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AUTOMATIC PROCEDURE OF SIDE SHIP LAUNCHING CALCULATION

Mochammad Ramzi
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: mochammadramzi@gmail.com

Florin Pacuraru
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: Florin.Pacuraru@ugal.ro

ABSTRACT

The side launching method has become a solution of transporting ship into water in restricted water/canal. Unfortunately, this method brings higher possibility of capsizing mainly occurring when the ship interacts with the water surface. Shipyards need detailed calculations and procedures to predict the outcome of ship in water, yet they are not able to perform due to its complexity of computation and its being time-consuming. Thus, this thesis proposes the automatic procedure of the side ship launching. Using the gravitational side launching theory, a code has been developed to solve the 3D launching case. Computation of ship motions, velocity and acceleration are conducted to predict the actual ship simulation. To simplify things, three phases of analysis are introduced corresponds to the kinematics behaviour of the object when interacts with water. From this study, the result shows a good agreement in comparison to shipyard calculation results with less than 5% differences. However, to be applied in shipyard, this simulation should be done further for the dynamic motion to capture all aspects.

Keywords: Side launching, kinematic, velocity, simulation.

1. INTRODUCTION

Once the ship construction is finished, it will be scheduled to be launched into water. Launching of ship is one of the most important procedures of the ship building process. It requires of the procedure, because during the launching, there are very few possibilities to correct the instabilities that may occur [1].

Numerical study of dynamic behaviour of ship using two methods of launching was described in [2]. The method of release is determined by the building up of a three dimensional mathematical model for two methods for all phases along with the design consideration. The mathematical model requires however to be developed in the 3D program in case of distribution of the drag effect force from bow to stern. It is due to the fact that variation of the drag force may induce instable launch.

A series mathematical models of side launching of ship have been developed by [3]. The approach is based on a model with three degrees of freedom and four phase procedure. A virtual weight and added mass moment have been introduced into mathematical calculation.

In general, commonly used methods for gravitational launching either longitudinal or side launching, are based on the solution of differential equations of ship dynamics or the energy balance [1]. The ship naturally depends upon gravity forces to slide down and vertical buoyancy when ship arrives in the water, force that allows ship to float, meanwhile, friction and water resistance contribute on laterally forces. The launching method for a vessel mostly depends on limited water space, short slipway, high water resistance experienced on ship due to projected area of water impact, short duration and water level and depth. Therefore, the well prepared configuration of launching, method and accurate prediction shall be applied in the preliminary stage.

Nowadays, most of the shipyards pay more attention to the simple 2D static calculation only and neglect the calculation starting from ship touching water to ship floating freely. In this paper, the automatic procedure for ship side launching calculation is developed using a modified mathematical model [1], in which the motion of a ship considers only three degrees of freedom (DOFs). The results obtained will be qualitatively compared to the reference data. The solution of the computational simulation in the kinematics approach to predict the whole phases of side launching and further can be applied to other ship launching case. A 3D practical simulation of this launching will be presented in this paper.

2. MATHEMATICAL MODEL

According to the kinematics assumption, motion of rigid body can be separated into the translation and rotational motions [4]. The basic equation of motion for the situation is depicted below. Sliding stage of ship launching is generally divided into three phases as the action forces vary.

The equations of these stages are basically the kinematics of two bodies applied to an inclined plane with the angle of slipways α, the friction coefficient and effect of drag [5]. This stage creates the relation of the ship and the cradles as one body which travel together having the same acceleration and speed. It is described by the following set of equations [1]:

Translation:

$$m\,x'' = P + W + N + R + B \quad (1)$$

Rotation:

$$I\,\phi'' = MW + MN + MR + MB \quad (2)$$

Where:

P - Gravity force working on G (N)
W - Friction force on slipway (N)
N - Reaction force from slideway (N)
R - Drag force (N)
B - Wind resistant force (N)
M - Mass of body (ton)
x" - Acceleration in translation components
ϕ" - Acceleration in rotational components

Because the ship and cradle slide to the slipway, the motion of the ship will be in translation. Two variables of motion (Y and Z direction) are involved. Motion in X direction is ignored in this case due to the absence of external force acting on this direction. The equation of motion in the coordinate is written in phases as per following and depicted in Figure 1.

