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Development of an Anti-Seasickness Bed used in Vessel

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Abstract: Roll and pitching motions of a vessel can seriously degrade the performance of mechanical systems and the effectiveness of personnel. Many studies on roll stabilization and trimming control system design have focused on stabilizing the vessel through the use of fins, tanks, rudders and flaps. However the ultimate objective of such approaches must be to improve boarding sensitivity. This paper presents an anti-seasickness bed that consists of a rotator and bearing system that does not make use of electric power. The advantages of this system are its simple construction, usefulness, and safe operation. In this study, the rotation angles of the upper plate of a bed according to change weight of the rotator have been calculated to determine the stability. As a result, it can be concluded that proposed stabilizing bed can be of practical use in the field.

Key Words : Seasickness, Tilt angle, Stability, Rotator, Boarding comfort

1. Introduction

In recent years, shipbuilding has focused on ensuring the stability of the hull and the convenience of the passengers. Hull vibrations are very sensitive to the details of the design of the hull form and can be easily affected by relatively small modifications of the naval architecture. Additionally, the motion of the hull can have an effect on the safety of the cargo and on the life of the crew and passengers. In particular, roll and pitching motions and a heaving of the hull can cause seasickness and can degrade the performance of mechanical systems[1,2]. In many studies, excellent solutions have been introduced where fins, tanks, rudders and flaps are used to reduce and suppress roll and pitching. These strategies mainly focus on improving the stability of the ship.

However, physical aspects that affect humans are not practically considered. Some papers have introduced a vibration reduction technique for the main hull using semi-active absorbers to improving boarding comfort. These articles considered oscillatory motion caused by repeated excitation from the propellers, the main engine, and wave load. Since high-pitched propellers and long-stroke diesel engines are more commonly used, widespread problems relating to the main hull require attention. Furthermore such vibrations affect the comfort of the passengers and crew and can damage the structure and impair the fighting efficiency of war ships[3,4]. These systems need to install hydraulic pressure and electrical systems, and as a result, these systems have a high price.

In this paper, we focus on the specialized category of equipment that will bring the riding

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comfort to humans. Specifically, we have designed a non-powered anti-seasickness bed to cope with unpredictable environments, including those caused by winds and waves. The designed system is composed of an upper bed, supporters, a rotator, and bearings. Compared to a hull control system, it is very simple and has properties that make it easy to implement. If we consider the characteristics of an ocean-bound vessel, we can see that ease of implementation of a real system is an absolutely necessary condition. Therefore, we introduce and verify the system properties of the proposed system through an experimental study.

2. Design of an Anti-Seasickness Bed System

In this system, an upper bed rotates using the bearings on base of the bed when the hull starts to be in motion. The bearings are placed on the base of the anti-seasickness bed, and they have rolling friction with rotator. The rotator is welded with the link, which is connected to the supports and the upper bed, as shown in Fig. 1.

The parts are used for high-strength support, like the support beam and the upper bed are made of aluminum alloy because the material can provide strength, corrosion resistance, and weight lightening. In this study, aluminium alloy (6063) is used as a material for the support beams and the upper bed due to weight lightening of the load parts. Copper alloy, which is heavier in weight, is used as the material for the rotator to constrain the rotation of the upper bed. The bed system has four springs on the base fixed hull to prevent a steep slope of the upper bed to be induced by the motion of the ship.

