# A study on the Motion Sickness Incidence According to the Position in the Ship

Dong Hyup Youn and Chung Hwan Park

*Abstract*—As the sea condition becomes rough, the crew and passengers on board are experiencing stress and motion sickness. Particularly, in the case of motion sickness, the ability to perform tasks falls sharply, and it takes considerable time to recover. In this study, the motion performance of wave in KVLCC2 was evaluated, and the vertical acceleration component of each ship's position in the actual sea environment condition was calculated by hull motion calculation method. The vertical acceleration spectrum was used to indicate the degree of motion sickness according to the change of velocity of KVLCC2. Motions sickness incidence (MSI) calculation was performed with 0 knots, 5 knots, 10 knots, 15 knots, 20 knots, and 25 knots. As a result, weights of vertical acceleration were higher in order, and higher in pitching than in rolling.

Index Terms—KVLCC2, MSI, vertical acceleration.

#### I. INTRODUCTION

cognitive ability, activity and skillfulness may occur. Severe motions of ships especially may cause undesirable results. Among such results, motion sickness is represented by symptoms cause symptoms such as dizziness, nausea, vomiting, headache, etc. When the human bodies are shaking, causing abrupt decreases in capabilities of performing the works of individuals, and considerable amount of time is needed for restoration of the original condition of the bodies due to delays or errors in mental activities caused thereby.

The studies concerning the level of motion sickness relating to motions of a ship have been diversely carried out. O'Hanlon (1973) developed a method of evaluating the motion sickness incidence(MSI) that evaluate the probability of occurrence as percentage on the basis of the level of the motion sickness occurring when an independent group consisting of at least 20 persons is exposed of such motions of the ship, by the function of frequency, amplitude and duration, and proceeded with the studies on the correlation between motion sickness and vertical acceleration motions [1], [2]. The study analyzing the level of motion sickness for the specific ship have been continuously conducted, and the research on the changes in the motion sickness incidence by location according to changes in the ship speed has also been conducted, and based thereon, the verification study also has been conducted [3], [4]. Meanwhile, in the recent study, revision of the model of a ship by which the vertical acceleration is measured low, from the early stage of the design through evaluation of the MSI of the ship, have been suggested as important matters for improving the level of

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motion sickness [5].

In the case of large vessels, as they have to sale for a long time, it is needed to reduce the stress or decline of the cognitive ability of human bodies by securing feeling of comfortable cruise.

This research has calculated the vertical acceleration components by location within the ship thorough the method of calculation of motion of the ship in KVLCC2, and indicated the level of motion sickness by comparing and examining the result of calculation for the changes in the ship speed and the guideline of the MSI, by using the vertical acceleration spectrum.

#### II. THEORETICAL BACKGROUND

### A. ISO 2631-3 Standards for Motion Sickness and Stress

The ISO 2631-3 standards for motion sickness and stress have been developed for evaluation of feelings of comfortable cruise of passengers, and they are generally used these days. In Fig. 1, the area for displeasure under the ISO 2631-3, which has provided for the relationship between acceleration and frequency, provides the function of frequency and the scope of the RMS value of acceleration. The variables related with occurrence of motion sickness include, without limitations axis of vibration, frequency of vibration, amplitude and duration of exposure [6].



Fig. 1. ISO 2631-3 severe discomfort boundaries.

## B. Method of Calculation of MSI

Motion sickness incidence of MSI refers to the motion

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sickness not showing any symptom of vomiting, and it is determined by the number of persons who can feel vertical acceleration. It can be known that the symptom of motion sickness is hugely dependent on acceleration and frequency [7].

Maxsurf V20 includes the data for the standard curve provided on the basis of the exposure time for the MSI evaluated at the various points of the ship and the data for the standard curve provided on the basis of the level of the vertical acceleration from the point of interest, and it may overlay the MSI curves which are changing depending on the level of the vertical acceleration from the point of interest [8].

## III. CONDITIONS FOR CALCULATION

To calculate the acceleration by location within the ship cruising in any sea area, the vertical acceleration component from the relevant location shall be calculated. The vertical acceleration is calculated by the method of calculation of the motions of the body of the ship, and the MSI for KVLCC2 is calculated using the vertical acceleration spectrum. The data for KVLCC2 are as described in Table I.

TABLE I:	MAIN	PARTICULARS	OF KVLCC2

Principal dimension	Value
Length between perpendiculars(L)	320m
Breadth moduled(B)	58m
Draught forward	20.0m
Draught after	20.8m
Displacement volume	312622m <sup>3</sup>
Block coefficient	0.809
Mid-ship section coefficient	0.998
Longitudinal center of gravity	11.1m
GM	5.71m
Transverse radius of gyration	0.40B
Longitudinal radius of gyration	0.25L

The conditions for calculation is as described in Table 2, and the average wind speed corresponding to the sea state 5 is 12m/s, the significant wave height is 3m, and the average wave period is 11.9s.

The location of calculation within the ship is as indicated in Fig. 2 by selecting main places of work and areas of accommodation in actual cruise. The coordinate system for the place of measurement of the MSI is as described in Fig. 2. The origin of the x-axis was placed at AP, and the coordinate system O (X, Y, Z) placed on the base line was selected for the origin of the z-axis. For the measuring points of the MSI, the parts of the stern, bow, deck of the portside on which the rolling is most severe, and bottom of the ship were selected, and the coordinate values for their locations are as described in Table II.

TABLE II: CALCULATION CONDITION OF MSI.

