Analysis of the vibration transmission and impediment characteristics of simplified double bottom

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ABSTRACT

Wave approach was used to investigate the characteristics of simplified double bottom’s vibration transmission and impediment. The impediment effect of different blocking mass arrangements was compared by analytical method. According to the limitation of several arranged blocking masses, the composite impediment measurement of combing blocking mass and damping layer is presented. Using impedence to simulate the non-reflection boundary, simplified model was calculated by FEM. The results of FEM coincided reasonably well with those of analytical prediction, which validated the equations from theoretical analysis. It is found that the vibration mode in both bottoms is bending and the vibration energy that transmits to the outer bottom reaches its maximum when bending or longitudinal resonance occurs in the bottom girder. Composite impediment measurement can not only cause as much transmission loss as that of several arranged blocking masses, but also widen the frequency band of vibration impediment. The study provides a theoretical analysis and numerical experiment basis for the vibration impediment of double bottom.

KEY WORDS: Simplified double bottom; wave approach; blocking mass; damping layer; impedence boundary.

INTRODUCTION

As China is establishing a "blue-water navy", more and more attention is drawn to a series of problems caused by structural vibration. Double bottom is a common type of structure in ship. The vibration excited by the power equipment on the inner bottom will be transmitted to the outer bottom through the girders and the acoustic radiation will significantly reduce the steady and fighting power. In recent decades, the US and Russia have realized the low noise of ships and cabin vibration environment has also been greatly improved. There is still a big gap of ship structure acoustic optimization between China and current international advanced level.

The structure of ship is made up of a series of welded metal components, which can be simplified into the shapes of “L”, “T”, “|” and so on. When the vibration wave passes through these discontinuously angular structures, not only the waved types may be converted, but also the vibration energy is transmitted and reflected (Kessissoglou, 2004, Langley and Heron 1990). In order to illuminate the mechanism of vibration transmission, researchers usually simplified these structures into semi-infinite length. Che (2008) studied the vibration energy transmission and reflection efficiency of a semi-infinite single angle structure and analyzed the influence of different angle and thickness to the transmission of vibration of different type of wave. Yao, Ji and Qian (2009a) studied the bending wave energy attenuation in different semi-infinite length angular structures and gave the engineering prediction formulas of sound insulation. For the double bottom of a ship, according to the research of Yao, Ji and Qian (2009b), the coupling effect of water become weaker, while the coupling effect of girders become stronger with the increase of frequency. The girders plays a greater role between double bottoms in high frequency range. The girders attached with damping material can effectively suppress the transmission of vibration energy in media and high frequency range. Cremer, Heckle and Ungar (1988) put forward the concept of vibration blocking mass, which can reflect part of the vibration energy back to the vibration source and it draws extensive attention as a way of wave impediment. Using wave analysis approach, Che and Chen (2007) studied the vibration energy blocking effect of blocking mass attached to the corner of a single angle structure, and found that the effect of blocking mass on the transmission of plane bending wave is similar to that of a “low pass filter”. Based on the experimental analysis of the acoustic transmission path between double-deck hull, the supporting plate composited by blocking mass is proposed by Liang, Ji and Ye (2012). The result shows that it can significantly reduce the vibration and acoustic radiation level. Blocking mass plays a good role in blocking vibration as a rigid means of wave impediment, but it can't consume vibration energy itself. Using blocking mass alone can greatly increase the weight of the structure, so composite wave suppression method becomes an option. Combining the mechanism of vibration blocking mass and damping material, Sun and Wang (2011) proposed the structural form of high transmission loss based on the numerical method, which could effectively suppress the vibration and acoustic radiation of the shell.

In order to further analyze the vibration transmission and impediment characteristics of double bottom, based on the above research, this paper studies the vibration transmission suppression effect of blocking mass and damping layer between double-bottom under the bending