Journal of Ocean, Mechanical and Aerospace
-Science and Engineering-, Vol.11

September 20, 2014

Motion of Ship-Shaped Floating Liquefied Natural Gas

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Paper History

Received: 2-September-2014
Received in revised form: 14- September -2013
Accepted: 17- September -2014

ABSTRACT

Floating Liquefied Natural Gas (LNG) recently are new in the offshore platform and operation, since it is new so it is important to analyzed the stability and seakeeping of this vessel. This project are conducting stability assessment and seakeeping of Floating Liquefied Natural Gas (LNG) with initially it has to design the hull by referring the basic dimension of FPSO KIKEH that located at the 120 km northwest of Labuan Island which is the environmental location of this project. Hence this project are using Maxsurf for designing the hull, Hydromax to do stability assessment and Seakeeper for seakeeping analysis which is to generate wave spectrum and Response Amplitude Operator and hence to analyzed the motion characteristic of this vessel behavior in the research location.

KEY WORDS: *Floating Production Storage Offloading; Seakeeping; Stability*.

NOMENCLATURE

FLNG	Floating Liquefied Natural Gas
FPSO	Floating Production Storage Offloading
LPG	Liquefied Petroleum Gas
LNG	Liquefied Natural Gas
RAO	Response Amplitude Operator
IMO	International Maritime Organization
VLCC	Very Large Crude Oil Carrier

1.0 INTRODUCTION

Floating Liquefied Natural Gas is the floating natural gas vessel that has same functioning and technology of Floating Production Storage Offloading vessel but the difference between two of them is this FPSO are their processing petroleum and gas also they are producing the Petroleum and transfer these product to the LPG or LNG tankers. Then the FLNG vessel is that has same technology of processing and producing, but they are focusing on the natural gas only. Furthermore FLNG are the floating platform that has facilities processes gas into liquids, this platform also functioning to store this liquids gas in the platform and this platform producing LNG in offshore area.

The important to establish the Floating Liquefied Natural Gas rather that the LNG conventional facilities are to reducing the total cost operating of the operation due to the less using pipelines that been using in the conventional facilities, and FLNG has the special functioning, let say if the field of the source are depleted, this vessel can be moved to the new location that has new source.

Usually this vessel is not moving but then it's in the condition of static, so in order to get this vessel in stable condition the research has to be investigate the adequate stability of vessel this will include the intact stability and also the hydrodynamic consideration of the vessel. This is because this vessel is located at the sea condition that has irregular sea condition that we not been able to predict. Moreover this vessel facilities has various liquid that tend to be flame or blow if design of the vessel and the choice making of sea condition not properly been choose, if we choose the high beam that has recently bad condition weather this vessel will collapse of capsize due to the high beam of wave.

Stability is one most mandatory design stage that needed to be carefully done by the designer in order to maintain the vessel in the upright position for long time of period because the failure of the stability on the vessel may cause many facilities above deck, under deck, mooring lines and turret for Floating Liquefied Natural Gas.

Based on my study, found that there is two problem that usually faced by the designer regarding the stability of the floating LNG vessel there are environmental impact on the big vessel like VLCC hull type which is effect on the stability and lastly are problem on the hull design, when it operate on the seaworthiness it roll angle excessive of more the 5° of rolling angle.

The objectives of the project were to design hull of Floating LNG by using basic dimension from FPSO KIKEH, based on the stability assessment by IMO criteria and determine wave spectra of Roll, Pitch and Heaving by using Pierson-Moskowitz formula, determine Response Amplitude Operator of heave, pitch and rolling motion and analyze motion characteristics in term of heaving, rolling and pitching in head, beam, and following seas.

The scope of study for this project will focus on the motion and stability of Floating Liquefied Natural Gas vessel motion of heave, pitch and roll motion. Furthermore, for this analysis we located the location of analysis at South Sea of China, the specific location is at 120 kilometers northwest of Labuan. Then, Figure.1 showed the picture of the exact location of the analysis; this picture was taken from Google Earth. Moreover, this project will cover ship condition in lightship and full load condition.

