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# Measurement of Maximum Vibration After the Addition of the Gorger Construction to Evaluate the Side Deck Girder Construction Planning in the Ship Engine Room

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ABSTRACT: The greatest vibration occurs in the engine room, but all other parts of the ship also experience vibrations because it is propagating. Even though there are methods to reduce these vibrations such as engine beds, they can only reduce the damaging effects and cannot completely eliminate the vibrations themselves. The method used in this research is to compare the measurement of good vibrations in the conditions before the addition of construction and after the addition of construction for later comparison with numerical calculation data. The purpose of this study is to obtain the maximum vibration value in the conditions after the addition of the gorger construction before the addition of the side deck girder construction as a means of evaluating the side deck girder construction planning in the ship engine room ship 2000 DWT. The result consideration of adding construction becomes one or the alternative in providing reinforcement so that it can reduce the vibration that occurs. From analyze results after addition of a sized T profile FB 180 x 8 mm FP 75 x 10 mm, which ranges from 28 - 29 $m/s^2$ for the x-axis vibration value, while for vibrations on the y-axis the maximum is 10-11 $m/s^2$, and on the maximum z-axis. at 20-21 $m/s^2$, this analyze vibration is based on the time between 0 - 15 seconds or per 15 second interval, able to reduce percentage of vibration in the ship engine room area is 34.91%.

## 1 INTRODUCTION

KM. Sabuk Nusantara is a ship built to fulfill the government of Indonesia's program on TOL LAUT through the ministry of Transportation. Like other sister ships, the Sabuk Nusantara ship, is also a development of previous designs [1]. This ship is pioneer ships to carry out inter-island shipping in Indonesian sea. The vibrations that occur on the ship have a side effect that has a large enough effect on the resistance of the ship construction [2]. In planning a construction of the internal part of the ship, see from the design ability and the capacity of the stress modulus it can accept [3, 4]. A construction that is constantly subjected to vibrations is at great risk of structural failure because the vibration itself is destructive [5].

The greatest vibration occurs in the engine room, but all other parts of the ship also experience vibrations because it is propagating. Even though there are methods to reduce these vibrations such as engine beds, they can only reduce the damaging effects and cannot completely eliminate the vibrations themselves [6]. The propeller design planning can also affect the vibrations that occur due to the less effective pitch planning immersed in a draft of ship [7, 8]. From the phenomenon that occurs, corrective steps can be taken to reduce vibrations that occur in the engine room of the ship. Ship vibration measurement process KM. Sabuk Nusantara 71 is carried out in several parts, and for a while it shows a fairly large indication of local vibrations in the engine room section of the ship, see figure 1.

Figure 1. Ship vibration measurement

Previous research has shown the path integration method is used to address a stochastic response of excited marine risers parametrically and externally with correlated noise [9 – 11]. On the basis of the nonlinear vibration equation, a vibration suppressor, first-order vibration modes are studied and their regulatory equations are formulated [12]. In the research with the title "Probabilistic analysis on parametric random vibration of a marine riser excited by correlated Gaussian white noises", Zhu et al. [13] explain the results of the different time interval approaches are compared with the results of the Monte-Carlo model (MCS) simulation to show adequate time intervals. After that, the path integration method file with the Gauss - Legendre scheme is used to obtain a solution for stationary displacement and velocity vibrations. The path integration solution (PIS) is compared to the equivalent linearization method (EQL) and MCS [13].

On the other side in the research with the title "Study on prediction methods and characteristics of ship underwater radiated noise within full frequency," Zhang et al. [14] explain the results that the calculation model has met the accuracy requirements. To calculate the resulting vibrations caused by the vibration of ships underwater at medium and low frequencies, the finite element method and the boundary element method (FE-BEM), the finite element and the infinite element method (FE-IFEM), and the finite element and the matching layer automatic (FE-AML) is applied and shows the respective results according to its characteristics. This matter demonstrated that FE-BEM is the preferred method for calculating ship underwater vibrations and radiation in both modeling scales and computational efficiency [14]. Calculation of hull vibrations and underwater radiation noise at a high enough frequency can be done to obtain noise and vibration predictions [15]. Local vibrations can be detected based on the directivity of the emitted waves and affect the vibration distance [16 – 18].

Meanwhile in research with the title "Vibration analysis of super-yachts: Validation of the Holden Method and estimation of the structural damping," Alesandro explain the shape of the ocean waves resulting from the hull being hit by the propeller spin, is one of the most significant sources of vibrations affecting the comfort of passenger ships. Consequently, the evaluation of the propeller-generated system via reliable numerical means during the early stages of ship design is essential [6]. A research result also shows that the predicted magnitude of the propeller-induced dynamic excitation is too high. In addition, the generated propeller induced force and excitation of diesel engine vibrations are applied to Finite Element modeling to perform a series of forced vibration analyzes and estimate the global structural damping coefficient of the ship [19]. A study is also needed to highlight the need to develop a new empirical methodology, an analog measurement system for application to modern ships [20].

