Research on Hydrodynamic Interference Suppression of Bottom-Mounted Monitoring Platform with Fairing Structure

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Abstract

In the disturbance of unsteady flow field under the sea, the monitoring accuracy and precision of the bottom-mounted acoustic monitoring platform will decrease. In order to reduce the hydrodynamic interference, the platform wrapped with fairing structure and separated from the retrieval unit is described. The suppression effect evaluation based on the correlation theory of sound pressure and particle velocity for spherical wave in infinite homogeneous medium is proposed and the difference value between them is used to evaluate the hydrodynamic restraining performance of the bottom-mounted platform under far field condition. Through the sea test, it is indicated that the platform with sparse layers fairing structure (there are two layers for the fairing, in which the inside layer is 6-layers sparse metal net, and the outside layer is 1-layer polyester cloth, and then it takes sparse layers for short) has no attenuation in the sound pressure response to the sound source signal, but obvious suppression in the velocity response to the hydrodynamic noise. The effective frequency of the fairing structure is decreased below 10 Hz, and the noise magnitude is reduced by 10 dB. With the comparison of different fairing structures, it is concluded that the tighter fairing structure can enhance the performance of sound transmission and flow restraining.

Key words: bottom-mounted, fairing, hydrodynamic interference, acoustic impedance, transmission loss


1 Introduction

Bottom-mounted acoustic monitoring platform is mainly used to detect the acoustic signal under the sea so that the marine environment information such as flow velocity, topography and depth can be obtained (Berteaux, 1976; Mavrakos and Chatjigeorgiou, 1997). With the special application features that it can work unmanned and silently in the severe environment, the bottom-mounted platform has become increasingly prevalent with the constantly development of marine exploration especially in ocean environmental monitoring, forecast and prevention of marine disaster, as well as military use etc. In order to obtain the marine environment profile data more accurately, the platform structure needs to be more steady and reliable, which has been an essential criterion in the design procedure (Roy, 1998; Morris, 1978; Lee, 1973; Cron, 1965). With the increasing application in some complex military areas, the low-noise requirement is proposed and the platform structure is required to have higher sensitivity for detecting and receiving the weak signal from the hash marine background noise.

As the most critical sensor, the hydrophone is placed inside the platform body to avoid or reduce the outside flow interference. While the signal interference generated from the hydrodynamic coupling effect of hydrophone suspension system and platform structure becomes a serious technical restrict in the accuracy and stability of the system (Yang, 2003; Hawkes and Nehorai, 2001). Hence the structural vibration induced by flow excitation to the platform body needs to be suppressed. In order to decrease the flow influence, the platform body is generally designed into the streamline shape. There have been different shapes for the existing monitoring platform until now, which are the vertical cylinder, horizontal cylinder or spindle (Ghasemloonia et al., 2015). Meanwhile, the entire monitoring system should also satisfy the requirements of conveniently launch-
ing and retrieving. Hence, the platform structure applied to underwater acoustic monitoring which needs the high adaptability and stability is necessary to be researched out.

Owing to the military sensibility of the underwater platform research, there are few relative reports and the main research works nearly focus on the statics analysis and structural design. Shonting et al. (1996) studied the emission undersea by the submerged system of single moored buoy. Wang researched the attitude of submerged buoy and the dynamic characteristics of mooring cable under tension to increase the anti-interference ability (Wang et al., 2012). Besides, many researches refer to the vortex-induced-vibration (VIV) analysis of marine offshore structures and semi-submersible platforms which can lead to the mechanical failures and low productivity efficiency. Sarpkaya (2004) gave a comprehensive review of the VIV research on the circular cylindrical structures. Kandasamy et al. (2016) concluded the vibration control methods for marine offshore structures subjected to the unsteady hydrodynamic forces. Oviedo-Tolentino et al. (2014) and Dewi et al. (1999) studied the VIV of a bottom fixed circular cylinder. Yuan et al. (2016) and Wu et al. (2014) analyzed the fluid and structure interaction of the AUV with different outline. Nevertheless, the relevant research on the hydrodynamic stability of bottom-mounted platform is really rare.

For the reduction of vibration influence, the modal frequencies of the platform body should be separated from the effective monitoring frequency range through the structure improvement and the vibration reduction treatments. The existing vibration evaluation methods are mainly carried out with the simulations and experiments, in which the sensors should be fixed on the structure (Kandasamy et al., 2016). Nevertheless, the additional test devices will generate some variances to the inherent vibration characteristics. Meanwhile, there are large differences for the modal parameters in different medium, and the difference value can reach 50%–70% (Kramer et al., 2013). Therefore, the evaluation process needs to be carried out in actual underwater environment by its own sensors which are the sound pressure and velocity sensors.

This paper describes a novel platform structure applied for underwater acoustic monitoring in shallow sea environment, which can effectively reduce the flow interference. The suppression effect evaluation based on the correlation theory of sound pressure and particle velocity for spherical wave in infinite homogeneous medium is proposed. Moreover, the cause of hydrodynamic noise is analyzed to better evaluate the flow restraining performance of the fairing structure. At last, the sea tests are carried out to compare the effect of different fairing structures. The sound pressure and velocity responses are analyzed in the frequency from 1 to 100 Hz, and the difference value of them is adopted to evaluate the flow restraining performance.

2 Bottom-mounted monitoring platform description

The platform body is designed as a bottom-mounted form on the seafloor, and the entire system is divided into instrument cabin part, retrieval unit and main body part, which is shown in Fig. 1.

![Fig. 1. Integral structure of the bottom-mounted monitoring platform.](image)

The entire system includes the main monitoring part and retrieval unit, which are shown in Fig. 2.

The main body consists of the instrument cabins and hydrophone frame. The instrument cabins include the electronic cabin and battery cabin which are used to acquire data and supply power. The hydrophone frame is used to fix the hydrophone with flexibility suspension, and the external surface is wrapped with fairing to reduce the flow interference. The fairing is comprised of the steel wire gauze and nylon fabric cloth which has better sound transmission and flow restraining.

The fairing is shown in Fig. 3.