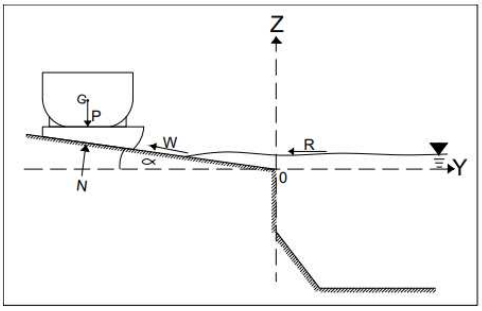


Fig. 1. Coordinate system of launching

Phase 1 the ship and cradle slide on slip way before touching the water. While *dv/dt* is derivative of velocity in Y-direction, *dw/dt* represents the derivative of velocity in Z-direction. Therefore, the governing equation becomes:

$$m\frac{dv}{dt} - m\,g - mg\sin\alpha - mg\,\mu\cos\alpha = 0 \quad (3)$$

$$m\frac{dw}{dt} - m\,g\cos\alpha - m\,g\,\mu\sin\alpha = 0 \quad (4)$$

Phase 2 the ship and cradle move to the slide way, and cradle enters the water. The governing equation can be expressed as:

$$m\frac{dv}{dt} - m\,g - m\,g\sin\alpha$$
$$-m\,g\,\mu\cos\alpha - Ry_{craddle} = 0 \qquad (5)$$

$$m\frac{dw}{dt} - m\,g\cos\alpha$$
$$-m\,g\,\mu\sin\alpha = 0 \qquad (6)$$

When transporting the ship to water, the cradle gives an influence in Y-direction due to the drag force (Ry) acting on front part. Thus, the governing equation will be added an effect of drag force from cradle.

Phase 3 the ship and cradle slide on the slip-way while ship body touches the water and the cradles are fully immersed. The governing equation will be modified to be:

$$m\frac{dv}{dt} - m\,g - m\,g\sin\alpha$$
$$-m\,g\,\mu\cos\alpha - Ry_{craddle} - Ry_{ship} = 0 \qquad (7)$$

$$m\frac{dw}{dt} - m\,g\cos\alpha$$
$$-m\,g\,\mu\sin\alpha - Bz = 0 \qquad (8)$$

In this phase, the ship starts to have its own buoyancy force which actualy replace the reaction force from the slipway and allows the ship to float. Moreover, the drag force appears not only acting on the cradle but on the ship also.

3. SLIPWAY, CRADLE AND SHIP MAIN DIMENSIONS

Initially, some particular data should be gathered and selected. The model characteristics of this case are distinguished into 3 parts, namely the vessel, cradle and slipway.

Fig. 2. Offshore supply vessel launching [6]

In this simulation, the offshore supply vessel is taken as a study case. To support and transport the ship, seven cradles are employed. Summaries of the dimensions of components of the launching are presented in the following Table 1, 2 and 3.

Table 1. Main dimensions of ship [6]

Description	Dimension
LOA	79.8 m
LPP	74.83 m
Breadth (B)	4.83 m
Mean draft (T)	2.652 m
VCG	6.647 m
VCB	1.44 m
Displacement	1933.76 kg

Table 2. Main dimension of cradle [6]

Description	Dimension
Length (m)	22.5 m
Breadth (B)	2.225 m
Height (H)	3.194 m
Centre of Gravity	[38.3, 3.025, 0.94]
Number of cradle	7
Displacement	301.3 kg

Table 3. Main dimension of slipway [6]

Description	Slipway 1A
Length	78.4 m
Distance between slipways	10 m
Water level (from 0 level)	4.83 m
High of the min level (from 0 level)	1.5 m
Inclination	1/8

4. RESULTS AND DISCUSSION

This section presents the flow of calculation used to obtain side launching simulation results. Figure 2 shows the flow on performing the computation.