Nevertheless, in each of these studies the application is carried out on passenger ships, considering that this passenger ship has a level of comfort that must be considered. The concept of vibration measurement is only centered on the simulation and not correlated with field measurements. So that it can make an opportunity for this research to have a correlation where both the calculation of vibrations that occur either before or after the addition of a construction is carried out. What is more of concern is that in this section the measurement is rotated in the engine room, so that it affects the performance of the ship's propulsion more.

The method used in this research is to compare the measurement of good vibrations in the conditions before the addition of construction and after the addition of construction. For later comparison with numerical calculation data. The purpose of this study is to obtain the maximum vibration value in the conditions after the addition of the gorger construction before the addition of the side deck girder construction as a means of evaluating the side deck girder construction planning in the ship engine room ship 2000 DWT.

## 2 MATERIALS AND METHODS

In this study, the ship used was KM. Sabuk Nusantara 71 with the main sizes, as can be seen in table 1.

Table 1. Main Size of the Ship

| Description | Score | Unit |
|---|---|---|
| LOA (Length of Over All) | 68.5 | Meter |
| LBP (Length between Perpendicular) | 63.00 | Meter |
| B (Bearth) | 14.00 | Meter |
| H (Hight) | 6.20 | Meter |
| T (Draught) | 3.50 | Meter |
| DWT | 2000 | Ton |

From the ship construction, the engine room section was previously seen from the need for additional construction. The engine room design can be seen in Figure 2.

This Figure 2, shows a very complex engine room construction design, the reinforcement system uses a solid floor where the web used is a type of web frame or T profile. The method used is the calculation according to the numerical approach assisted by computational software. The approximation to the calculation of the formula vibration, itself is outlined in the equation:

$$mx + kx = F\_ \sin \omega t \tag{1}$$

where $mx$ is the approximation to get mass (kg) and multiplied by the displacement distance. For $kx$ is the constant of the type of vibration that occurs multiplied by the addition of the length of the object's position. and $F$ is the force (N) and w is the weight of the object (ton) sin $wt$ is the position of the vibration that is formed. From equation number 1 then if it is described further, an approach can be written as in the following equation

$$x = A_1 \sin \omega_n t + B_2 \cos \omega_n t + \frac{U_0}{1 - \omega^{2/\omega n^2}} \tag{2}$$

where ωn = k / m and the coefficients A1, B1 depend on the velocity and displacement of mass when t = 0. After the calculation values are obtained, they are grouped to be analyzed and compared. From equationNumber 2 the comparison uses a combined graph to determine the maximum value of vibration after and before the addition of the side girder construction.

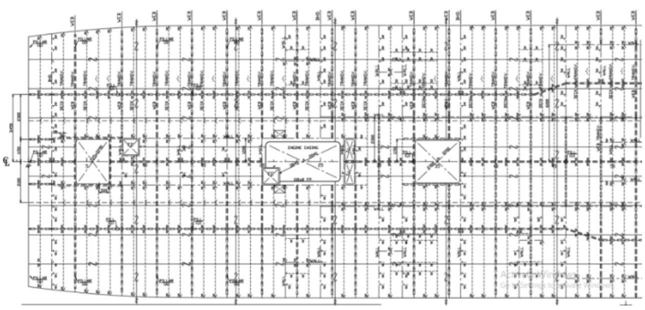

Figure 2. Engine Room Construction

## 3 RESULTS AND DISCUSSION

Based on the measurement results, it is reviewed into several points that represent the vibrations that occur on the ship while operating. The measurement results can be seen in Figure 3.

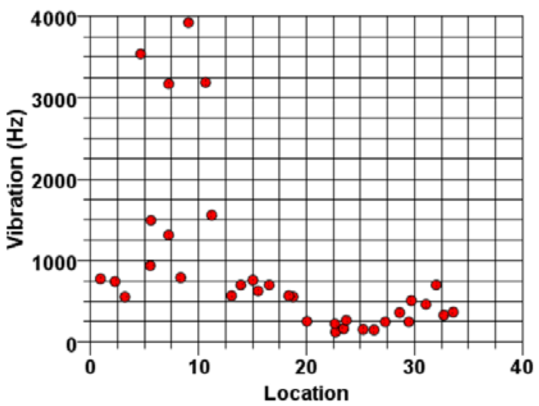


Figure 3. Evaluation Result Vibration Test

From 32 measurement points location, measurement results obtained both vertically and horizontally, obtained plot data that shows the highest value at location number 10, this shows that in that area it is very necessary to provide reinforcement to reduce the level of vibrations that occur and reduce the occurrence of excessive vibrations. Then, the addition of the T profile size as a damper medium to reduce the vibration level is planned according to the modulus calculation with the profile size as shown in Figure 4.