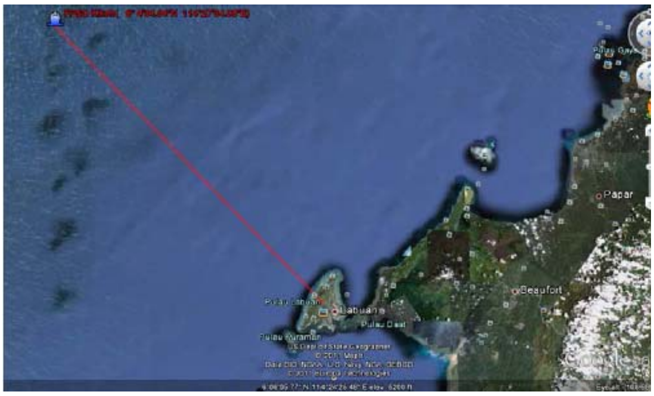

Figure.1: Location of FPSO KIKEH.

2.0 SIMULATION

This paper calculated and analyzed using commercial software which is MAXSURF for designing the model of floating LNG, HYDROMAX for stability assessment and SEAKEEPER for estimation Response Amplitude Operation and wave spectrum analysis.

In the simulation, wave data is collected from the Malaysia Metrology Department of Malaysia. All the data are the wave data, which is, contain the wind speed, wave period and wave frequency, which is the data from 1995 until 2008. Then all the data are analyzed by using Microsoft excel to get the significant wave data. Thus, Table.1 is the data that are been analyzed and summarized indicate the environment condition.

Moreover, after the wave, data were collected then the initial designs of Floating LNG are begin by using MAXSURF software. These designs are not fully design but it is design by using basis ship that taken from MAXSURF design that is the VLCC design of hull. So the detailed information about the design particular will be discussed.

Then the next step, are when finish the design of floating LNG, the generating the offset data from MAXSURF software. This offset data are important to use in the calculation of equation of motion. Then after all, the offset data been set, hydrostatic data need to be generated or calculated by using HYDROMAX software. This hydrostatic data are important to overview the characteristic of vessel when in the static condition.

Then the project will proceed to the stability calculation and assessment by using HYDROMAX and calculation. From the HYDROMAX the stability assessment will carried out the GZ curve analysis by using IMO criteria that usually using for indicating the stability of the vessel. Then after the stability then proceed to calculate the added mass of the vessel by using the SEAKEEPING software that will generate the result of added mass of vessel.

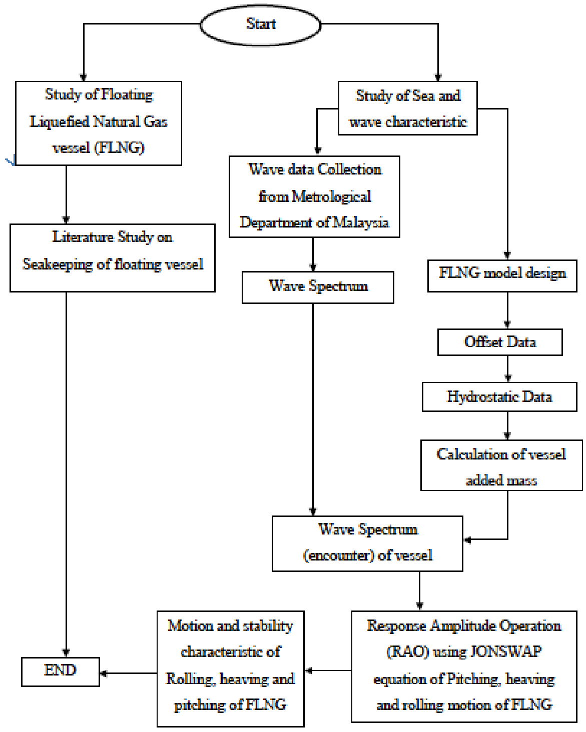

Figure.2: Flowchart to analyze Floating LNG

Table.1: Environmental Condition

Return Period (year)	Wind speed (knot)	Wave period (sec)	Wave height (meter)
1	30	8	3.5
10	45	14	4
100	45	14	4

After analyzing and calculating added mass of vessel, wave spectrum and wave encounter spectrum by using JONSWAP formula were estimated using the SEAKEEPER software. This software analyzed motion of the vessel such as rolling, pitching and heaving.

