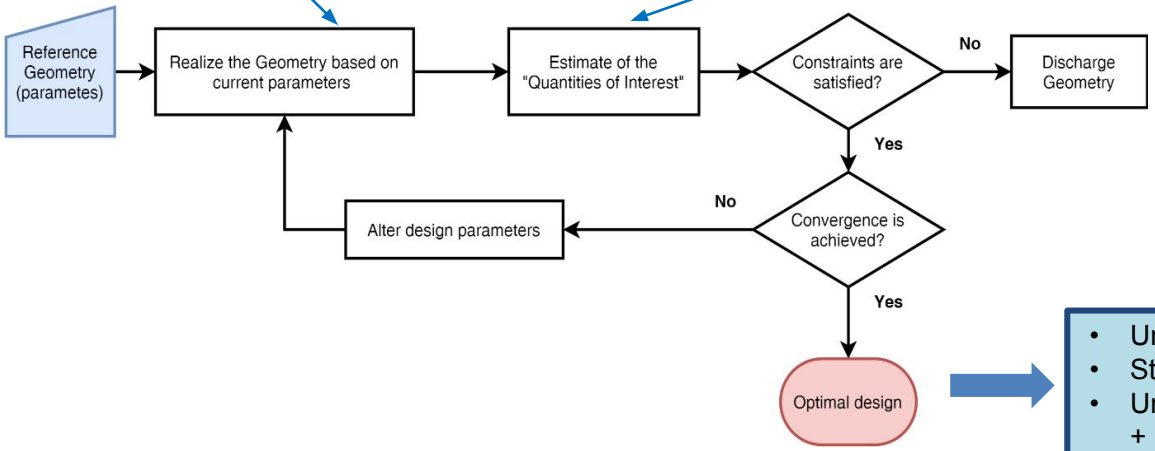
Propellers' design optimizing at the same time noise emission and efficiency



- **Parametric description using B-Splines;**
- **35 free design variables;**



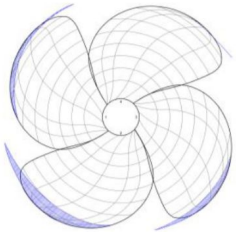
- **BEM for the estimation of KPI;**
- **18 design objectives/constraints at different propeller functioning conditions** (cavitation/boat speed/engine matching)

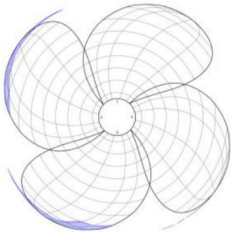


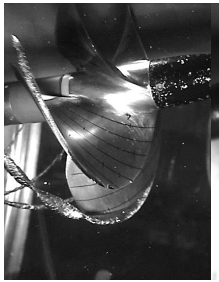
- Unsteady cavitating BEM
- Steady non cavitating RANS
- Unsteady non cavitating BEM + ETV

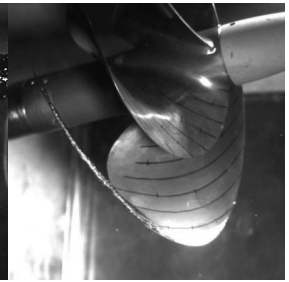
Model test with original and optimized propellers at cavitation tunnel and towing tank

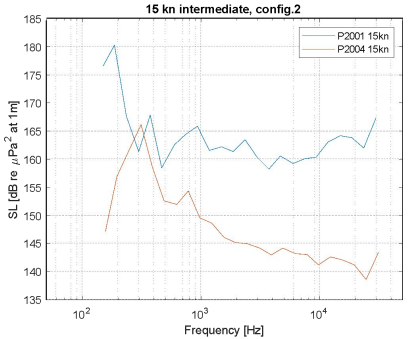
15 kn, intermediate
Reference prop. (P2001) vs Optimized prop. (P2004)

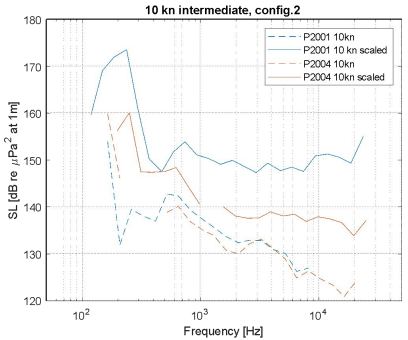










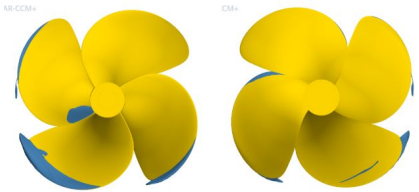


Detailed numerical analyses of the original and optimized propellers Full Scale (Model Scale Cond. C)

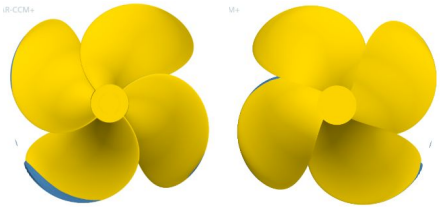
	Sea Trials			Numerical Analyses				
	V_s	RPM	$10K_Q$	V_s	RPM	$10K_T$	$10K_Q$	σ_N
Original Prop.	19.6kn	801.3	0.500	19.3kn*	801.3	0.251	0.499	≈1.38
Optimized Prop.	18.7kn	810.4	0.444	18.6kn*	810.4	0.229	0.443	≈1.36

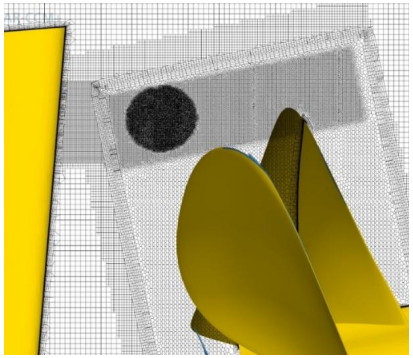
*Fixed propeller RPM and absorbed torque from sea trials (tuning of ship speed)

Original Propeller, Full Scale



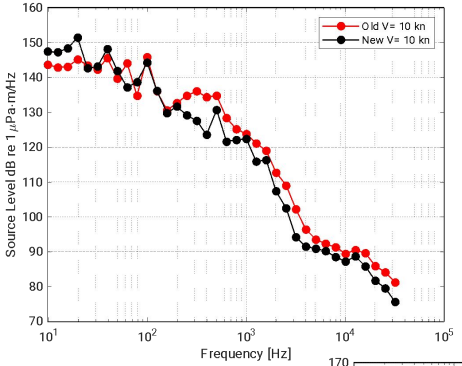
Optimized Propeller, Full Scale

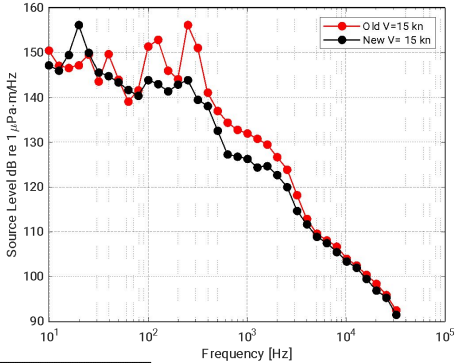


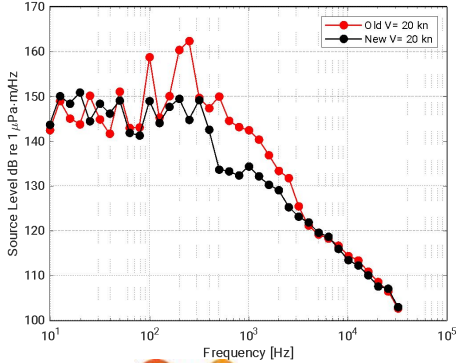


- S-A IDDES analyses;
- **130** Million cells;
- **1440** step per revolution - **28** revolutions;
- Schnerr-Sauer homogenous mixture cav. Model;
- fully appended ship;
- «frozen» free surface;

Full Scale Trials







Optimised propeller shows a reduction in URN in the frequency range up to abt. 3 kHz for all speeds tested

Conclusions

Conclusions

- Propeller design by optimisation has proven to be an efficient way of designing propellers with lower URN;
- Efficiency increase and Noise reduction are conflicting objectives; even if further analyses and cases need to be considered in order to have a general overview, in a large number of cases a trade-off is possible with URN improvements (5-10 dB) and (at least) constant efficiency;
- The ship operator has to be deeply involved in the optimisation process to clarify the ship operational profile (speeds of interest); this is of great importance when shipowner and/or route / operating speed change in time during ship life;
- Propeller design cost is limited, allowing this solution to be viable for newbuildings and retrofits;
- Propeller manufacturing is important to keep the same advantages estimated during design and model tests;