

Saeful\_2020\_IOP\_Conf.\_Ser.\_  
Mater.\_Sci.\_Eng.\_875\_012072.p  
df  
*by*

---

FILE	SAEFUL_2020_IOP_CONF._SER._MATER._SCI._ENG._875_012072.PDF (1.14M)		
TIME SUBMITTED	09-OCT-2020 05:31PM (UTC+0700)	WORD COUNT	3710
SUBMISSION ID	1410021252	CHARACTER COUNT	17803

PAPER • OPEN ACCESS

## NC3 CPP Jacket Launching Analysis by Using Numerical Simulation (Case Study of NC3 Gas Field, SK316 Block Bintulu Sarawak Malaysia)

To cite this article: M H M Saeful *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **875** 012072

View the [article online](#) for updates and enhancements.



The banner features a dark blue background with a globe and circuit-like patterns. On the left, there are three circular logos: the top one is 'ECS' (Electrochemical Society), the middle one is 'I&E' (International Association of Analytical Chemists), and the bottom one is 'THE KOREAN ELECTROCHEMICAL SOCIETY'. The central text reads 'Joint International Meeting PRiME 2020 October 4-9, 2020'. Below this, a light blue bar contains the text 'Attendees register at NO COST!'. On the right side, there is a logo for 'PRIME PACIFIC RIM MEETING ON ELECTROCHEMICAL AND SOLID STATE SCIENCE 2020'. At the bottom right, a blue button with white text says 'REGISTER NOW' followed by a right-pointing arrow.

# NC3 CPP Jacket Launching Analysis by Using Numerical Simulation (Case Study of NC3 Gas Field, SK316 Block Bintulu Sarawak Malaysia)

M Saeful M H<sup>1\*</sup>, Juswan<sup>1</sup>, and D Paroka<sup>1</sup>

<sup>1</sup>Department of Ocean Engineering, Engineering Faculty, Hasanuddin University, Makassar, Indonesia

\*Email: saefulmh@gmail.com

**Abstract.** In most relatively shallow waters, fixed platforms are the optimum economical choice. One of the important aspects of offshore fixed platform design is their installation procedure. Among the several conditions during installation, launching is probably the most critical. This operation has to be modelled and examined carefully in order to insure safe separation of jacket from barge. Sensitivity studies are performed to clarify the influences of the initial condition of launch barge to the jacket launch process. Launch analysis is carried out by using numerical simulation methods that supported by MOSES software. Jacket structure and launch barge are modelled on SACS and MOSES respectively. The jacket structure is laid on top of barge with the position of the top of jacket in the stern launch barge. Simulation results on the base case with a barge initial trim is 3.5° and a draft at midship is 6.1 m show that the jacket launch process can take place safely. Sensitivity analysis shows that the greater the trim angle and the initial draft of the barge the shorter the sliding speed and the reaction of the rocker arm decreases. While changes in the LCG jacket and the additional weight of the jacket have a significant effect on the bottom clearance and jacket free floating conditions after being separated from the launch barge.

1

## 1. Introduction

Jacket platform is one of the most widely used platforms in the offshore engineering field. The size of jackets becomes larger and larger with the development of oil and gas exploration. The jackets are transported to the operation water with barges after they have been fabricated in the shipyard, then the jackets slip into the water. This slipping process is called launch and it is the most hazardous stage during the installation of a jacket. Jacket is firstly fixed to the barge at the beginning of a launch operation. Secondly, the ballast of the barge is adjusted to ensure the barge with a predetermined trim. Then, the jacket is released and slides into the sea driven by its gravity or an external force depending on the specific case. Finally, the jacket leaves the barge and reaches a balance position after certain duration. The duration of jacket launch only lasts from 1 to 2 minutes. Moreover, the state of the jacket is out of control after the jacket is released. Therefore, evaluations on every aspect of this process must be made carefully before the launch at sea.