3.0 RESULT AND DISCUSSION

3.1 Hull Design and Tank Arrangement

The floating LNG models were design by using MAXSURF. The principal particular of this vessel is length of 337 meter, breadth of 54.56 meter, depth of 27 meters and with draught of 13.51 meters. Lines plan, half breadth and body plan, hydrostatic data and tank design is shown in Figures.3, Figure.4 and Figure.5, respectively.

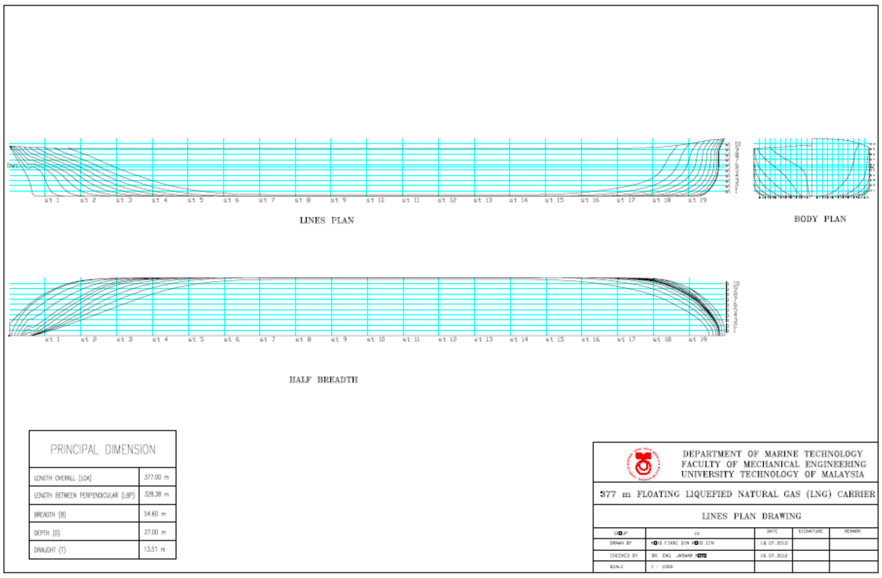

Figure.3: Lines plan, half breadth and body plan.

Draft at Amidship m	0	1.93	3.86	5.79	7.72	9.65	11.58	13.51
Displacement tonne	336.3	24148	51757	80796	110632	141078	172036	203491
Heel to Starboard degrees	0	0	0	0	0	0	0	0
Draft at FP m	-0.243	1.687	3.617	5.547	7.477	9.407	11.337	13.267
Draft at AP m	0.243	2.173	4.103	6.033	7.963	9.893	11.823	13.753
Draft at LCF m	0.096	1.916	3.846	5.776	7.706	9.637	11.569	13.501
Trim (+ve by stern) m	0.487	0.487	0.487	0.487	0.487	0.487	0.487	0.487
WL Length m	158.183	318.035	320.332	322.107	323.763	325.493	327.107	328.52
WL Beam m	41.752	52.416	54.465	54.6	54.6	54.6	54.6	54.6
Wetted Area m^2	4293.219	13744.567	15367.384	16789.576	18161.98	19481.54	20814.57	22178.22
Waterpl. Area m^2	4291.394	13410.085	14398.981	14897.174	15243.22	15520.7	15768.09	16029.97
Prismatic Coeff.	0.268	0.732	0.763	0.782	0.797	0.81	0.82	0.83
Block Coeff.	0.105	0.634	0.691	0.73	0.757	0.777	0.793	0.806
Midship Area Coeff.	0.821	0.938	0.943	0.96	0.97	0.976	0.98	0.983
Waterpl. Area Coeff.	0.313	0.779	0.805	0.831	0.85	0.866	0.879	0.894
LCB from Amidsh. (+ve fwd) m	-83.466	5.194	7.575	8.375	8.696	8.779	8.686	8.411
LCF from Amidsh. (+ve fwd) m	-64.956	9.599	9.769	9.716	9.381	8.746	7.648	6.07
KB m	0.071	1.003	2.011	3.019	4.023	5.027	6.031	7.036
KG m	8.469	8.469	8.469	8.469	8.469	8.469	8.469	8.469
BMt m	1341.579	110.134	60.934	41.665	31.63	25.522	21.426	18.504
BML m	16099.46	3393.77	1780.011	1231.466	953.128	783.711	670.922	594.362
GMt m	1333.057	102.676	54.487	36.228	27.198	22.094	19.001	17.084
GML m	16090.94	3386.312	1773.564	1226.028	948.695	780.282	668.496	592.942
KMt m	1341.65	111.137	62.944	44.684	35.654	30.549	27.457	25.54
KML m	16099.53	3394.773	1782.022	1234.484	957.152	788.738	676.952	601.399
Immersion (TPc) tonne/cm	43.995	137.48	147.618	152.726	156.274	159.118	161.654	164.339
MTc tonne.m	164.788	2490.16	2795.397	3016.566	3196.183	3352.239	3502.213	3674.357
RM at 1deg = GMt.Disp.sin(1) tonne.m	7823.924	43271.409	49217.387	51083.756	52512.95	54397.63	57048.67	60670.61
Max deck inclination deg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Trim angle (+ve by stern) deg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Figure.4: Hydrostatic data.

