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MODIFICATION OF THE MAIN DECK OF PC40 USING THE SANDWICH PLATE SYSTEM TO SUPPORT MARINE DEFENSE OPERATIONS

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Abstract. Indonesia is the largest archipelagic maritime country in the world, it should strengthen its ability to secure a very wide territorial waters, in order to ensure the security and safety of shipping in Indonesian jurisdictional. PC 40 ship is a reliable TNI-AL patrol ship with relatively small dimensions and will be easy to operate in archipelagic areas. In general, structural construction on conventional PC 40 ships, along with the times, the Sandwich Plate System material has been found to have characteristics that provide advantages in terms of strength and a simpler structure compared to conventional construction. the construction structure uses conventional aluminum using the Sandwich Plate System material with an aluminum-elastomer-aluminum configuration in the flat plate structure on the main deck of the TNI-AL PC 40 Ship. Analysis based on finite element on main deck construction with load loading. From the simulation results, the maximum stress for aluminum material is 17 MPa using stiffeners, while the construction with sandwich plate material system produces a maximum stress of 15 MPa reducing the use of 15 stiffeners, with maximum deformation for conventional aluminum.

Keywords:sandwich plate system; finite element method; tension; main deck.

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INTRODUCTION

80% of Indonesia's territory is sea and it covers an area of 5,800,000 km2 with a coastline of 80,791 km. Geographically, Indonesia has a strategic location between the intersection of two oceans and two continents. So that the Indonesian sea becomes a very important sea lane for world trade routes and international shipping routes(Pranoto & Octavian, 2015). Indonesia is an archipelagic country, this is strong evidence that these conditions are needed to have very strong security in the sea and air (Aziz-Boaron et al., 2012). This becomes very important, because from a traditional security point of view the threats will come from the sea and the air. Threats to the security of a country are not always military invasions from other countries (Li & Vashchilko, 2010); (Peterside, 2014).

This 40 M fast patrol boat has a specification of 45.5 meters long, 7.9 meters wide and weighs 220 tons. This ship is capable of traveling at a maximum speed of 24 knots (Coutts, Piola, Hewitt, Connell, & Gardner, 2010), a cruising speed of 17 knots and an economical speed of 15 knots, and has an endurance of six days. The warship is also equipped with two radar units and a 30 mm gun and will be manned by 35 soldiers.

The PC 40 ship is one of the mainstay defense equipment of the TNI-AL because the PC 40 ship has an excess with a relatively small size that will be easy to operate in border areas. Especially small islands border areas that are vulnerable to threats (Kakazu, 2011); (Kennedy, 2018).

The material on the PC 40 ship, in general, is aluminum. However, aluminum is still considered to be less effective in terms of weight in the ship design process. Recent research has led to the development of new materials in shipbuilding applications (Corigliano, Crupi, Guglielmino, & Sili, 2018). One of them is sandwich panels.

The strength of ship construction is a major factor in the design of ship construction(Mallam, Lundh, & MacKinnon, 2015), especially on the main deck. The calculation of the strength of the main deck construction is taken into account because the load received by the main deck is greater because the main deck accommodates weapons and deck navigation(Miranda, Correia, Santos, Ribeiro e Sousa, & Cortez, 2011); (Lovska, 2015). Due to the main problem above, this study will provide an alternative structural design from the design by changing the base plate on the main deck which initially used aluminum material to become a Sandwich Plate System (SPS) material with an aluminum-elastomer-aluminum configuration to obtain a construction without pillars and reinforcement (Feng, Li, Liu, Niu, & Li, 2010); (Ryu, Ju, & Yoon, 2014); (Stihl, Chassard, Feldmann, & Bild, 2013). with a force that is within the standard permitted on the ship.

Based on this, in this study, a numerical simulation analysis will be carried out to identify the strength comparison of the construction structure using conventional aluminum with the construction structure using a steel base plate using the Sandwich Plate System (SPS) material with aluminum elastomer aluminum configurati on in the flat plate structure (Hou et al., 2019). on the main deck of the TNI - AL PC

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40 ship (Khaloo, Khoshnevis, & Yekrangnia, 2019).

METHODS

The method used in this research is numerical modeling method. In this study, the model is analyzed using finite elements to determine changes in the model due to a given load. The model will be analyzed by reducing the beam on the construction.

RESULTS AND DISCUSSION

Determining the thickness of the Sandwich Plate System

Where the core material is an elastomeric Core Material which has its own material criteria value. The following criteria values for the steel are:

Modulus Elasticity = 2.792 x 103 N/mm2
Shear Modulus = 1.396 x 103 N/mm2
Poisson Ratio = 0.001
Density = 1.73 x 10-9 Tons/mm3

After knowing the value of the material criteria Core Material Syntheticresin the next step is to determine the thickness of the sandwich consisting of core steel and steel which will then be used as a substitute for conventional steel. Based on Lloyd's Register (2015) the core thickness should not be below: tc = 15 mm.