Vasicek and Lu [1] presented a numerical model of jacket launching. They used an iterative finite difference scheme to solve the governing equations of motions. Sphaier et al. [2] describe the theoretical backgrounds of a launch modelling software. In their work, the system of governing differential-algebraic equations is solved (algebraically) at the beginning of time step with accelerations and reaction



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

forces as unknowns. These values are assumed constant through the time step and displacements at the end of time step are calculated. Nelson et al. [3] presents a numerical modelling of a similar case; lifeboat launching. Similar to Sphaier et al. [2], accelerations and reaction forces are calculated at the beginning of each time step. Reactions are considered constant through the step and the resulting system of differential equations is solved using the Runge-Kutta method. Jo et al. [4] found that with large trim and draft, structural loads of jacket tend to decrease. And trim contributing more than draft on structural load. He also did a sensitive analysis on trim, draft of barge and centre of gravity etc. Jo et al. [5] built numerical models to analysis various conditions for the launch procedure and discussed and investigated the launching criteria.

In this article, we conducted a numerical simulation method that supported by MOSES software and performed a sensitivity studies to clarify the influences of the initial condition of launch barge to the jacket launch process.

## 2. General Equation

The Newton-Euler equations of motion state that rate of change of system momentum equals the forces acting on system. We consider jacket and barge as two separate systems, with the common reaction forces acting on both. In practice jacket is placed on barge deck such that their CG's lay in a vertical plane above each other, eliminating any yawing moments. Therefore, launch is essentially a two-dimensional problem. In this regard and by assuming jacket and barge as rigid bodies, position of each body can be represented by three components, namely X, Z and  $\theta$  coordinates of their CG. Equations of motion for these six degrees of freedom are as follows [6]:

$$\left. \begin{aligned} m_j \ddot{X}_j &= P_c^X + P_w^X + P_{F,j}^X \\ m_j \ddot{Z}_j &= P_c^Z + P_w^Z + P_{F,j}^Z - W_j \\ I_j \ddot{\theta}_j &= M_c^Y + M_{F,j}^Y + (P_c^X + P_w^X) \times (Z_c - Z_j) - (P_c^Z + P_w^Z) \times (X_c - X_j) \end{aligned} \right\} \quad (1)$$

$$\left. \begin{aligned} m_b \ddot{X}_b &= P_c^X + P_w^X + P_{F,b}^X \\ m_b \ddot{Z}_b &= P_c^Z + P_w^Z + P_{F,b}^Z - W_b \\ I_b \ddot{\theta}_b &= M_c^Y + M_{F,j}^Y + (P_c^X + P_w^X) \times (Z_c - Z_b) - (P_c^Z + P_w^Z) \times (X_c - X_b) \end{aligned} \right\} \quad (2)$$

where  $m$  is mass,  $I$  is moment of inertia about CG of body. While  $X, Z, \theta$  is component of position vector,  $P$  is forces,  $M$  is moment,  $W$  is weight. Subscript  $j, b$ , denote jacket and barge respectively and subscript  $c, w, F$  denote contact, winch and fluid (hydrodynamic and hydrostatic) forces respectively. Double dot denotes second derivative with respect to time. The hydrodynamic force acting on the jacket barge during the launch process can be expressed with respect to drag force and inertial force as follows [7]:

$$F_h = F_d + F_a \quad (3)$$

$$F_d = \frac{1}{2} C_d \rho A_w V_n |V_n| \quad (4)$$

$$F_a = -M' A_n \frac{dM'}{dt} V_n \quad (5)$$

where  $F_d$  is drag force,  $F_a$  is added mass force,  $C_d$  is drag coefficient,  $\rho$  is water density,  $A_w$  is the submerged area,  $V_n$  is the normal velocity component,  $M'$  is added inertia mass and  $A_n$  is normal acceleration.

### 3. Jacket Launching System

The jacket was successfully launched and installed in 145.27 m deep waters with the assistance of the launching barge. To describe the motion of the jacket launching system, two coordinate system are introduced [8]: the global coordinate system ( $o_g - x_g y_g z_g$ ) and body fixed coordinate system. As shown in Figure 1, the former system is fixed with respect to the earth, and its x-y-plane coincide with the water surface. The jacket fixed coordinate system ( $o_j - x_j y_j z_j$ ) moves with the jacket and its x-y-plane coincides with the jacket waterline. In addition, the barge fixed coordinate system ( $o_b - x_b y_b z_b$ ) moves with the barge and its x-y-plane coincides with the barge keel. The origin of each coordinate system is located in the central plane for simplicity.