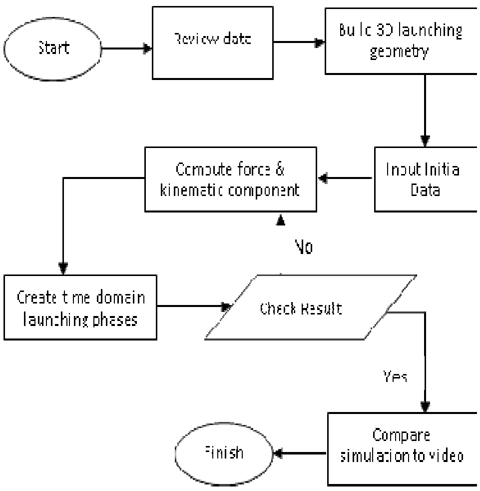


Fig. 3. Flow chart of research

A 3D global model shall be constructed as the domain. The global coordinate system is situated at the edge of the quay and it defines the x coordinate axis along its edge, meanwhile, y and z coordinate directions are defined as perpendicular towards the edge and vertical, respectively. The G center of gravity will be located in the plane defined by these coordinate directions. Figure 4 displays the 3D model side launching in consideration of the water level.

The sliding stage is subdivided in phase 1, phase 2 and phase 3, considering the linear translation of the vessel and the cradles from the moment they started to release to the moment of cradle tipped the ground ways end and ship float.

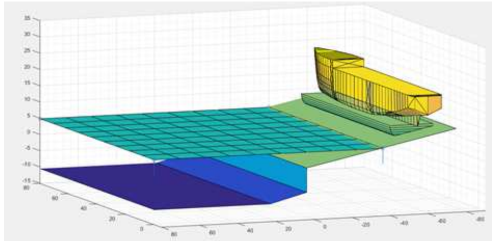
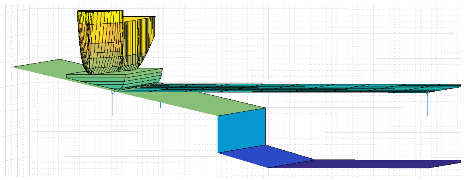
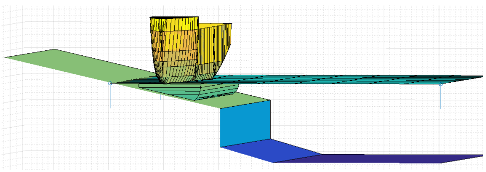


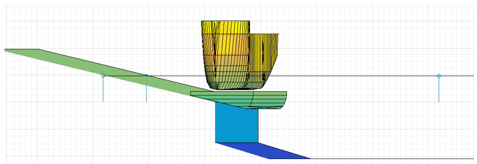
Fig. 4. 3D view model of launching



Phase 1



Phase 2



Phase 3

Fig. 5. Phases illustration of side launching

The computational simulations were performed and the results will be discussed accordingly. The magnitude of forces in function of time at phase 1 indicates constant values at 2.068 MN in the Y direction and -0.174 MN in the Z direction. As the cradle touches the water in phase 2, the summatory of lateral forces reduces moderately due to drag force hit the cradle. Eventually, at phase 3, lateral force drops resulting a decreasing of ship speed and acceleration while vertical force increase due to buoyancy force. The captured summatory forces are displayed in Figure 6.

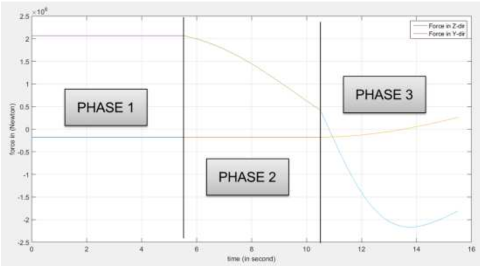


Fig. 6. Summatory forces in function of time for all phases

Correspondingly, the evolution of motion, launching speed, and acceleration of the ship are discussed. The evolution of those parameters can be represented function of time for each of the phases in the figure 7, 8 and 9.

