Case Study: RINA

A leading Italian certification company for the shipbuilding industry helps customers reduce noise and vibration levels of vessels earlier in the development cycle through the use of MSC.Software's MD Nastran.

About The Company

RINA and its subsidiary companies operate in the fields of ship classification, certification and advanced services that are aimed at improving product quality and safety.

RINA is a thought leader for this industry, guiding the qualitative development of the market, promoting awareness of measures to ensure safety and environmental protection and an adherence to strict quality measures.

The Challenge

Like in other industry segments, shipbuilding engineers are influenced by a growing trend in reducing noise levels to ensure acoustic comfort in all areas occupied by the personnel and/or by passengers. For this reason shipowners request that the naval dockyards build ships characterized by optimal noise levels. RINA was tasked with finding a solution that could handle these complex, large-scale problems with ease and accuracy.

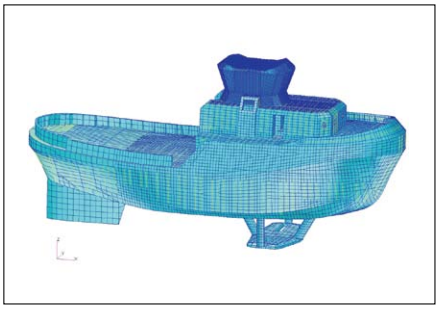
New regulations define the levels of acoustic comfort of vessels according to four different thresholds: class A for cruise liners, class B for ferries, class C for cargo boats, class Y for pleasure craft. For example, the allowed noise levels correspond to 75 dB in the working areas of cargo boats and to 45 dB for pleasure craft or passenger rooms in cruise liners.

RINA has been one of the first certification companies that decided to adopt and apply the above-mentioned acoustic comfort regulations, certifying about 50 ships and 20 pleasure yachts with respect to the acoustic levels.

"The above-mentioned regulations specify that a detailed map of the noise levels must be determined for any new vessel," explains Angelo Tonelli, Research Engineer from the Naval Vessels Technical Section of RINA. "If the experimental measurements show that the new vessel does not conform to the specifications, the dockyard can run into exorbitant costs. At the very least, the engineering team will be forced to rebuild one or more cabins in order to increase the level of acoustic isolation by adding damping material, floating pavement and/or absorbing panels. In the case of cruise liners and pleasure vessels, high noise levels in the cabins are simply unacceptable, since a "noisy" cabin cannot be used, which in the worst case might lead the customer to have a negative experience with the cruise line brand. The fine that must be paid by the dockyard in this case can be quite steep."

Because of these considerations, it is clear that it is of crucial importance for a naval shipyard to make sure that the maximum noise levels remain below the thresholds imposed by the regulations as early as possible in the development cycle of the vessel. For this purpose, it makes sense to rely on advanced simulation technologies, enabling the noise levels to be predicted starting from the finite element models of the vessel itself.

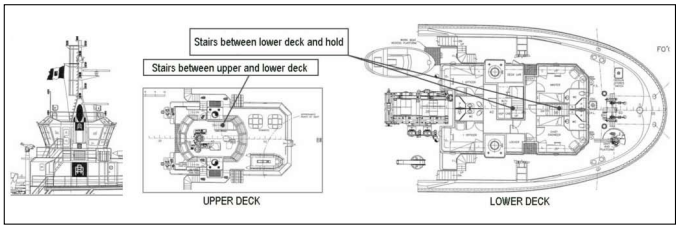
A typical application example of this methodology is provided by RINA S.p.A. due to a specific request of the "Rimorchiatori Riuniti di Genova" shipyard during the development process of a deep sea tug boat (with cabins). During the certification process, the shipyard decided to request RINA provide the additional service of estimating the vibration and noise levels on the deck, with the purpose of satisfying the Italian regulatory requirements related to vibration and noise in all areas of the vessel occupied by personnel.



Tag boat prototype and finite element model

"Even if in the case of tug boats the COMFORT regulations are normally not applied (since these regulations have been developed for cargo ships more than 200 ft long), we decided to conclude our project by performing an estimation of the noise levels of this vessel upon specific request of the shipyard, which intended to build a high-quality product for its final customer" said Tonelli. "Due to the small dimensions of the vessel and to the fact that ducts and engines are located very close to the areas occupied by the workers, we knew that the boat in question was potentially characterized by vibrational and acoustic issues similar to the ones of a cargo boat." In this particular case, the main concern of the shipyard was the fact that the engine outtakes (see picture 2) had to be positioned aside of the deck and actually run through the areas where the personnel cabins are located. Given that exhausts and engines represent the main source of vibration in a boat, the final configuration led to the possibility that high noise levels could be reached in particular areas of the vessel.