From Fig. 2, we express the moment of inertia of the rotator as

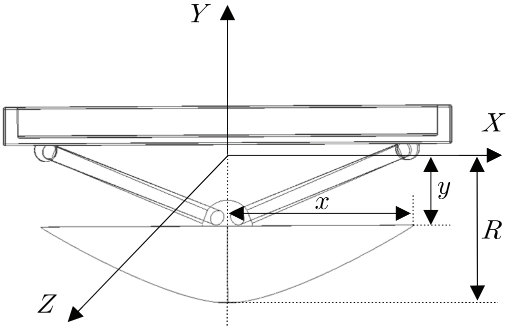


Fig. 2 Schematic diagram for analysing system dynamics

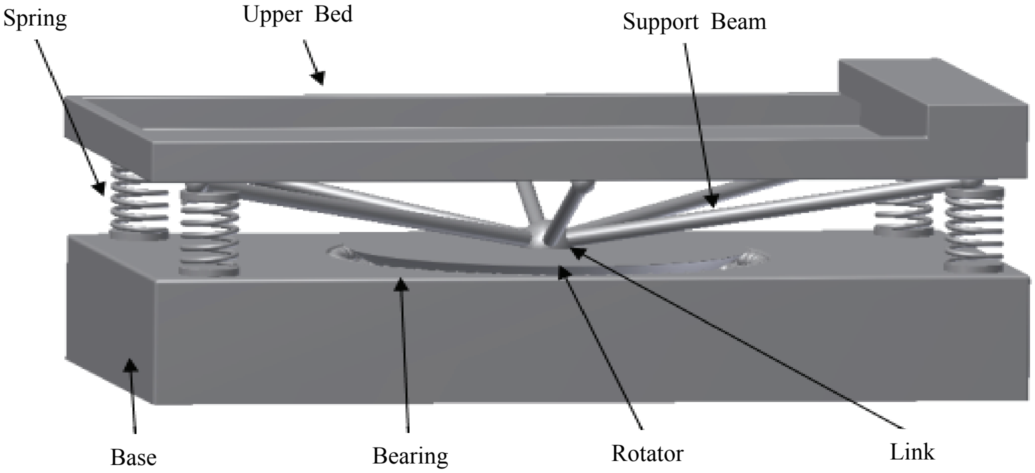


Fig. 1 Anti-seasickness bed system with no external power

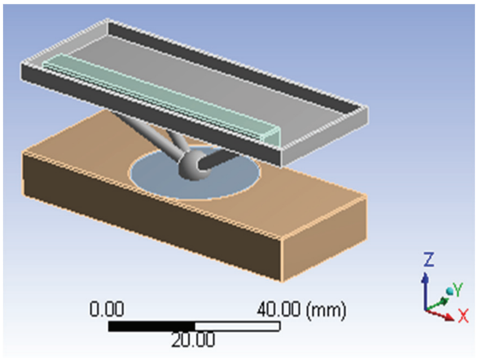
$$I=\int \frac{1}{2}\rho\pi(R^4-2R^2y^2+y^4)dy=\frac{6}{35}mR^2 \quad (1)$$

Where, ρ is density of the rotator, R is radius of the sphere including the rotator, y is the coordinate of rotation of the axis, and m is the mass of the rotator.

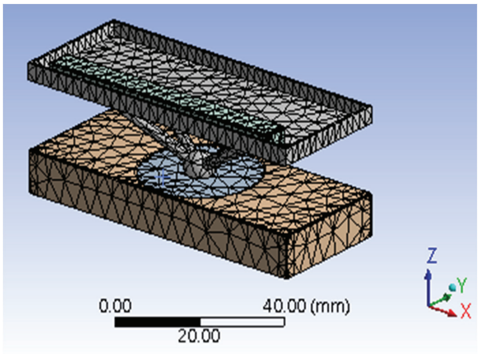
The rotator has the most moment when a man moves to the edge of the upper bed.