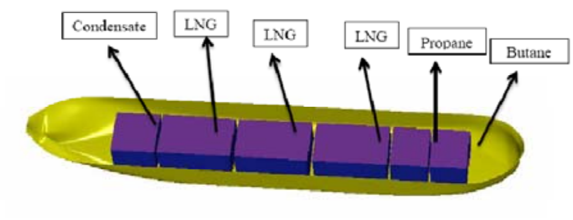

Figure.5: Tanks arrangement.

3.2 Stability Analysis

Stability of a ship is very important especially to the floating structure that is faced the weather condition during the operation. In order to estimate whether the ship or floating structure is stable or not it must pass all the IMO stability criteria which is from A.749 (18). Thus, in order to evaluate this criterion the GZ and KN curve must be calculated and generated by using HYDROMAX software, which is software to evaluate and analyzed the stability of ship. Before stability assessment is determined, loading condition is firstly to determine, thus Table A.1 is the result of full load condition.

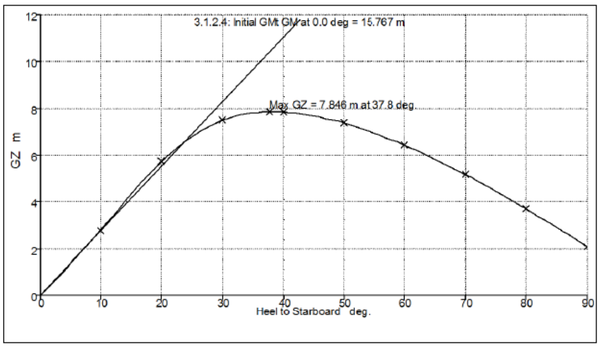

Figure.6: GZ curve for full load condition.

The stability criteria should be obeying the rule from IMO stability criteria A.749 (18). In order to state the ship or vessel are stable it has to pass the minimum requirement that list down from Table.2 is the result from the stability criteria calculated from GZ curve both from Figure.6.

Table.2: Full Load Condition

Item Name	Weight (tonne)	LCG (from mid-ship) m	VCG (From Keel) m	Free surface moment (tonne.m))
Lightship	133480	4.317	6.715	0
Condense Tank	7380	-94.012	11.81	27675
LNG Tank	15000	-52.414	11.81	56250
LNG Tank	15000	-0.187	11.81	56250
LNG tank	15000	52.982	11.81	56250
Propane tank	8700	92.612	11.81	32625
Propane tank	9015	119.032	11.81	33806.248
Total	203575	LCG=8.680	VCG=8.469	262856.25

FS corr.=1.291

VCG fluid=9.761

3.3 Ship Motion

Pitching and heaving are calculated by using Strip Method and for Rolling are by approximation because from referring to the Bhattacharya of Dynamics of Marine Vehicle mention that if there is no data for rolling motion so it can be approximate the added mass from 10-20% of mass of ship of added mass.