After we know the plate thickness parameters of each part on the ship based on Lloyd's Register (2015) we can only calculate the thickness for the top layer and the bottom layer of the faceplate can be seen in the following equation:

$$t1 = 0.3\ (tRules - taR) + ta1$$
$$t2 = 0.3\ (tRules - taR) + ta2$$

Where:

taR : rule thickness (mm)
ta1 : thickness for the top layer on the faceplate (mm)
ta2 :thickness for the bottom layer on the faceplate (mm)

Then:

$t1 = 0.3\ (12 - 2) + 2$
$t1 = 5$ mm 4 mm
$t2 = 0.3\ (12 - 2) + 0$
$t2 = 3$ mm 4 mm

From the above calculation, it can be concluded that the thickness obtained is t1 = 4 mm, tc = 15 mm, t2 = 4 mm. And the total thickness of the sandwich is 23 mm.

Structural Modeling Using Finite Element Analysis Software

In analyzing ships using the finite element method application, you must first create a model on the software. In making the model it must be in accordance with the structure of the ship. In the design of the structure, all elements must be assigned a certain size. Size must be proportioned strong enough to withstand the forces that may occur. Each structural element must also be sufficiently rigid so that it does not bend or deform excessively when the structure is used.

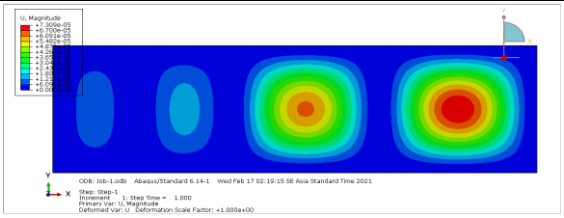


Figure 1. structural elements

The model is made with the help of the FEM application program.

No	Tipe Kontruksi	Tebal Penampang (mm)			Jumlah *deck beam*
1	Konvensional	7			31
		t_1 (mm)	tc (mm)	t2 (mm)	
2	SPS A	4	15	4	31
3	SPS B	4	15	4	26
4	SPS C	4	15	4	21
5	SPS D	4	15	4	16

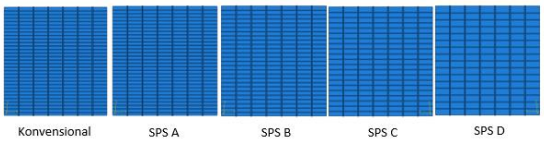


Figure 2. FEM application program

Load model loading is

Used to provide loads, pressures, boundaries on the test object. The load module is also used as a means to enter the type of boundary conditions to be modeled.

The load module is used to determine the type of load applied to the model. The applied load is a pressure of 500N on the entire cross-sectional plate.

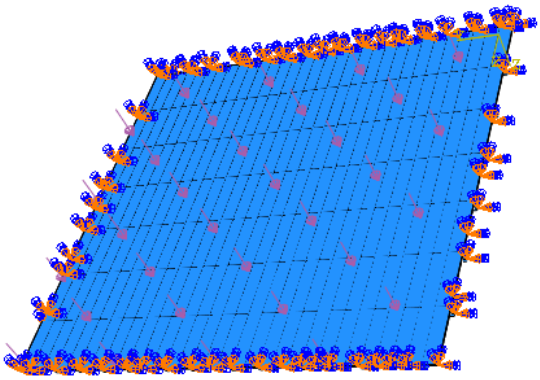


Figure 3. structural model being analyzed

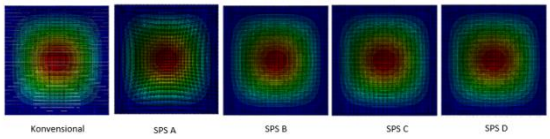
Each structural model being analyzed must define boundary conditions to ensure the analyzed model runs well. This connection model is given a boundary condition in the form of clamping on the side of the model and displacement on the

side of the model.

Results of Strength Analysis using Finite Element Analysis Software

The results of Strength Analysis using Finite Element Analysis Software in this section, the results of finite element analysis are presented to thoroughly observe the comparison of structural strength between the existing car deck model and the modified structural model where there are differences in core material properties, and number of stiffener configurations. Permitted criteria for different models, to investigate their performance and to relate them to each other.

The following is a contour drawing that shows the position of the maximum stress that occurs in the main deck construction using aluminum and SPS.



	Konvensional	SPS A	SPS B	SPS C	SPS D
Tegangan maks	17,8 MPa	15,2 MPa	15,6 MPa	16 MPa	16,5 Mpa

The results of the Finite Element analysis between different load cases are shown in a sequentially presented von Mises stress comparison between the conventional model and the modified model. From the illustrated diagram, in a comparison between the modified SPS A model which has the same stiffener configuration, the application of sandwich material can reduce the von Mises stress in the range of 15%, while the SPS D model with the simplest structure can reduce the stress by 7%.

CONCLUSIONS

Research that has been carried out on the PC40 ship model regarding the comparison of the structural strength of the vehicle deck construction using conventional steel and the Sandwich Plate System is the response of the structure with the highest stress in the von Mises stress ratio between the conventional model and the SPS model. SPS A which has the same stiffener configuration, the application of sandwich material can reduce the von Mises stress in the range of 12%, while the SPS D model with the simplest structure can reduce the stress by 7%. weight comparison that occurs between the use of conventional aluminum construction with complete reinforcement and the Sandwich Plate System with a reduction in reinforcement of 9.7 tons with a percentage value of 5.1%.

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