

ENERGY HARVESTING UTILISING THE GYROSCOPIC EFFECT

N.C. Townsend nick@soton.ac.uk

The Concept

The rolling and pitching motions of a marine vessel can induce gyroscopic precession.

Gyroscopic precession creates a relative motion within a vessel.

This provides a means to recover wave energy and reduce the net energy use of marine vessels.

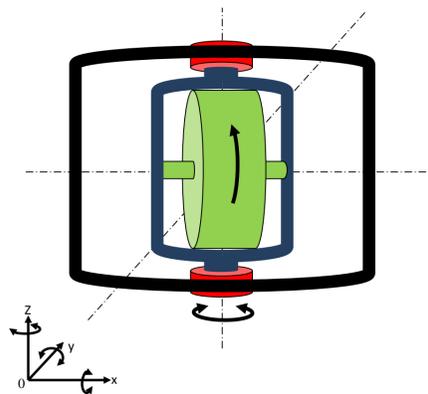


Figure 1: A Schematic of a Single Unit Gyroscopic System

Motivation and Aims

The motivation behind the project is to ...
... develop an understanding of the recoverable power from a gyroscopic system(s) on various marine vessels and structures.

The project aims to...

- 1.) Develop a theoretical model and verify the model through experimental testing,
- 2.) Identify the potential applications and system(s) design requirements and,
- 3.) Develop the system commercially.

Theoretical Studies

The full (6DOF) equation of motion of the system can be expressed as: (Cummins equation plus the gyroscopic effect)

$$[\underline{M}_{RB}^h + \underline{A}^h(\infty)]\ddot{\underline{\xi}} + \underline{B}^h(\infty)\dot{\underline{\xi}} + g^h \underline{\xi} + \int_{-\infty}^t \underline{K}^h(t-\tau)\dot{\underline{\xi}}(\tau)d\tau = \tau_{\omega}^h + \underline{R}(\underline{\xi})\dot{\underline{H}}^b$$

Where $\dot{\underline{H}}$ represents the gyroscopic terms, which can be expressed as:

$$\dot{\underline{H}} = \sum (\underline{A}_i \underline{I}_i) \dot{\omega}_i + (\dot{\underline{A}}_i \underline{I}_i + \underline{\Omega}_i^{\times} \underline{A}_i \underline{I}_i) \omega_i$$

There are more unknowns than equations. Expressing the Power Take Off (PTO) in the form:

$$I_g \ddot{\beta} + B_g \dot{\beta} + C_g$$

Where the power is given by:

$$P = B_g \dot{\beta}^2$$

Given an initial motion, the gyroscopic motion can be determined and the new ship motion can be determined at every time step.

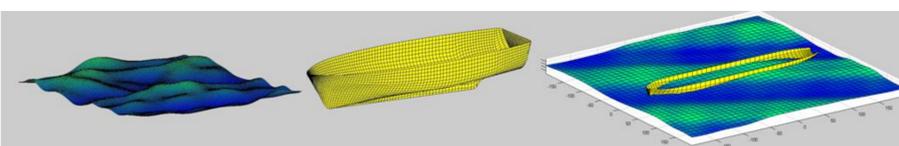


Figure 3: Theoretical Model Images

Experimental Studies

Several experimental gyroscopic systems have been developed and tested.

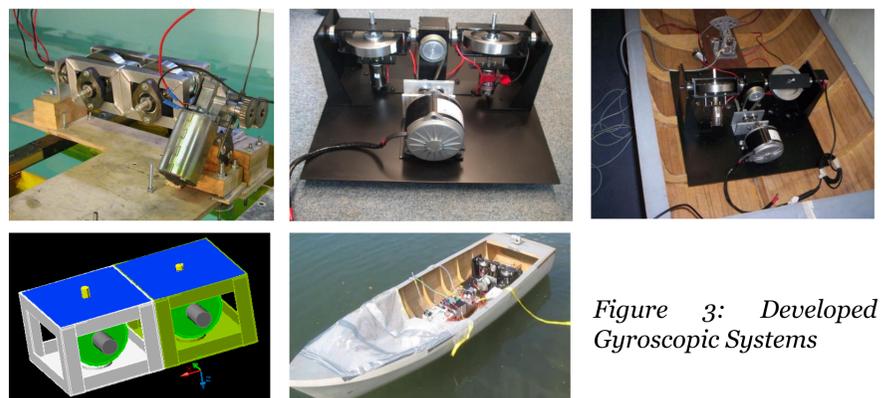


Figure 3: Developed Gyroscopic Systems

Experimental sea trials will be conducted in 2011.

Conclusions

For marine craft that operate in waves the system could be very useful providing a means to recover wave energy, improving operational effectiveness and reducing environmental impact.

Potentially, the system could be applied to any moving object or vehicle to enable energy recovery.