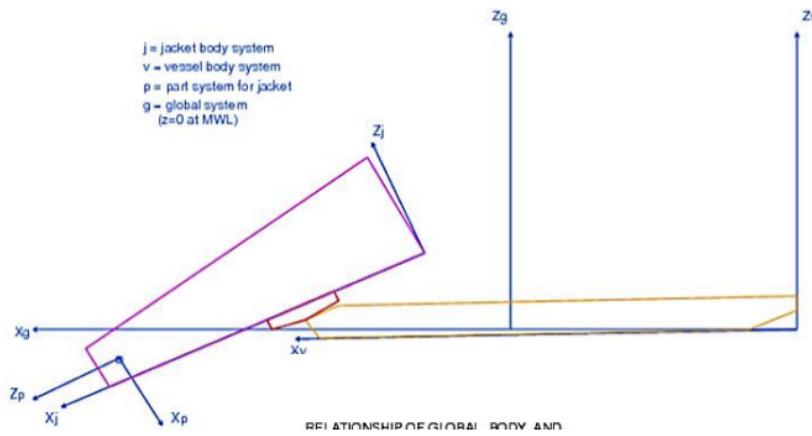


Figure 1. Launch coordinate system

#### 3.1. Launching Barge and Jacket

The jacket is designed for the area near the NC3 and NC8 gas field in Sarawak Malaysia. The barge was built by Heerema Marine Contractors. Detailed information for the jacket and barge is given in the Tables 1 and 2.

Table 1. Main dimension of the jacket

Jacket Details	
Number of Legs	8
Number of Horizontal Levels	6
Water Depth at MSL	104.270 m
Overall Height	115.120 m
Mudline Horizontal to Top Horizontal	103.820 m
Top Horizontal Above MSL	6 m
Length x Breadth at Jacket Top	65 m x 24 m
Length x Breadth at Jacket Bottom	65 m x 48 m

**Table 2.** Main dimension of the barge

Description	Data	
Principal Dimension		
Length Over All	165	M
Breadth	42	M
Depth	10.7	M
Lightship Parameter		
Lightship Weight	11267	MT
LCG	3.65	m Aft of Midship
TCG	0.00	m from centerline
VCG	8.62	m from base line
Deck Loading	20	MT/m <sup>2</sup>
Maximum Allowable Rocker arm Reaction (each)	7500	MT
Rocker arm Height	2	m
Rocker arm Width	2	m
Rocker arm Length	10	m
Skid Beam Height	2.05	m
Skid Beam Width	2	m
Skid Beam Length	145	m
Skid Beam Spread	13 m (min) to 35 m (max)	

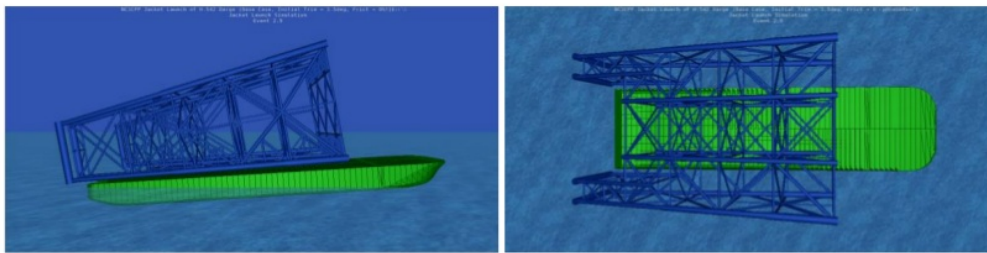
### 3.2. Launching Condition

To initiate the launching process, the barge was ballasted to the launching condition with the mid-ship draft of 6.1 m and trim of 3.5° for base condition. The initial conditions include the barge trim and draft, the longitudinal position of the jacket COG (LCG) and the jacket weight. To quantify the effect of these parameters, the critical launching process, including the jacket pitch motion, the launch velocity, the bottom clearance of jacket and the maximum rocker arm force under the specified condition, are investigated. The non-dimensional values describing every type of launching response under various conditions depend on the ratio of every value to its maximum value. The sensitivity analyses are conducted using the numerical method and the relevant initial condition are listed in the Table 3 as follows:

**Table 3.** Launch initial condition

Items	Cases	Trim (deg)	Draft (m)	LCG deviation (m)	Weight % (ton)
Base Condition	Case 0	3.5	1.0	0.0	0.0
	Case A-1	2.0	1.0	0.0	0.0
Initial trim condition	Case A-2	3.0	1.0	0.0	0.0
	Case A-3	4.0	1.0	0.0	0.0
	Case A-4	5.0	1.0	0.0	0.0
	Case A-5	6.0	1.0	0.0	0.0
	Case A-6	7.0	1.0	0.0	0.0
	Case A-7	8.0	1.0	0.0	0.0
	Initial draft condition	Case B-1	3.5	1.5	0.0
Case B-2		3.5	2.0	0.0	0.0
Case B-3		3.5	2.5	0.0	0.0
Case B-4		3.5	3.0	0.0	0.0
Case B-5		3.5	3.5	0.0	0.0

Items	Cases	Trim (deg)	Draft (m)	LCG deviation (m)	Weight % (ton)
LCG Condition	Case C-1	3.5	1.0	+1.75	0.0
	Case C-2	3.5	1.0	+0.75	0.0
	Case C-3	3.5	1.0	0.0	0.0
	Case C-4	3.5	1.0	-0.75	0.0
	Case C-5	3.5	1.0	-1.75	0.0
Jacket Weight	Case D-1	3.5	1.0	0.0	+5%
	Case D-2	3.5	1.0	0.0	-5%



**Figure 2.** Initial launch condition

### 3.3. Launching Stages

The launching operation can be divided into four stages [9]:

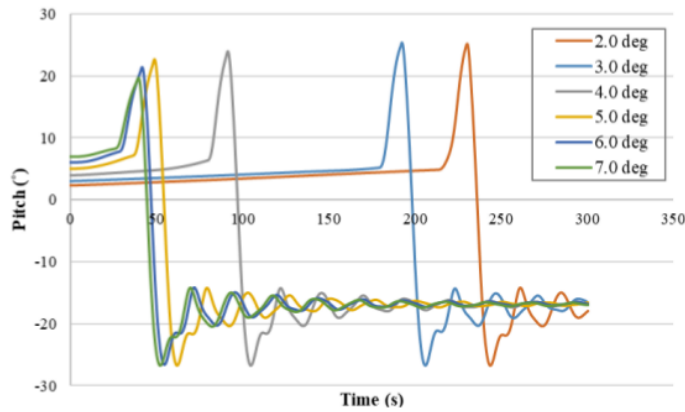
- Ballasting stage: the barge is ballasted to achieve the desired trim and draft.
- Sliding stage: the jacket slides on the barge due to its self weight without tipping of the rocker arms.
- Tipping stage: the jacket slides with tipping of the rocker arms until the rocker arms rotate up to the maximum allowable angle and the jacket is launched into the sea.
- Self-righting stage: the jacket once freed from the barge, oscillates a few times and comes to rest.

## 4. Sensitivity Analysis

Sensitivity analysis are carried out to quantify the effect of the initial launch conditions such as the trim and draft barge, the longitudinal position of the jacket COG, and the jacket weight to the critical launching process, including the jacket pitch motion, the launch velocity, the bottom clearance of jacket and the maximum rocker arm force [9, 10].

