Myanmar Maritime University

Marine Mechanical Engineering Department

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Experimental study on ship motions in waves

Marine Mechanical

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Introduction

Sea waves can condition different aspects of harbour activities. Among those related to ships, operating conditions regarding ship manoeuvring at entrance channels or when they are moored at a dock are emphasized. In these cases, it is important not only to characterize the wave field in the ship surroundings but also the ship responses to the forces it is subjected to, whether they are common or extreme.

In this extent, numerical modelling is a common tool to characterize the ship response to the incident sea waves but it has to rely on important simplifications and parametrisation of the complex phenomena involved in the ship-wave interactions. Therefore, numerical models of this kind always lack validation and calibration. It is in this sense that physical modelling does represent an extremely important tool allowing to replicate complex physical phenomena in an easier and more controlled way.

Objectives

With the objective of validating and calibrating a numerical model of the behavior of a free ship, a set of physical model tests was run in order to measure the ship movements when subjected to different incident sea waves (regular and irregular) including different wave angle attacks. With the data, it was possible to determine the movement of the ship along its three degrees of freedom (rolling, pitching & heaving). Transfer functions are established and compared with numerical ones obtained with the oil-tanker model. The tests can run with different kind of waves in wave generator.

Conceptual Arrangement for mounting the model

There are six possible arrangements for mounting the model under the carriage

a) Rigidly restrained
b) Free to heave and pitch (unpowered model)
c) Free to surge, heave and pitch (unpowered model restrained by springs)
d) Free to surge, heave and pitch (powered model)
e) Model restrained only by umbilical cable (powered model)
f) Self-contained model (no carriage)

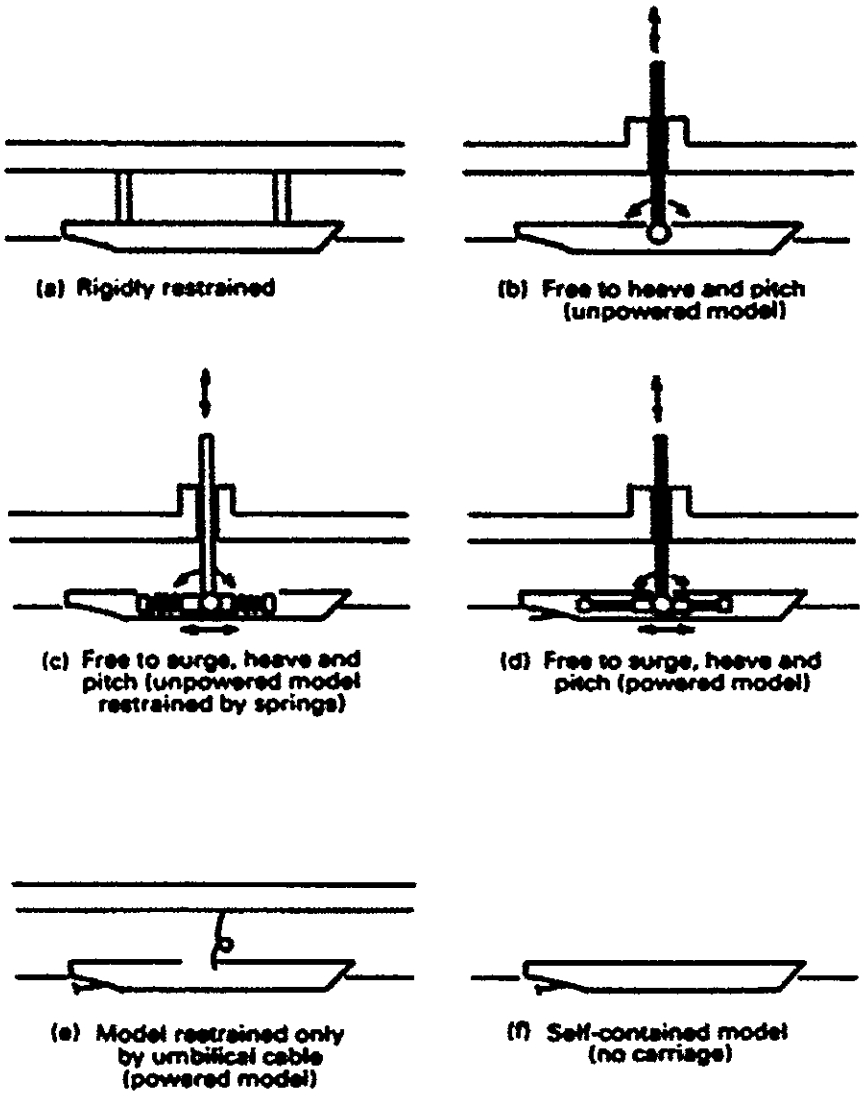


Fig 1. Possible arrangements for mounting the model under the carriage

Design Specifications

Frame is made of aluminium and mounted on the wave generator to steady a model in required position and prevent unwanted motions. Shafting system enables the model to move require motions and connect with the model.

To measure the motions and resistance of the model, gyro sensor (ADXL 335), ultrasonic sensor and load cell (10 kg) are used.

