ABSTRACT

The motion instability is an important issue that occurs during the operation of towed underwater vehicles (TUV), which considerably affects the accuracy of high precision acoustic instrumentations housed inside the same. Out of the various parameters responsible for this, the disturbances from the tow-ship are the most significant one. The present study focuses on the motion dynamics of an underwater towing system with ship induced disturbances as the input. The study focuses on an innovative system called two-part towing. The methodology involves numerical modeling of the tow system, which consists of modeling of the tow-cables and vehicles formulation. Previous study in this direction used a segmental approach for the modeling of the cable. Even though, the model was successful in predicting the heave response of the tow-body, instabilities were observed in the numerical solution. The present study devises a simple approach called lumped mass spring model (LMSM) for the cable formulation. In this work, the traditional LMSM has been modified in two ways. First, by implementing advanced time integration procedures and secondly, use of a modified beam model which uses only translational degrees of freedoms for solving beam equation. A number of time integration procedures, such as Euler, Houbolt, Newmark and HHT-α were implemented in the traditional LMSM and the strength and weakness of each scheme were numerically estimated.

In most of the previous studies, hydrodynamic forces acting on the tow-system such as drag and lift etc. are approximated as analytical expression of velocities. This approach restricts these models to use simple cylindrical shaped towed bodies and may not be applicable modern tow systems which are diversified in shape and complexity. Hence, this particular study, hydrodynamic parameters such as drag and lift of the tow-system are estimated using CFD techniques. To achieve this, a RANS based CFD code has been developed. Further, a new convection interpolation scheme for CFD simulation, called BNCUS, which is blend of cell based and node based formulation, was proposed in the study and numerically tested. To account for the fact that simulation takes considerable time in solving fluid dynamic equations, a dedicated parallel computing setup has been developed. Two types of
computational parallelisms are explored in the current study, viz; the model for shared memory processors and distributed memory processors. In the present study, shared memory model was used for structural dynamic analysis of towing system, distributed memory one was devised in solving fluid dynamic equations.

Finally the developed numerical model has been validated experimentally through towing tank trails. For this purpose, a detailed experimental set-up has been made including the fabrication of towed body and associated electronics, sinusoidal input motion generation mechanism, sensors for real time measurement of pitch and heave etc. Finally, heave instability of the towed body was experimentally estimated, compared with simulated values.

**Keywords:** Fluid structure interaction, underwater towing, CFD, Time integration, parallel computing, Finite difference method