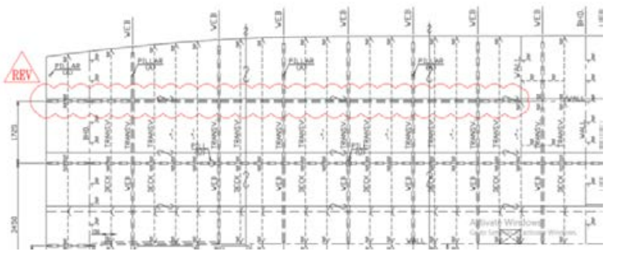

Figure 4. Addition plan side deck girder construction in engine room

The profile size used is FB 180 x 8 mm FP75 x 10 mm. From the side deck girder construction, the vibration analyze are then carried out again after the construction is installed. From the calculation results according to the numerical approach, the results are as shown in Figure 5.

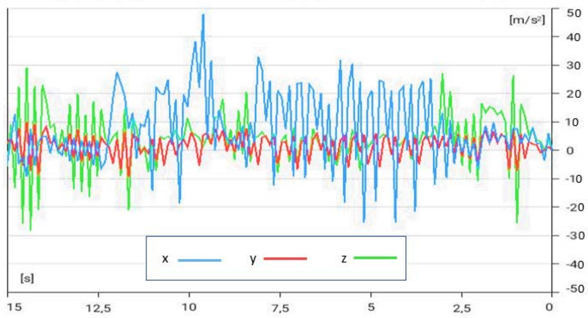


Figure 5. Vibrations before adding a side deck girder

From figure 5, it can be seen that the waveform still has a high enough peak value, which ranges from 48 - 49 m/s² for the x-axis vibration value, while for vibrations on the y-axis the maximum is 8-9 m/s², and on the maximum z-axis. at 28-29 m/s², this calculation vibration is based on the time between 0 - 15 seconds or per 15 second interval. Then it is compared with the calculation after adding the side deck girder construction, as shown in figure 5.

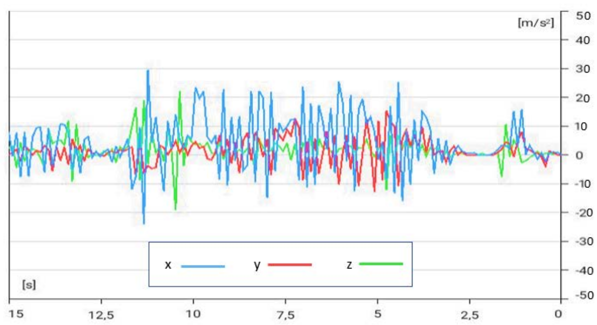


Figure 6. Vibrations after adding a side deck girder

From figure 6, it can be seen that the waveform still has a high enough peak value, which ranges from 28 - 29 $m/s^2$ for the x-axis vibration value, while for vibrations on the y-axis the maximum is 10-11 $m/s^2$, and on the maximum z-axis. at 20-21 $m/s^2$, this calculation vibration is based on the time between 0 - 15 seconds or per 15 second interval. From the comparison results, the percentage of vibration reduction on the x-axis was 40.28%, on the y-axis 33.33%, on the z-axis of 27.59%. So that the average decrease in vibration due to the addition of side desk girder construction in the ship engine room area is 34.91%. This shows the effect of vibration reduction because the modulus of the profile that is planned is suitable and is able to provide construction strength in the ship engine area, so that it can be optimal in its application.

## 4 CONCLUSION

The vibration of a structure makes the comfort level of use and hunger deficient. Therefore, we need an additional construction that can reduce the vibrations that occur. The modulus of calculation of construction planning construction succeeds in making vibrations from the results shown at the beginning of the measurement. The consideration of adding construction becomes one or the alternative in providing reinforcement so that it can reduce the vibration that occurs.

Based on the results of vibration analyze, it was found that the vibration value decreased after adding the construction of the side deck girder to the engine room. From calculation results, which ranges from 28 - 29 $m/s^2$ for the x-axis vibration value, while for vibrations on the y-axis the maximum is 10-11 $m/s^2$, and on the maximum z-axis. at 20-21 $m/s^2$, this vibration sample is measured based on the time between 0 - 15 seconds or per 15 second interval.