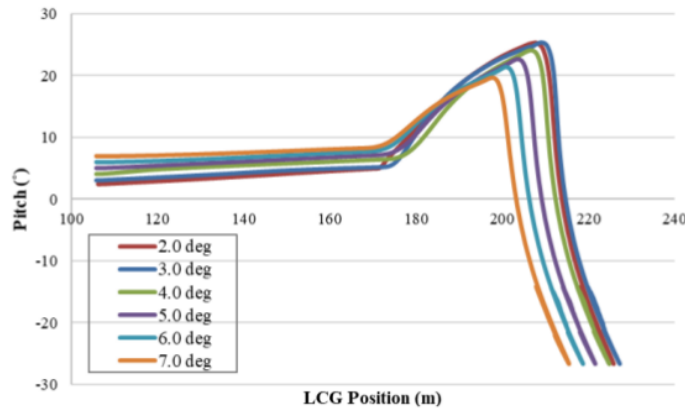
### 4.1. Barge Trim and Draft

For a successful launching operation, the pitch motions should be investigated to insure the stability of the jacket [8]. Figure 3 shows the time series of the pitch motions that obtained from the numerical simulation. The tipping time occurs when the relative angle of the jacket begins to increase significantly.



**Figure 3.** Comparison of the jacket pitch motion to time

Jacket begins to separate from the launch barge when the relative angle of the jacket is decrease significantly. As the initial trim angle increases, the time taken for the jacket to slide and then separate from the barge is also getting shorter. For an initial jacket angle of  $7.0^\circ$  it only takes 40 s from the jacket begin to slide until the jacket separated from the barge. Whereas the initial trim angle of  $2.0^\circ$  takes 180 s from the jacket begin to slide until the jacket separated from the barge. Figure 4 shows a graph of the comparison of pitch jacket motion to the position of the longitudinal centre of gravity jacket. The jacket's maximum trim angle decreases as the initial trim angle of the barge increases. This is due to the large trim angle conditions, some of the jacket structure has been submerged in water and has buoyancy so that the gravity of the structure that acting is corrected by the buoyancy force at the initial launch conditions.



**Figure 4.** Comparison of the jacket pitch motion to LCG position

Variation of the critical launching responses against the barge trim are presented in Figure 5. Through a comparison of these eight trim conditions, one can conclude that the initial trim has a slight effect on the maximum rocker force. Taking the maximum rocker arm force under the trim of  $2.0^\circ$  as the reference, the corresponding values in case A-2, case 0, A-3, A-4, A-5, A-6 and A-7 are reduced by 4.0%, 11%, 21%, 33%, 42%, 48% and 52% respectively. Clearly, a large trim lead to a reduction in the maximum rocker arm force. Similar trends are evident in the free sliding, tipping time, and separate time. A large trim corresponds with more rapid launching.

By contrast, the trim exerts no noticeable effect on the bottom clearance. A possible contribution to this interesting phenomenon may be the jacket gravity. As the initial trim angle increases, the friction on the jacket decreases, which result in a higher sliding velocity. Moreover, the effect of increasing

displacement and velocity during the tipping stage, thereby increasing the hydrodynamic force on the jacket, directly reduces the maximum rocker arm force.

The same analysis is also carried out on the maximum trim barge due to trim variations. The maximum trim barge increases with increasing initial trim angle. This is caused by the shift of the jacket COG above the barge. Movement of the jacket over the barge will cause a moment so that the location of the barge COG will shift into another point which causes the barge will have a trim by stern [10].