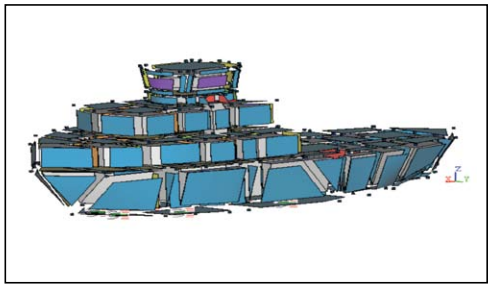
MSC Software



Design drawings of upper and lower deck

The Solution

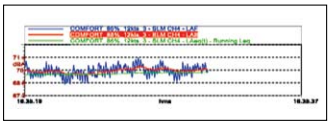
RINA chose MSC.Software's MD Nastran as the solution of choice for this simulation. MD Nastran, a comprehensive solution for next-generation design and development, offers true multidiscipline simulation in one, fully-integrated system. Designed for manufacturers who need to perform interoperable, multidisciplinary analyses on ever-more complex models, MD Nastran offers key capabilities that drive efficiency and streamline processes.



SEA Model

For example, vibroacoustics has traditionally been addressed by a two step process, but MD Nastran provides an integrated and efficient solution that includes both the structural and acoustic simulation capabilities within a single software package, mitigating the need for multiple codes.

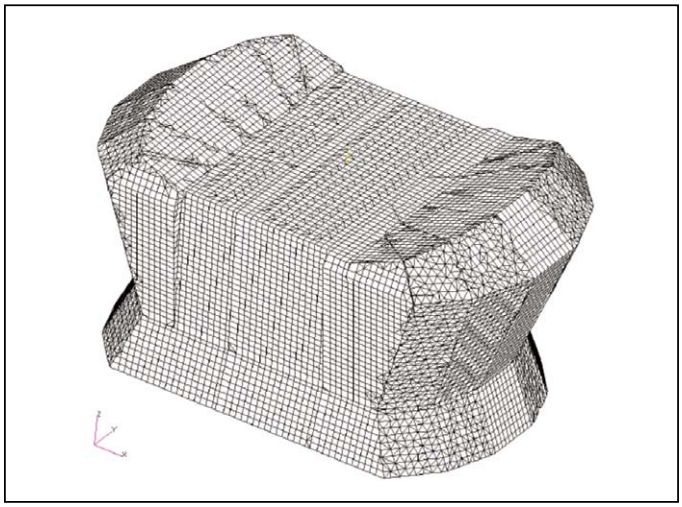
The acoustic simulation was first conducted with SEA (Statistical Energy Analysis) simulation tools, as normally done in the shipbuilding industry, due to the huge dimension of the models and to the fact that normally the acoustic sources (propellers and engines) are positioned far away from the cabins. The SEA simulation predicted values on the deck (which represents the area of the ship where the crew is located most of the time) below 65 dB, whereas experimental measurements showed peak values up to 69 dB, which is lower than the threshold imposed by the regulations but significantly higher than the limits requested by the customer.



Acoustic pressure measurements: time histories with different time-constants. A-filter weighted and unweighted spectra.

"Additionally to the SEA simulations and to the experimental measurements (see picture), given the acoustic low-frequency components of the noise spectrum, it was decided to perform a simulation with MD Nastran, in order to verify whether a finite element based methodology could be used to provide additional information on the noise transfer path" explained Tonelli. "The SEA methods, normally used for acoustic simulations related to bigger vessels, provide in fact only the noise mean values in the different cavities (ignoring possible peaks distant from the mean value) and do not allow detailed vibroacoustic simulations (specifically related to lower frequency values) to be performed. Moreover, the consistent amount of data required to characterize the material's acoustic behavior is not always available and represents the major cause of uncertainties on the reliability of the final results. In this particular case, related to a relatively small model, the vibroacoustic prediction with a finite element model was definitely possible, since the available model (ca. 500,000 d.o.f.) enabled frequencies up to 150 Hz to be analyzed, range corresponding to the dominant frequencies of the vibroacoustic problem. In addition, the fact that the cabins were built over the engines justified the decision to investigate the noise distribution in detail in all areas occupied by the crew in order to accurately determine the structural noise propagation path and to understand whether the main contribution would come from the glass panels or from the structural walls."