Evaluation results from the addition of a sized T profile FB 180 x 8 mm FP 75 x 10 mm, able to reduce percentage of vibration on the x-axis was 40.28%, on the y-axis 33.33%, on the z-axis of 27.59%. So that the average decrease in vibration due to the addition of side deck girder construction in the ship engine room area is 34.91%.

## REFERENCES


[1] Tillig F., Ringsberg J. W., "Design, operation and analysis of wind-assisted cargo ships," Ocean engineering, vol. 211, pp. 107603, 2020.

[2] Qian J., Chen L., "Random vibration of SDOF vibro-impact oscillators with restitution factor related to velocity under wide-band noise excitations," Mechanical Systems and Signal Processing, vol. 147, pp. 107082, 2021.

[3] Guo H. P., Zou Z. J., Wang F., Liu Y., "Numerical investigation on the asymmetric propeller behavior of a twin-screw ship during maneuvers by using RANS method," Ocean Engineering, vol. 200, pp. 107083, 2020.

[4] Ortolani F., Capone A., Dubbioso G., Pereira F. A., Maiocchi A., Di Felice F., "Propeller performance on a model ship in straight and steady drift motions from single blade loads and flow field measurements," Ocean Engineering, vol. 197, pp. 106881, 2020.

[5] Zheng H., Liu G. R., Tao J. S., Lam K. Y., "FEM/BEM analysis of diesel piston-slap induced ship hull vibration and underwater noise," Applied Acoustics, vol. 62, no. 4, pp. 341-358, 2001.

[6] Zambon A., Moro L., Biot M., "Vibration analysis of super-yachts: Validation of the Holden Method and estimation of the structural damping," Marine Structures, vol. 75, pp. 102802, 2021.

[7] Chitrakar P., Baawain M. S., Sana A., Al-Mamun A., "Current status of marine pollution and mitigation strategies in arid region: a detailed review," Ocean Science Journal, vol. 54, no. 3, pp. 317-348, 2019.

[8] Eskandarian M., Liu P., "A novel maneuverable propeller for improving maneuverability and propulsive performance of underwater vehicles," Applied Ocean Research, vol. 85, pp. 53-64, 2019.

[9] Baltzer J., Maurer N., Schaffeld T., Ruser A., Schnitzler J. G., Siebert U., "Effect ranges of underwater noise from anchor vibration operations in the Wadden Sea," Journal of Sea Research, vol. 162, pp. 101912, 2020.

[10] Guo J., Huang S., Nikolay T., Li M., "Vibration damping of naval ships based on ship shock trials," Applied Acoustics, vol. 133, pp. 52-57, 2018.

[11] Li D. Q., Hallander J., Johansson T., "Predicting underwater radiated noise of a full scale ship with model testing and numerical methods," Ocean Engineering, vol. 161, pp. 121-135, 2018.

[12] Wang F., Lu Y., Lee H. P., Ma X., "Vibration and noise attenuation performance of compounded periodic struts for helicopter gearbox system," Journal of Sound and Vibration, vol. 458, pp. 407-425, 2019.

[13] Zhu H., Geng G., Yu Y., Xu L., "Probabilistic analysis on parametric random vibration of a marine riser excited by correlated Gaussian white noises," International Journal of Non-Linear Mechanics, vol. 126, pp. 103578, 2020.

[14] Zhang B., Xiang Y., He P., Zhang G. J., "Study on prediction methods and characteristics of ship underwater radiated noise within full frequency," Ocean Engineering, vol. 174, pp. 61-70, 2019.

[15] Li L., Gu X., Sun S., Wang W., Wan Z., Qian P., "Effects of welding residual stresses on the vibration fatigue life of a ship's shock absorption support," Ocean Engineering, vol. 170, pp. 237-245, 2018.

[16] Bai Y., Jin W. L, "Ship Vibrations and Noise Control", in Marine Structural Design, 2nd ed., Oxford: Butterworth-Heinemann, pp. 259-273, 2015.

[17] Borelli D., Gaggero T., Rizzuto E., Schenone C., "Onboard ship noise: Acoustic comfort in cabins," Applied Acoustics, vol. 177, pp. 107912, 2021.

[18] Cinquemani S., Braghin F., "Decentralized active vibration control in cruise ships funnels," Ocean Engineering, vol. 140, pp. 361-368, 2017.

[19] Soni T., Das A. S., Dutt J. K., "Active vibration control of ship mounted flexible rotor-shaft-bearing system during seakeeping," Journal of Sound and Vibration, vol. 467, pp. 115046, 2020.

[20] Liu H., Lian Z., Gong Z., Wang Y., Yu G., "Thermal comfort, vibration, and noise in Chinese ship cabin environment in winter time," Building and Environment, vol. 135, pp. 104-111, 2018.