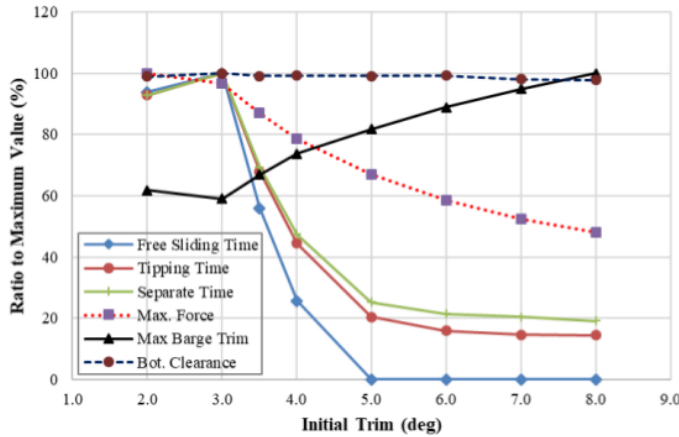


Figure 5. The effect of initial trim variation to launch responses

Figure 6 shows the influences of the barge draft on the jacket motion and maximum rocker arm force. A slight correlation is observed between the draft and the maximum rocker arm force. More specifically compared with case 0 the maximum rocker loads in case B-1, B-2, B-3, B-4 and B-5 are reduced by 4.0%, 8.0%, 11%, 14% and 17% respectively. This indicates that a large draft can also reduce the maximum rocker arm force. The opposite relationship is observed between the tipping time and the draft. In addition, there is no explicit correlation between the bottom clearance and the draft. One possible reason for this phenomenon may be that the buoyancy increases due to the larger displacement, which results in a longer tipping time. Correspondingly, the maximum rocker arm force decreases slightly with a larger draft due to the compensation for the jacket weight by the buoyancy.

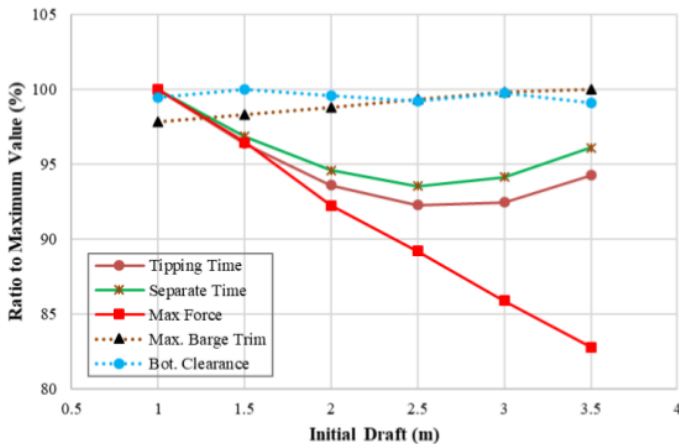


Figure 6. The effect of initial draft variation to launch responses

4.2. Longitudinal Position of the Jacket COG

Figure 7 shows the influences of the jacket LCG on the motion responses and rocker arm force. A positive LCG deviation means that it moves closer to the barge stern, whereas a negative value indicates a farther distance from the barge stern. As shown in Figure 7, the bottom clearance is reduced by 15 m as the deviation of the jacket LCG changes from +1.75 to -1.75. In addition, a longer duration will be generated when the jacket COG moves farther from the barge stern. From the structural load perspective, the maximum value of the rocker arm force is 3038 MT. The maximum rocker arm force from LCG position of -1.75 to +0.75 are increase by 3.1% to the maximum value.

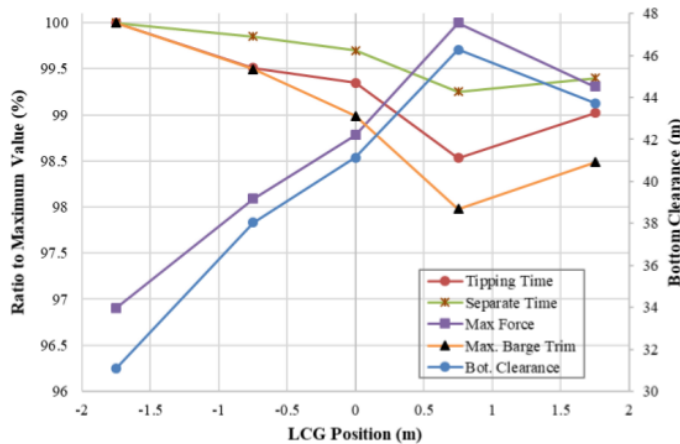


Figure 7. The effect of initial LCG variation to launch response

4.3. Jacket Weight

Analysis of adding a jacket weight to the launching process aims to determine whether the final condition of the jacket after the launch process is complete still meets the safety requirements or not. Table 4 is a comparison data of the launching responses on cases of structural weight changes.