3. Modeling and boundary condition

The assembly of the manufactured anti-seasickness bed consists of a weight, upper bed, support beam, link, rotator, and a base bed, as shown in Fig. 3. The rotator is expressed in a simple form to model the bearing contact part between the base of the bed and the rotator. To perform a simple analysis, the bearings are replaced with friction surfaces that have the bearing's friction coefficient. Therefore the rotator has a rolling motion on the base of the bed by face contact. The base is connected with the hull, which is defined as a rigid body due to its high stiffness. The link bonded on the rotator is generated with a mesh by a shell element that will enable non-linear analysis. The support beam is bonded with the link and the upper bed, and the position of the weight does not change if it is placed on the center of the upper bed. However, a sleeping person on a bed always moves around, so the weight is placed on the edge of the upper bed to apply a maximum moment at the rotator, with its mass changing from 50 kg to 100 kg. The finite element method(FEM) is carried out for the model by using the ANSYS Workbench software. The software is a simulation program that can analyze the rotational motion of the upper bed. A proper reaction moment is given to the gravitation of the weight on the upper bed.



(a) Simple form



(b) Mesh by a shell element

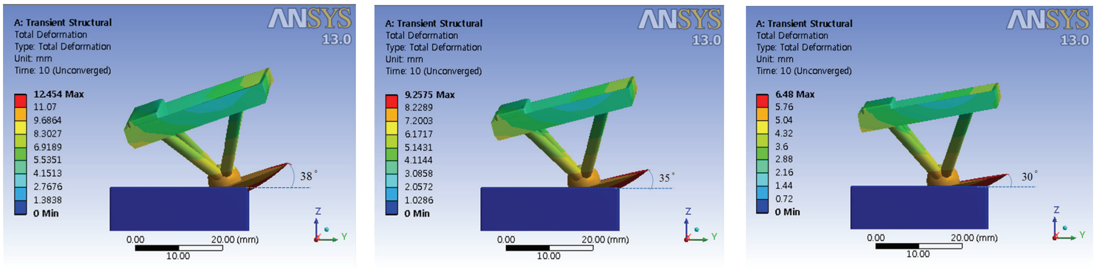
Fig. 3 Modeling for the anti-seasickness bed

4. Results of the simulation

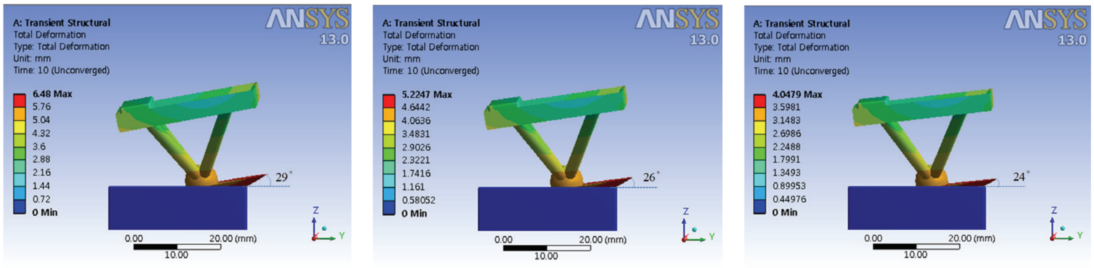
A man on the bed will fall off it if the gradient of the upper bed exceeds an angle of 30°. Therefore the gradient of the upper bed should always be maintained at an angle less than 30° for the safety of the sleeping person.

As shown in Fig. 4, the final position of the upper bed changed from the initial stage according to the change of the masses of the weight and the rotator as a result of the analysis[5~7].

In the case of a rotator mass of 80 kg, tilt angles of the upper bed were obtained between 28° to 38° when the changed from 50 kg to 100 kg, as shown in Fig. 5(a). This result show that a rotator mass of 80 kg is not sufficient to maintain the stability of the bed.