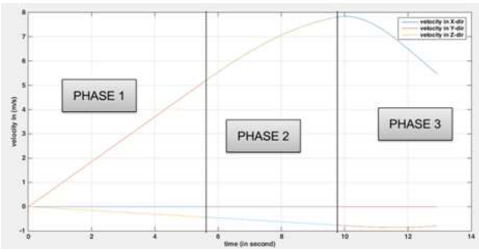


Fig. 7. Evolution of ship velocity in time for all phases

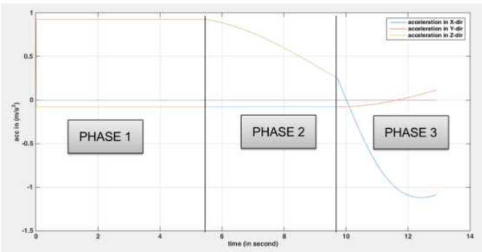


Fig. 8. Evolution of ship acceleration in time for all phases

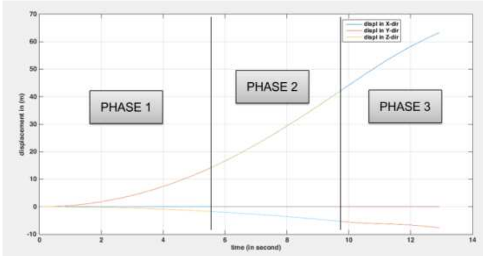


Fig. 9. Evolution of ship displacement in time for all phases

The effect of difference between the reaction force and gravity force due to 7.13 degree platform's angle allow the bodies to slide steady in the Y and Z direction with a steady rise of resultant velocity up to 5.15 m/s at the end of phase 1. In this phase, the friction causes the duration of sliding of 5.53 m/s. As the cradle touch the water, dynamic friction start to reduce and drag force effect arise, contributing to velocity slow increments at phase 2. This may result in a shorter travel time and reduced acceleration. At final step, ship and cradle trends continue to decelerate followed by a decrease of speed as a product of drag force acting on the two bodies on the Y axis and the bouyancy of ship on the Z axis.

The comparison of the result obtained by based on the automatic procedure developed by the author revealed a good correlation with reference data in all phases. Thus, table 4 below presents the output summary against data obtained.

Table 4. Summary result of simulation

	Simulation	**Data**	**Diff.**
Phase 1	x = 14.22 m v = 5.15m/s a = 0.932 m/s^2	x = [-] V = 5.3 m/s a = 0.93 m/s^2	**< 2.7%**
Phase 2	x = 42.44m v = 7.69 m/s a = 0.181 m/s^2	x = 44.27m V = - m/s a = - m/ s^2	**<5%**
Phase 3	x = 63.79 m v = 5.18 m/s a = - 1.11m/s^2	x = 63.66 m V = - m/s a = - m/s^2	**<1%**

Table 5. Comparison of simulation and real case launching duration

	Simulation	Real Case
Phase 1	5.53 s	5.53 s
Phase 2	4.2 s	± 4 – 5 s
Phase 3	3.2 s	± 3 – 4 s
Total	12.93 s	± 12 – 14 s

The comparative analysis presented in Table 4, shows a difference of up to 5%, which is promising. The highest difference can be seen in phase 2 which comes from travel distance output result 1.83 m short due to the accuracy of drag force applied on the cradle.

5. CONCLUSIONS

An automate procedure of ship launching was studied using the numerical code simulation approach based on the aforementioned assumptions and approach. The computational simulation results are appropriately presented and compared. The results from phase 1 to 3 show good agreement to the reference results by the indication of less than 5% difference. Improvement of simulation codes is required to perform phase 4 (dynamic motion of ship in water) in order to capture the whole phenomena of side launching.

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7. REFERENCES

[1]. **Jong D. P.,** "*Numerical simulation of the side launching of a ship"*. Master thesis. University of Groningen, 2004.

[2]. **Leavitt. C. M.**, "*Ship design and construction. Society of Naval Architects and marine engineers"*, New York, pages 657-697, 1980.

[3]. **Ye. Z.,** "*Dynamics of ships side launching"*. Elsevier Science Ltd. Computers & structures Vol 53 no. 4 pp 861-865, 1994.

[4]. **A. Fitriadhy and A.M.A. Malek**, "*Computational fluid dynamics analysis of a ship's side launching in restricted waters",* Journal of Mechanical Engineering and Sciences. Volume 11, Issue 4, pp. 2993-3003, 2017.

[5]. **Cardona J. S.,** "*Design of a controlled side launching system for tugboats"*, Master thesis. University of Galati (EMSHIP), 2017.

[6]. **Damen Shipyard**, *"Ship loading conditions. report of intact stability"*, 2013.

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