inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 43.2

ENERGY METHOD APPLIED TO STRUCTURE-BORNE TRANSFER IN SHIP STRUCTURES

A Blanchet (1), G Chatel (2) & M Philipps (2)

(1) Chantiers de l'Atlantique, 44608 Saint-Nazaire, France, (2) SECAV, 6, Bd de Brazza, 13008 Marseille, France

1. INTRODUCTION

In spite of the important progress made to predict noise level in ship accomodation, structure-borne sound transmission in ship structures remains one of the most important problems at the design stage of the ship. The purpose of this paper is to present a method to calculate the transfer between the vibratory power injected into the engine seating and the velocity level transmitted in the built-up plate structure.
A ship is an important steel structure made of coupled stiffened plates with structural discontinuities as, stiffeners, joints, pillars...
In order to predict the structure-bome transfer we use a smooth energy formulation for a two dimensional structure with cylindrical waves propagation. In this study we take into account flexural waves in the plate and each type of discontinuity is characterized in terms of reflection and transmission coefficients.
The velocity level transmitted in the built-up plate structure is then calculated taking into consideration the driving-point mobility of the receiving plate obtained with a numerical prediction.

2. CALCULATION OF ENERGY FLOW

A sofware DEVNA was developped in order to calculate the transmission of the vibrations in the ship structure, for medium and high frequencies.
The vibratory power injected in a structure by an excitation force is equal to the product of the force squared by the real part of the driving-point mobility.
DEVNA has a data base on the mobilities of different machinery foundations used currently in ship building, in order to quantify the vibratory power transmitted into the bed plates by each of the engine supports.

Energy flow propagation in ship structure is calculated by using a smooth energy formulation and by taking into account only flexural waves. Energy flow propagation between the bed plates and the structure of the upper deck takes place in several paths of which the main ones are the hull, the steel divisions and the pillars.
The figure 1 shows three energy flow paths between the bed plates and one of the plates of the upper deck. The structure is a one dimensional system for the pillars and a two dimensional system for the coupled plates in the hull and on the decks.

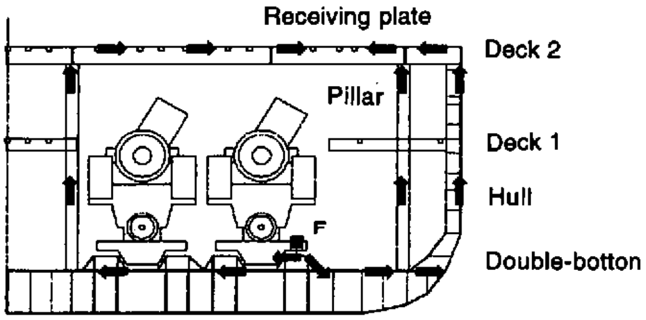

Fig. 1 - Schematic representation of the energy flow paths

In the one dimensional system, the following formula enables the calculation of the energy flow in a point distant by x from the source, in function of the vibratory power W injected to the structure.

$$P(x) = W \cdot e^{-\frac{\eta\omega}{c_g} x} \qquad (1)$$

Where η is the structural loss factor, ω is the circular frequency and c_g the group velocity .
Figure 2 shows the vibratory power injected in the beam, the energy flow propagation P and the energy density stored in an elementary volume.

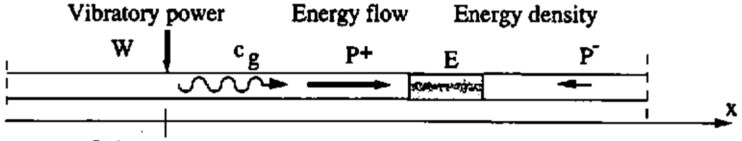

Fig. 2 - Schematic representation of energy flow propagation

In a two dimensional system such as structures made of coupled stiffened plates, the energy flow propagation takes place in cylindrical waves.

Figure 3 shows a cylindrical wave propagation in plates and also reflection and transmission of energy flow on a structural discontinuity such as a large stiffener or a junction between deck and hull.

