VIBRATION ANALYSIS

Vibration comfort levels are becoming increasingly important for yacht owners. In order to meet vibration targets and achieve maximum vibration reduction, it is essential to study the vessel's structural behaviour. The perspective of Van Cappellen Consultancy is to check the vibration behaviour of the construction during the yacht's design phase. Construction parts are modelled in finite element (FE) software and analysed.

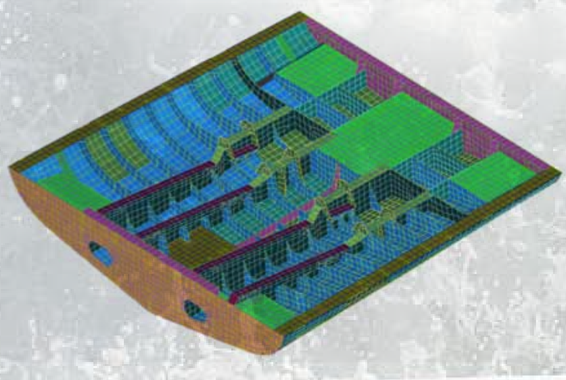
Van Cappellen Consultancy prefers to calculate natural frequency using FEM to using simplistic formulas, as FEM facilitates the analysis of complex geometries, orthotropic materials (e.g. composites), etc. and of structural modifications, such as material thickness and the addition of stiffeners or frames. Effective assessment of such structural measures is performed using FEM.

We perform such calculations as:

Input mobility calculation

The dynamic behaviour of foundations is of huge interest as regards the transfer of acoustic energy from machinery to the vessel's structure. The idea behind this is fairly simple: "the less energy transmitted into the vessel's structure, the less energy available for the radiation of noises into interior spaces".

Using FEM, the input mobility of a foundation can already be calculated during the early design stage. The figure below presents an example of an FE model used to calculate input mobility of the diesel engine foundations of a 135' aluminium yacht.



Natural frequency calculation

Normal mode analysis of local structures (e.g. decks, bulkhead, etc.) is executed using the FE model. The results identify natural frequencies and accompanying mode shapes. When energy is fed into a structure at a frequency that coincides with the major natural frequency, an initially small vibration can be amplified. The human body can sense low frequency vibrations in particular and experiences it as uncomfortable.

6-DOF calculation

The main objective of decoupling the engine (source) from its support structure (receiver) through resilient mounts is to reduce structure-borne sound transmission from machinery into the vessel's structure. This process is known as 'isolation'.

If machinery is installed on resilient mounts, this is called a physical mass/spring system, which is known to have six rigid body modes (natural frequencies). The calculation of these frequencies, at which this physical phenomenon is expected, is referred to as a six-degrees-of-freedom calculation (6-DOF).

At Van Cappellen Consultancy, these calculations are performed using FEM.

Example

A support frame used underneath generator sets involves standard factory produced frames. Although Van Cappellen Consultancy can design a complete new support frame, it is more common to modify an existing frame. Mobility, dynamic stiffness, interaction between resilient mounts and frame, as well as the location of the mounts, can be checked using FEM.

With a double resilient mounted generator set, the mass and stiffness of the sub-frame (positioned between the upper and lower mounts) will be checked together using the 12-DOF calculation.

Van Cappellen Consultancy
Noise and Vibration Control

Calculations in association with Techno Fysica

Axial/Whirling calculations

Whirling is a well-known phenomenon that can occur in shaft line systems. Exposed to periodical loads, these systems can be damaged by lateral or axial vibrations. Lateral vibrations are known as 'whirling vibrations'. To prevent the shaft line system from being exposed to unacceptable vibrations, it is important to be sure that the frequencies of influencing forces do not coincide with that of the shaft's natural frequencies.

If the shaft is running at a certain speed, shaft deflections, stresses, bearing reaction forces and noise can increase to very high levels.

Several classification societies, such as Lloyd's Register, even require this kind of an analysis.

Calculations in association with FEMTO

Global hull model and forced vibrations

To determine the low frequency vibration modes, the entire vessel needs to be modelled and analysed to determine whether the vessel's natural and drive line's disturbing frequencies will result in resonance.

The engine room and aft section of the vessel will be modelled in more detail, so that local natural frequencies can also be identified and, if necessary, altered.

FEMTO will build an FE model to calculate the lowest natural frequencies (up to 50 Hz) and the accompanying mode shapes.

The propeller's excitation can be simulated using frequency or harmonic response analysis. At previously determined locations, the sensitivity of a structure/location to propeller excitations within a certain frequency range can be determined. With the correct structural damping in the model, conclusions can be drawn about the expected vibration amplitude. For this purpose, relevant parts of the vessel will have a finer mesh.

In addition to this load case, a spectral load can be applied to the mounting of the engines.

The mass of large items or structures present on board that do not contribute to stiffness and strength are applied in the model using point mass elements or locally increased densities. To tune the exact mass and centre of gravity of the vessel's FE model, the construction material's density may be changed in such way that these model values reflect those of the actual vessel.