Table 4. The launching responses on cases of structural weight changes

Items	Units	Base Case	Case D-1 (+5%)	Case D-2 (-5%)	Allowable Value	Remarks
Jacket Weight	MT	7620	8001	7239	-	
Max. Rocker arm	MT	3001	3162	2833	7500	OK
Bottom Clearance	m	41	31.02	43.13	10.427	OK
Floating Weight	MT	7620	8001	7239	-	
Total Buoyancy	MT	8983.48	8983.48	8983.48	-	
Reserve Buoyancy	%	17.89	12.28	24.10	10	OK

The maximum reaction that occurs in the rocker arm with the addition of 5% by weight of the jacket structure is 3162 tons. This value still meets the maximum reaction limit of the H-254 rocker arm barge which is 7500 tons. Likewise, the minimum reserve buoyancy and bottom clearance required by Nobel Denton. Nobel Denton requires that the reserve buoyancy jacket in the intact condition must be greater than 10% and the minimum bottom clearance is 10% of the water depth to prevent damage to the jacket structure due to collision with mudline [9]. Based on the simulation data in Table 4 shows that the reserve buoyancy jacket with the addition of 5% structure weight is 12.28% and the bottom clearance is 31.02 m. This value still meets the minimum requirements so the jacket is safe to launch.

## 5. Conclusion

The greater the trim angle and the initial draft of the barge the shorter the launch speed and the reaction of the rocker arm will be smaller and the bottom clearance of the jacket decreases if the LCG jacket moves towards the bottom of the jacket (the LCG jacket deviation is negative). Bottom clearance for various changes in LCG jacket still meets the minimum required value.

## References

- [1] Vasicek, Daniel and Lu, Cheng-Heng (1979). "Launch and floatation analysis of offshore structures part 2 – barge and jacket interaction on launch analysis." *Petroleum Engineer International*, Vol. 51, No. 6, PP. 10-16.
- [2] Sphaier, S. H., Vasconcellos, J. M., Esperanca, P. T. T. and Ferreira, M. D. A. (1985). "The study of jacket installation using INPLA system." *Proc. Of the 5th International Symposium on Offshore Engineering*, Federal University of Rio de Janeiro, Brazil, PP. 541-573.
- [3] Nelson, J. K., Fallon, D. J. and Hirsch, T. J. (1991). "Mathematical modeling of free-fall lifeboat launch behavior." *Proc. of International Conference of Offshore Mechanics and Arctic Engineering*, PP. 695-702.
- [4] Jo, C. H., Kim, K. S., Kim, J. H., etc. Criterion of offshore jacket launching analysis[A]. In 2001.
- [5] Jo, C. H., Kim, K. S., Lee, S. H. Parametric study on offshore jacket launching[J]. *Ocean Engineering*, 2002, 29 (15): 1959-1979.
- [6] Nourpanah, N., Pirooz, M. D. 2008. Numerical Modeling of Launching Offshore Jackets from Transportation Barge & the Significance of Water Entry Forces on Horizontal Jacket Members. *Journal of Faculty of Engineering*. Vol. 42, No. 6. PP. 809-821.
- [7] R., H. M., D., P. M., R., B. M. A physical and numerical modeling for launching of jackets (case study on Balal PLQ Platform)[J]. *Journal of Offshore Mechanics and Arctic Engineering*, 2008, 130 (3).
- [8] Ultramarine Inc. 2001. Reference Manual for Moses.
- [9] NOBLE DENTON NO:0028/NDI. 2005. Guidelines for The Transportation and Installation of Steel Jackets.
- [10] Hu, Z., Li, X., Li, J., Yang, J.M. 2016. *Comparative Study on a Jacket Launching Operation in South China Sea*. *Ocean Engineering* 111 (2016) 335–347.

ORIGINALITY REPORT

---

% **29**

SIMILARITY INDEX

%

INTERNET SOURCES

% **29**

PUBLICATIONS

%

STUDENT PAPERS

---

MATCHED SOURCE

---

**1**

Xiong, Lingzhi, Jianmin Yang, Xin Li, and Xin Xu. "Study on Numerical Simulation of Jacket Launching Progress", Volume 5 Ocean Engineering, 2013.

Publication

% **9**

---

9%

★ Xiong, Lingzhi, Jianmin Yang, Xin Li, and Xin Xu. "Study on Numerical Simulation of Jacket Launching Progress", Volume 5 Ocean Engineering, 2013.

Publication

---

EXCLUDE QUOTES ON

EXCLUDE BIBLIOGRAPHY ON

EXCLUDE MATCHES < 5 WORDS