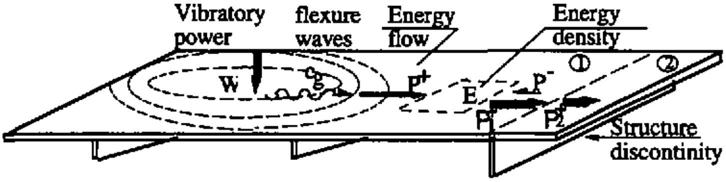

Fig. 3 : Schematic representation of cylindrical wave propagation

Each element of structure crossed by the vibratory wave, is characterized by the structural loss factor τ_i, the group velocity cg_i and the length covered l_i in the element of the structure.

Each type of singularity is associated at a transmission coefficient Γ_k, ratio of transmitted $P^+_{(k)}$ to incident energy flow $P^+_{(k-1)}$. Energy flow P(r) in a point of the structure is in terms of the product of the attenuation on the N plates crossed and of the product of the transmission coefficient of the M singularities encountered.

$$P(r) = \frac{W}{2\Pi r} \cdot \prod_{i=1}^{N} e^{-\frac{\eta_{(i)}\omega}{c_{g(i)}} \cdot l_{(i)}} \cdot \prod_{k=1}^{M} \Gamma_k \qquad (2)$$

The transmission coefficient Γ of the singularities have been determined experimently from measurements carried out on passenger ships.

3. EXPERIMENTAL RESULTS

We have used this method for two types of passenger ships in order to determine the structure-borne transfer between a force applied on main engine bed plate and the velocity level transmitted to a receiving plate in the upper deck.

Vibratory transfer measured on board between the main engine bed plate and the upper deck and the vibratory transfer calculated by the Devna software are compared on graph figure 4. The structures are those of a main engine room of a liner. The thick curve corresponds to the results of the measurement carried out on board. The thin curve corresponds to the results of the calculation by DEVNA. The calculation takes into account twelve propagation paths in the ship structure. It is observed that the differences between the measured transfer and the calculated transfer are relatively small and that the form of the calculated curve is similar to the measured transfer.

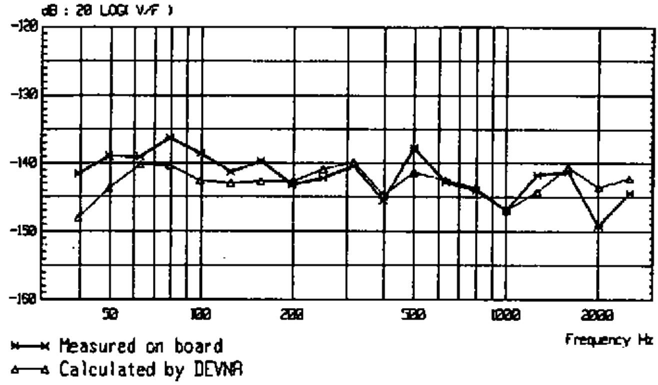

Fig. 4 : Comparison of vibratory transfers measured and calculated

4. CONCLUSION

Smooth energy formulation has enabled the calculation of the vibratory energy flow in different propagation paths in a ship structure. The vibratory transfer is calculated by taking into consideration the nature and the geometry of the elements situated along the path of the waves.
The method also takes into account local resonances by the use of the driving-point mobility of the excitation structure and the driving-point mobility of the receiving structure.
It is observed that the results of the calculation are very satisfying in the case of passenger ship presenting structures on a large scale. It appears necessary to make a further study of the vibratory transfer in the structures of much smaller ships.

References

[1] A. LE Bot, M. Ichchou, L. Jezequel, "Smooth energy formulation for multi-dimensional problem" - Euro.Noise (1995).
[2] A. Blanchet, G. Chatel, "Prediction of structureborne noise transmission in ships - accuracy consideration" - PHASE Congress (1992)
[3] G. Chatel, A. Blanchet, "Noise prediction method for ship passenger accomodations" - Inter Noise (1993)
[4] G. Chatel, "Software for predicted noise in ship accomodation" - Euro.Noise (1995).