Technical and Economic Analysis of a Conversion on a Single Pontoon to a Multi Pontoon Floating Dock

Tehnička i ekonomska analiza pretvorbe samostalnoga pontona u višestruki plutajući pontonski dok

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Abstract

The conversion of floating docks from single pontoon to multi pontoon is a beneficial alternative for shipyards to enhance the performance of the facilities owned. The objective of this research is to analyze technically and economically the conversion of single pontoon floating dock to multi pontoon. The results of calculations used the 2.2 Finite Element Method software was the amount of the stress at the floating dock after the conversion of 14.635 MPa is smaller than the permitted stress of 160 MPa. Besides that, the pump ballast filling capability after conversion is 54.16 minutes. The decrease in Ton Lifting Capacity (TLC) can be determined by the difference in the load that occurs in the floating dock. After the floating dock is converted using the same TLC, it changes from 2.07 m to 2.11 m. The freeboard height is >300 mm so it is still able to work on the same TLC. There are 4 stages at the production stage, making access to the pontoon, installing bulkhead and additional reinforcement, removing the pontoon, dismantling and installing the pump, and reconnecting with the sidewall. The analysis results found that the conversion costs was IDR 20,051,463,949, the economic analysis conducted also obtained savings for floating dock reparation costs of IDR 6,559,475,128 to IDR 4,143,346,112. When one pontoon is repaired, the rest of the pontoon can still be used and get an income of IDR 3,292,265,120 thus the total cost is IDR 851,080,992. Saving amounting to IDR 5,708,394,136 is used to pay off investment costs.

KEY WORDS
single pontoon
floating dock
multi pontoon
conversion

Sažetak

Pretvorba plutajućih dokova iz samostalnog u višestruki ponton korisna je alternativa za brodogradilišta da bi se povećala uporaba vlastitih postrojenja. Cilj je ovoga istraživanja tehnička i ekonomska analiza pretvorbe samostalnoga plutajućeg u višestruki plutajući dok. Rezultati izračuna dobiveni su 2.2 softverskom metodom Finite Element, što je bio iznos opterećenja na plutajućem doku nakon pretvorbe 14.635 MPa koji je manji od dopuštenoga opterećenja od 160 MPa. K tome, kapacitet pumpe punjenja balasta nakon konverzije iznosi 54.16 minuta. Smanjenje kapaciteta podizanja u tonama (Ton Lifting Capacity – TLC) može se odrediti razlikom u opterećenju koje se događa u plutajućemu doku. Nakon što se plutajući dok preinači, upotrebljavajući isti TLC, on mijenja vrijednost s 2.07 m na 2.11 m. