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**An increasing number of MARIN's clients consider low-frequent, broadband excitation caused by cavitating propeller tip vortices as the most important topic in inboard noise and vibration abatement.**

Propeller tip vortex cavitation on scale model.

# Inboard noise from cavitating propeller tip vortices

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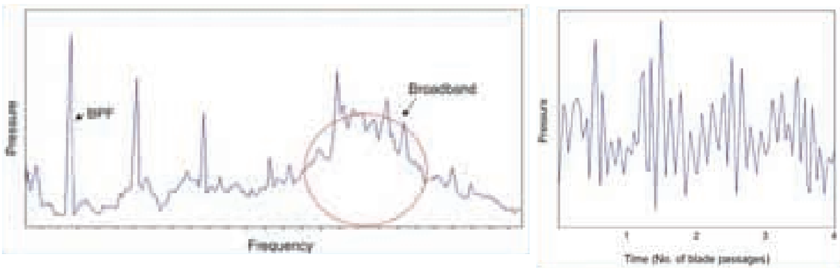
Cavity dynamics in the vicinity of ship propeller blades cause pressure fluctuations which excite the hull structure above the propeller. As these pressure fluctuations act largely in phase over the aft-body surface, cavitation is very effective in generating inboard noise and vibration. The last decades however, have seen a considerable reduction in cavitation-induced hull pressure forces, leading to lower inboard noise and vibration levels.

Unfortunately, an opposing trend of increasing low-frequent broadband hull pressure fluctuations is also witnessed within a range of about 20 to 70 Hz. This trend has received a lot of attention as the ship's aft-body structure is likely to be excited at resonance in this range of frequencies. Such resonant vibrations often cause annoyance, despite the low magnitude of the excitation forces involved.

As a result of changes in propeller design philosophy many modern propellers show leading edge or tip vortex cavitation. As yet, there is no clear understanding of the physical mechanisms underlying the type of broadband excitation they are causing. The lack of theoretical models has led to the development of empirical methods to relate tip vortex characteristics to inboard noise (e.g. Ræstad's Tip Vortex Index).

The notion of broadband noise being completely random in nature is not confirmed when pressure time traces are studied. It seems that bursts of energy in the frequency range of interest cause a 'ringing' effect, superimposed on the tonal components at blade passage frequency. Such a phenomenon has been observed in time traces of pressure signals measured with flush mounted pressure transducers on board passenger vessels.

Typical hull pressure spectrum showing broadband excitation in between spikes at multiples of BPF.




At MARIN's Depressurised Towing Tank detailed model scale studies are conducted, where high-speed video images and hull pressure data are synchronised to study the character of the cavity dynamics and resulting pressure pulses. Combining information from such studies with results from wake flow experiments, CFD computations and experience, allows for the best trade-off between propulsive efficiency and low noise levels.

Practical design studies need to backed up by background research (see references) as there is still much to be learned in this field.

## REFERENCES


- "Aspects of the cavitating propeller tip vortex as a source of inboard noise and vibration"; Erik van Wijngaarden, Johan Bosschers, Gert Kuiper; ASME Fluids Eng. Div. Summer Meeting and Exhibition; June 19-23, 2005, Houston, TX, USA.
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