M10 INERTIAL BEHAVIOR OF OFFSHORE DEVICES

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In the last years, there is a continued growth in the number of offshore operations for handling large equipment and objects, with emphasis on installation and maintenance of devices for exploiting marine renewable energy like generators to harnessing wind, waves and currents energy.

During the manoeuvring behaviour of this kind of devices, by its size and the effect of its interaction with the surrounding fluid, is very important the effect of inertial forces and moments, that requires a specific modelling.

An immersed object in a fluid is subjected to different types of local forces whose integration along its surface gives the resultant force and torque which can be classified into next types:

- Gravitational. Its resultant is the weight of the object, including the water within its interior.
- Hydrostatic pressure. Its resultant is the buoyancy force.
- Hydrodynamic forces, which are non-linear and they are function of the relative velocity between the fluid and the object surfaces.
- Aerodynamic forces. Due to its minor magnitude, it can be neglected in a first approximation.
- Inertial forces. Their components can be calculated as the product of the mass of every object item by its acceleration. For underwater devices the mass analysis is more complex than for an object moving inside the air.
- External forces, produced mainly by the action of mooring ropes, electrical cables, waves (mainly the excitation and radiation forces), the reaction from other bodies in contact, other nearly devices after exploiting marine energy.
- The actuators elements to control the motion, which can be external or internal type. In many cases they use a water volume change in specific compartments, called ballast tanks.

This paper specially discusses the masses and moments of inertia modelling problem, with the aim to use it in the simulation of the complex manoeuvres of these devices and in the study of the automatic control systems for their offshore operations.

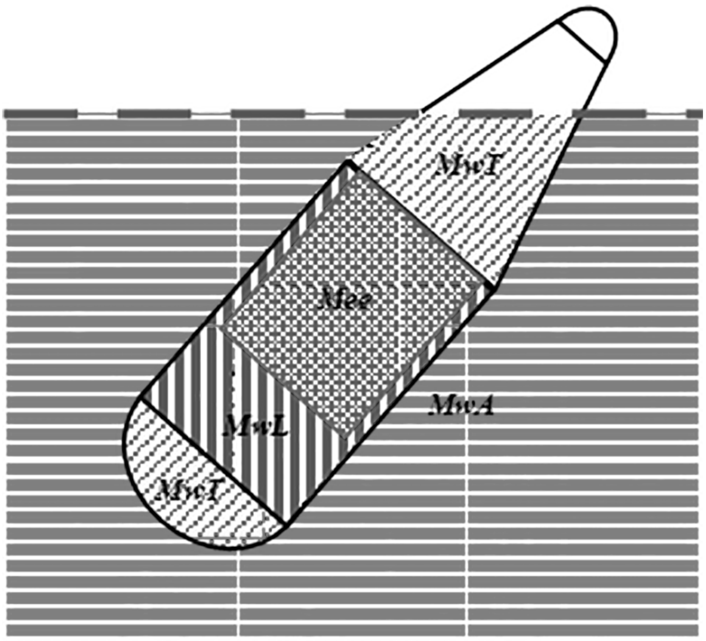

Fig. 1. Masses classification for an object floating in water

Summarizing the scope of the problem in Fig. 1 is showed a typical breakdown of the masses (and thus the moments of inertia) of a portion of a partially submerged device. It can be seen that the total mass is equal to the sum of:

- The mass of the solid part of the object (Mee), consisting of the mass of the structure and the equipment installed in the device. This group includes the internal fluids of the equipment and tanks. By this when they are partly filled and have an important size is suitable to take into account the effect of the free surface.
- The mass of water in ballast tanks (MwL). This mass is a very important part of the set, allowing the float level control, changes of depth and orientation of the device.

  The control of this mass is done by filling and emptying various sea water tanks, which are usually large.

  Thus in their their behaviour is very important the free surface, which changes the position of the centroide of the mass with object orientation. Moreover, if the movements are rapid, it appears a complex variation of the form of water surface (sloshing).

  Another effect is that, in the case of tanks communicated with the outside air if the tank is sealed, with changing depth, hydrostatic pressure, volume changes, and consequently the mass of ballast water.
- The trapped water mass (MwT) in the inner parts of the object that are in communication with the sea water. Usually correspond to spaces between the hydrodynamic envelope and the structural hull. As seen in Figure 1 in completely submerged spaces, this mass is equal to the volume of space by the density of water, but when it comes to the surface must take into account only the volume of the immersed part and the effect of the free surface.
- The mass of water added (MwA), which is the water mass surrounding the object and which is accelerated as a result of the body movement.

Given the importance and complexity of the added mass modelling, a method for its early design identification, developed by the R&D Group on Marine Renewable Energy Technologies of the UPM (GITERM) will be presented.

Finally, it will be showed an example of the use of the models presented in the paper in the simulation and test of the emersion manoeuvre of a cylinder from underwater to the surface.

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