Thus from SEAKEEPER software the software that are analyzed the motion of this project model of Floating LNG Carrier, hence from Figure.7 show the result for Wave spectral, while Figure.8 shows the encounter wave spectral density result, and Figure.9 shows the result of three type of motion spectral density which is heave, pitch and rolling motion.

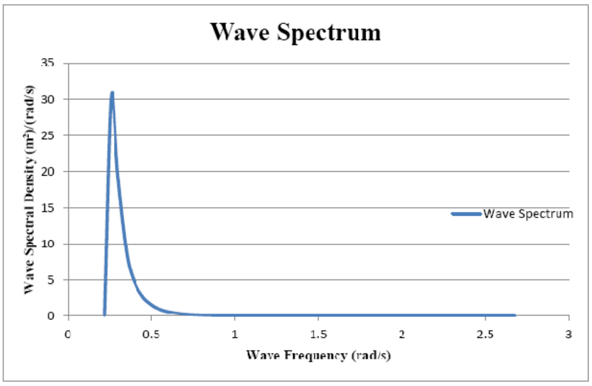

Figure.7: Wave spectrum.

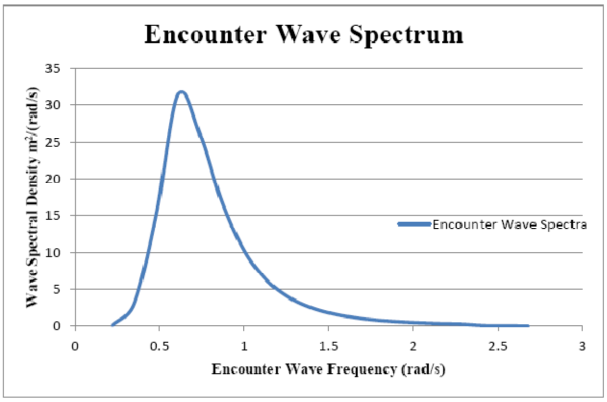

Figure.8: Encounter wave spectrum.

In order to know whether this vessel is suitable to operate at the desired location of the research it is essential to generate the Response Amplitude Operator (RAO) of the ship. Hence, RAO of the ship was analyzed by SEAKEEPER Software, which generate three different types of RAO motions, which are heave, pitching and rolling motion. The result for RAO four types of wave heading which are 0°, 60°, 90° and 18°0 wave heading are shown in Figures.9, 10, and 119.

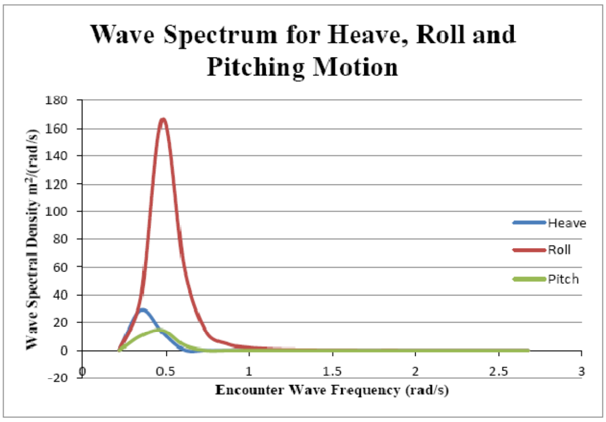

Figure.9: Wave Spectrum for heave, pitch and rolling motions.

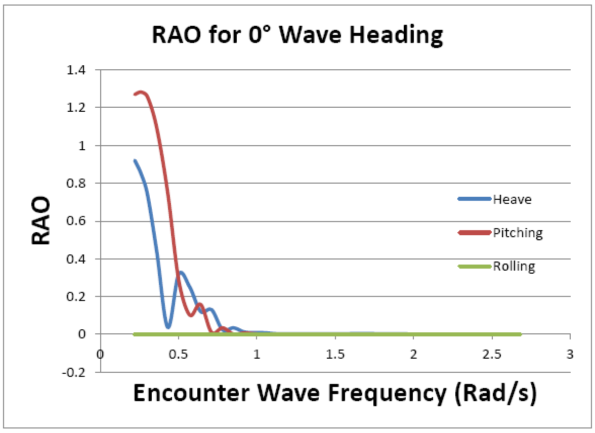

Figure.8: RAO result for 0° wave heading.

