Nonlinear System Identification of a Moored Structural System

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ABSTRACT

This paper addresses the practical application of a multiple-input/single-output nonlinear system identification technique on ocean structural systems. An ocean structure exhibiting nonlinear behavior due to geometric nonlinearity of mooring line angles and the complexity of hydrodynamic excitations is chosen for this analytical study. Given the input wave characteristics, wave force and the system response, the method identifies the hydrodynamic drag and inertia coefficients from the wave force model formulated by relative-motion Morison equation. The reverse multiple-input/single-output technique correctly identified the parameters of the nonlinear system. The applicability of the method is demonstrated through a numerical example with noisy periodic wave excitation.

KEY WORDS: Nonlinear; system identification; multiple-input; single-output; hydrodynamics.

INTRODUCTION

Complex nonlinear responses have been observed in various compliant ocean systems characterized by nonlinear mooring (restoring) force and coupled fluid-structure interaction (exciting) force (e.g. Thompson, 1983; Bishop and Virgin, 1988). Gottlieb (1991) studied the nonlinear behavior of a multi-point symmetric moored structural system under periodic excitation. Lin (1994) extended this analysis by incorporating random noise perturbations. Small body mooring systems are generally solved by a relative-motion Morison formulation (Patel, 1989). It has been observed from the literature that the hydrodynamic drag ($C_D$) and inertia ($C_M$) coefficients for sphere are not constants and reasonable estimate could be $0.1 \leq C_D \leq 1.0$ and $1.0 \leq C_M \leq 1.5$ respectively (Grace and Casino, 1969; Grace and Zee, 1978).

It is important to identify the hydrodynamic coefficients and system parameters to quantitatively examine the nonlinear behavior. Bendat (1990, 1998) has used parallel multiple-input/single-input (MISO) procedures for identifying parameters of nonlinear systems. A method for nonlinear system identification to determine amplitude and frequency dependent properties on different types of nonlinear systems such as Duffing, Van der Pol, etc. has been developed by Bendat et al (1992). With the input and output data known, based on multiple input/single output linear analysis of reverse dynamic system, Reverse MISO technique identifies the linear and nonlinear system properties.

This paper presents the application of the parallel and reverse MISO technique on a nonlinear spherical mooring system subjected to periodic with white noise excitation. The description of the system, the derivation of analytical model, implementation of the technique and validation through a numerical example based on experimental observations (Yim et al, 1993) are presented.

SYSTEM CONSIDERED

A general single-degree-of-freedom (SDOF), two-point moored structural system restricted to move only in the surge direction is chosen for the study. The model is represented by a submerged rigid body, hydrodynamically damped and an excited nonlinear oscillator (Fig.1).

Fig 1: Definition sketch of the mooring system a) Plan b) Profile.