Item	Calculation condition
Sea State Number	5
Encounter angler	120°, 150°, 180°
	0 knots, 5 knots, 10
Ship speed	knots, 15knots,
	20knots, 25 knots



Fig. 2. MSI measurement location of KVLCC2.

#### IV. RESULT OF CALCULATION

Fig. 3- Fig. 11 show the results of calculation of the MSIs for the changes in the ship speed under the sea state No. 5. Fig. 3-Fig. 5 show the results for the changes in the ship speed when the angle of incident wave was  $120^{\circ}$ . They show that there is a probability that 10% of the passengers exposed for 8 hours at point A have motion sickness when the ship speed is at least 5 knots per hour, and there is a probability that 10% of the passengers exposed for 8 hours at point A, point B and point C have motion sickness when the ship speed is at least 25 knots per hour.



Fig. 3. Vertical acceleration due to the ship speed (120°, Point A).



Fig. 4. Vertical acceleration due to the ship speed (120°, Point B).

Fig. 6 - Fig. 8 show the results for the changes in the ship speed when the angle of incident wave was  $150^{\circ}$ . They show that there is a probability that 10% of the passengers exposed for 8 hours at point A have motion sickness when the ship speed is at least 5 knots per hour, and there is a probability that 10% of the passengers exposed for 8 hours at point A and point B have motion sickness when the ship speed is at least 10 knots per hours.



Fig. 5. Vertical acceleration due to the ship speed (120°, Point C).



Fig. 6. Vertical acceleration due to the ship speed (150°, Point A).



Fig. 7. Vertical acceleration due to the ship speed (150°, Point B).



Fig. 8. Vertical acceleration due to the ship speed (150°, Point C).



Fig. 9. Vertical acceleration due to the ship speed (180°, Point A).







Fig. 11. Vertical acceleration due to the ship speed (180°, Point C).

Fig. 9 -Fig. 11 show the results for the changes in the ship speed when the angle of incident wave was  $180^{\circ}$ . They show that there is a probability that 10% of the passengers exposed for 8 hours at point B have motion sickness when the ship speed is at least 5 knots, and there is a probability that 10% of the passengers exposed for 8 hours at point A and point B have motion sickness when the ship speed is at least 10 knots.

Fig. 12-Fig. 14 indicate the probability of incident wave for the ship speed when exposed for 120 minutes at each point according to the angle of incident wave under sea state No. 5.



Fig. 12. Percentage of exposure for 120 minutes each angle (Point A).



Fig. 13. Percentage of exposure for 120 minutes each angle (Point B).



Fig. 14. Percentage of exposure for 120 minutes each angle (Point C).

Fig. 13 is for the case of exposure for 120 minutes at point A, and it shows that there is a probability that 7.45% of the passengers have motion sickness when the angle of incident wave was  $120^{\circ}$ . It is shown that the probability of incident wave goes up as the angle of incident wave gets closer to the

side in the case of point A.

Fig. 14 is for the case of exposure for 120 minutes at point B, and it shows that there is a probability that 1.44% of the passengers have motion sickness when the angle of incident wave was  $180^{\circ}$ . It is shown that the probability of incident wave goes up in the case of head-on waves at the point B.

Fig. 15 is for the case of exposure for 120 minutes at point C, and it shows that there is a probability that 0.92% of the passengers have motion sickness when the angle of incident wave was  $120^{\circ}$ . It is shown that the probability of incident wave goes up as the angle of incident wave closer to the side in the case of point C.

## V. CONCLUSION

The results of calculation of the MSI for the changes in the ship speed are as below:

- The ship speed is 5 knots per hour, if the angle of incident wave is 120°, there is a probability that 10% of the passengers exposed for at least 8 hours at point A have motion sickness.
- 2) The ship speed is 10 knots per hour, there is a probability that 10% of the passengers have motion sickness if exposed for at least 8 hours at point A and point B with the angle of incident wave at 120°, at point A with the angle of incident wave at 150°, or at point B with the angle of incident wave at 180°.
- 3) The ship speed is 15 knots per hour, there is a probability that 10% of the passengers have motion sickness if exposed for at least 8 hours at point A and point B with the angle of incident wave at 120°, or 150° respectively.
- 4) The ship speed is 20 knots per hour, there is a probability that 10% of the passengers have motion sickness if exposed for at least 8 hours at point A and point B with the angle of incident wave at 120°, 150° or 180° respectively.
- 5) The ship speed is 25 knots per hour, there is a probability that 10% of the passengers have motion sickness if exposed for at least 8 hours at point A, point B and point C with the angle of incident wave at  $120^{\circ}$ ,  $150^{\circ}$  or  $180^{\circ}$  respectively.
- 6) As the ship speed goes higher, there is a probability of having motion sickness in the order of point A, point B and point C, in the case of point BC with the ship speed not less than 20 knots, there is no probability that 10% of the passengers have motion sickness if exposed for longer than 8 hours.
- 7) It is shown that there is rarely any occurrence of motion sickness at point C as the probability of occurrence of motion sickness is less than 1% if the exposure time is longer than 8 hours at point C, regardless of the ship speed and direction of the incident wave.
- 8) As the ship speed increases, the weight of the vertical acceleration goes higher, and the weight of the vertical acceleration is highest when the angle of incident wave is 120°

Henceforth, I have to draw up a general layout drawing taking the working environment within ships into account,

and I am planning to proceed with the researches on ship design taking account of vertical acceleration.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTIONS

DongHyup Youn and ChungHwan Park conducted the research. DongHyup Youn and ChungHwan Park analyzed the data. DongHyup Youn wrote the paper, ChungHwan Park checked the paper, all authors had approved the final version.

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