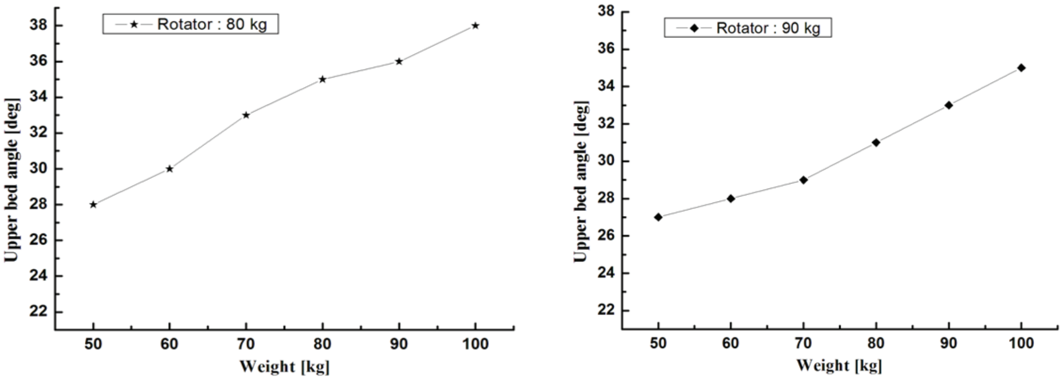


(a) Rm : 80 , W : 100 (b) Rm : 80 , W : 80 (c) Rm : 80 , W : 60

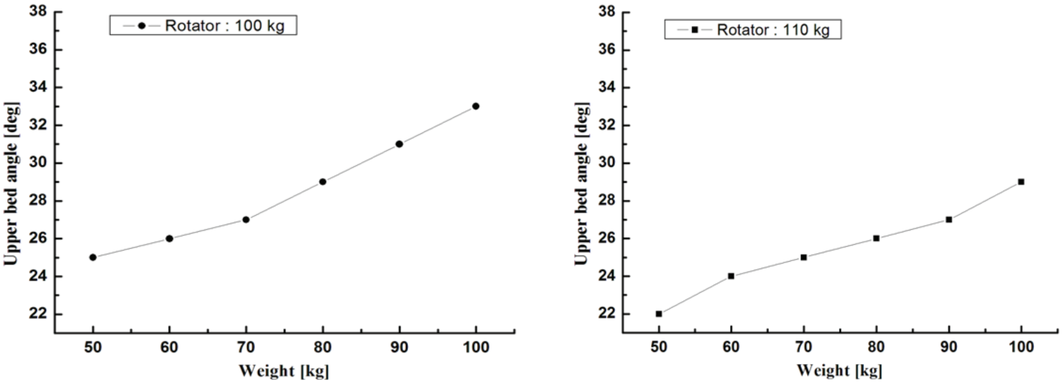


(d) Rm : 110 , W : 100 (e) Rm : 110 , W : 80 (f) Rm : 110 , W : 60

Fig. 4 Motion analysis according to change of the weight and mass of rotator
(Rm : Rotator mass[kg], W : weight[kg])



(a) Rotator mass : 80 [kg] (b) Rotator mass : 90 [kg]



(c) Rotator mass : 100 [kg] (d) Rotator mass : 110 [kg]

Fig. 5 Result of motion analysis

Also, in the case where the rotator mass has a weight less than 100 kg, the tilt angles of the upper bed reached a measurement of over 30° when the weight was above 80 kg, as shown in Fig. 5(b) and 5(c). In the case of a rotator mass of 110 kg, the tilt angles of the upper bed were maintained below 30° at all times, as shown in Fig. 5(d). This result indicate the design necessary to maintain the stability of the bed without being affected by the mass of the weight on the upper bed.

5. Conclusion

We have developed an anti-seasickness bed that can secure the stability of a bed used in a ship. The main contributions of this work can be summarized as follows.

1) We have designed a bed used in a vessel with the use of external power to cope with unpredictable environments like winds and waves.

2) The designed system is composed of an upper bed, supporters, a rotator, and bearings. Compared to hull control systems, it is very simple and has properties for easy implementation.

3) In the case of rotator mass of 110 kg, the tilt angles of the upper bed were below 30° at all times. This means that it is shown that the bed can remain stable without concern for the weight fo the mass on the upper bed.

4) Therefore, we have succeeded in developing an anti-seasickness bed to be used within a ship.

This bed system is expected to improve the boarding comfort for the crew and passengers.

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