The finite element analysis was conducted on a vibroacoustic model which included both the structural mesh and the acoustic cavity mesh. Given the purpose of the simulation, it was decided the simulation should consist of an acoustic cavity model related to upper and lower deck. The MD Nastran Structures Package was used to generate the acoustic cavity model that enables identification of the cavities starting from a finite element model, eliminating the cavities that are not relevant for the particular application and generating the acoustic model through a completely automated process. The cavity model was then automatically coupled with the structural model, leading to the realization of a complete vibroacoustic model.



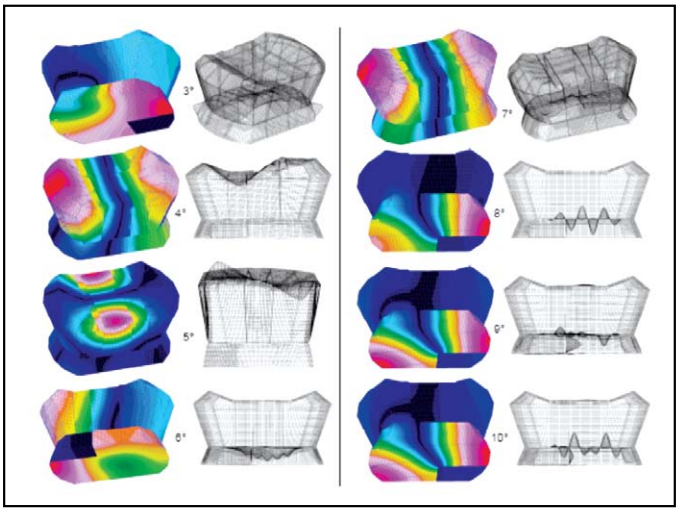
Acoustic cavity representation of the tug boat

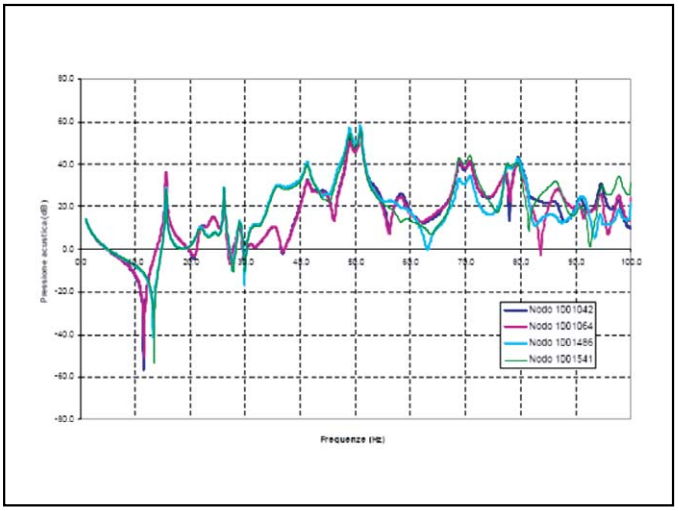
To obtain information related to the resonances of the modes of the coupled model, the vibroacoustic transfer functions corresponding to the following inputs and outputs were calculated:

- Input: velocity in-phase and out-of-phase motion imposed on two deck nodes corresponding to the exhaust attachment points
- Output: measurement points on the deck positioned at different heights on the vertical symmetry axis and on the edge and middle points of the deck

The Benefits

Using MD Nastran, RINA was able to solve both interior and exterior acoustic problems within a single software package and obtain a faster, more accurate, and efficient simulation solution. The MD Nastran simulation provided consistent information related to the mode shapes of the coupled model, that show the resonances of the system, as well as to the acoustic pressure in selected points of the structure, providing additional detail on the overall noise distribution.





Mode shapes and frequency response of the vibroacoustic model

"The results provide valuable information which helps us to determine corrective actions, with the purpose of reducing the noise levels on the deck. As an example, the results shown above confirm that some of the resonances identified through the simulation match the corresponding frequency components observed through experimental measurements" said Tonelli.

"Moreover, through the analysis of the fluid/structure coupling modes, it is possible to understand whether the resonances are due to the openings between upper and lower deck (for the stairs), that, not being connected to the structure, can be considered as cavity boundaries and represent acoustic reflection surfaces, or whether they are caused by the natural modes of the deck structure."

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