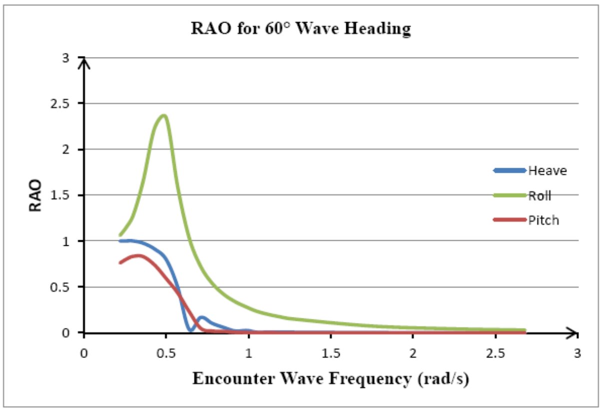

Figure.10: RAO result for 60° wave heading.

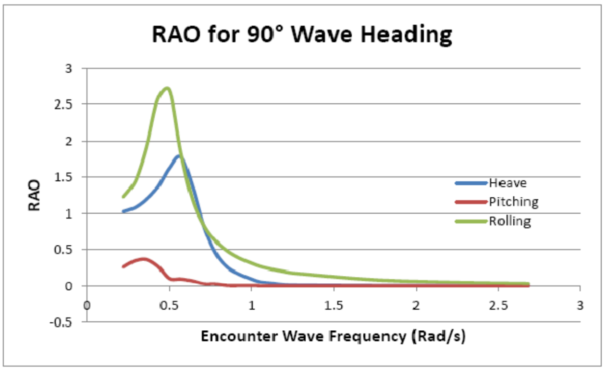

Figure.11: RAO for 90° wave heading

Table.3: Added mass for heave, pitch and rolling motion.

Motion Added mass	Added Mass (Tonnes)	% mass of Ship
Heaving	199206.65	98%
Pitching	176541.304	86%
Rolling	30536.228	15%

Table.4: IMO Stability Criteria

IMO Stability Criteria		Result			
Criteria	**Required**	**Lightship**	**Status**	**Full Load**	**Status**
Area 0 to 30	Shall not less than 3.151 [m.deg]	190.468 [m.deg]	PASS	123.868[m.deg]	PASS
Area 0 to 40	shall not be less than 5.157 [m.deg]	313.482 [m.deg]	PASS	201.454[m.deg]	PASS
Area 30 to 40	shall not be less than 1.719 [m.deg]	123.014 [m.deg]	PASS	77.586[m.deg]	PASS
Maximum GZ at 30 or greater	shall not be less than 0.2 [m.deg]	11.667 [m.deg]	PASS	7.491[m.deg]	PASS
Angle of maximum GZ	Shall not be less than 25 [deg]	41.6 [deg]	PASS	37.8[deg]	PASS
Initial $GM_{tranverse}$	Shall not be less than 0.35 [m]	24.952 [m]	PASS	15.767[m]	PASS

5.0 CONCLUSION

Finally, from this Stability of Floating Liquefied Natural Gas (LNG) projects are concluding that:

1. Hull of Floating LNG was successfully design by using Maxsurf.
2. Wave spectrums for roll, pitch and heaving motion have been identified by using Pierson – Moskowitz wave spectra.
3. This Floating LNG is stable and safe to operate production facilities with pass all the IMO stability criteria.
4. Response Amplitude Operator (RAO) for heave, pitching and rolling motion was identified and analyzed.
5. Rolling angle of Motion Characteristic analysis was identified and archived the degree of rolling angle below 3°.

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ACKNOWLEDGEMENTS

The authors would like to convey a great appreciation to Ocean and Aerospace Engineering Research Institute, Indonesia for supporting this research.

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