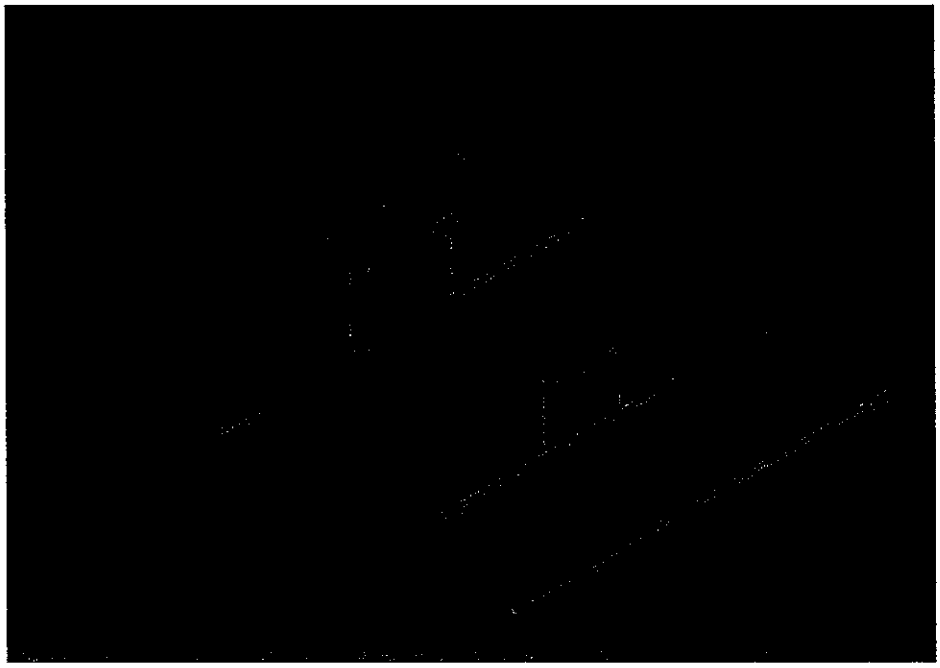


Fig 2. Inventor rendering of the Ship Motion Testing Frame

Applications of the ship motion analysis experiment

- Using our design, various experiments such as ship motion in 3DOF (roll, pitch and heave), and resistance test with wave. The data from the gyro sensor can be used to improve the stabilizer's performance. When there are containers, we can also calculate how to work the ballast tank by using that data.

Sensors

Three types of sensors are used in our project.

1. GY 61 ADXL 335
2. Ultrasonic
3. Load cell(10kg)

GY 61 ADXL 335

- mounted on the flange of the main shaft to measure pitching and rolling in degrees.
- maximum range of rolling angles due to joints are starboard 85 degrees and port 85 degrees.

- maximum range of pitching angles due to design are fwd 35 degrees and aft 35 degrees

Fig 3. Location of GY 61 ADXL 335

Ultrasonic

- one of the shafts must be connected on the LCF point of the model.
- Plate is mounted on this shaft. (smooth plate is more suitable)
- Ultrasonic sensor is mounted on the frame and detected the movement of the plate to measure heaving in cm.

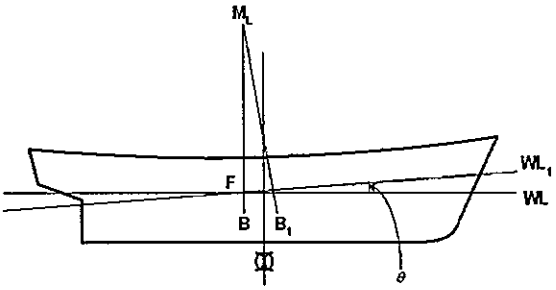


Fig 4. Location of Ultrasonic Sensor

Load cell

- Mounted in another shaft at the forward part of model to measure resistance in kg.

Fig 5. Location of Loadcell

Operation

When the wave generator generates wave, the model will cause three degrees freedom (pitching, rolling, heaving) and resistance due to wave will also be occurred. The output data of 3DOF and wave resistance can be measured and displayed in serial monitor or graph in simultaneously.

Fig 6. Ship motions analysis in wave generator tank

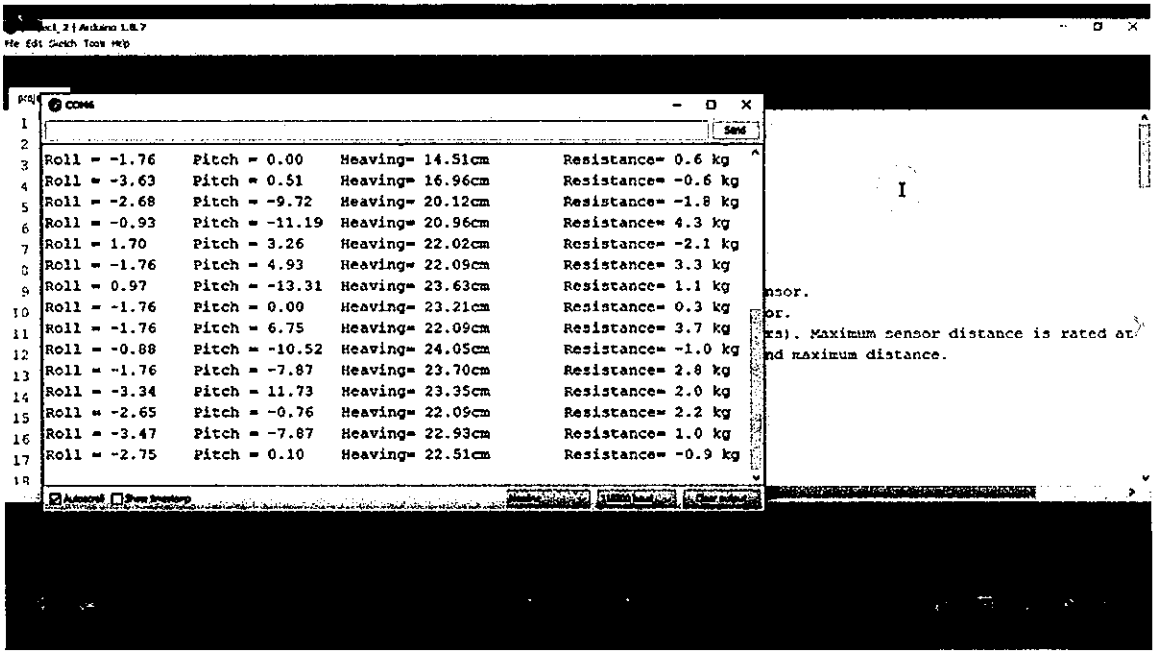


Fig 7. Output data displayed in Serial Monitor

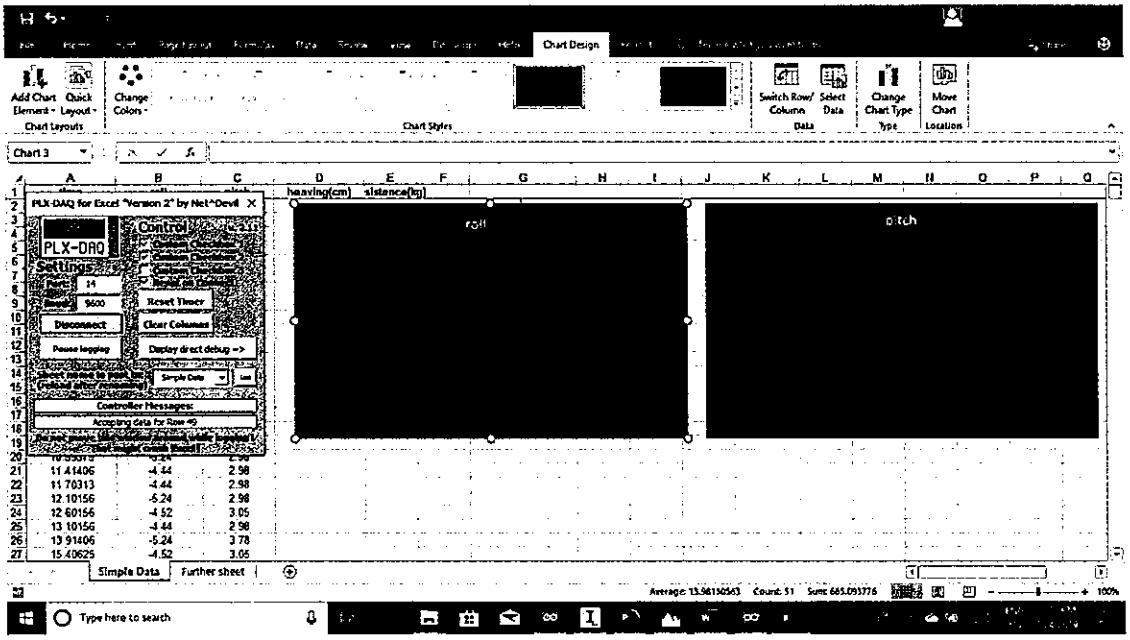


Fig 8. Output data displayed in Graph

Result

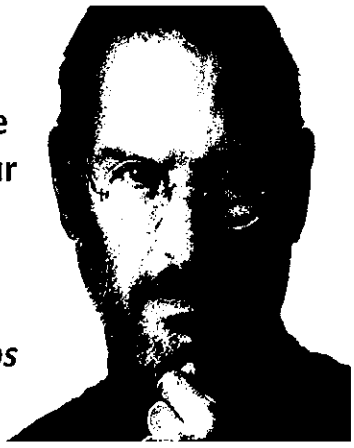
When the experimental results are compared with the theoretical result, they are approximately similar. Error percentage will depend on voltage supply, wires loose and other mechanical problems.

Advantage

- Easy to assembly the models
- Can calculate the motion of any ship type model
- less cost than any other of ship motion testers

"Simple can be harder than complex: You have to work hard to get your thinking clean to make it simple"

Steve Jobs



KEEP MOVING FORWARD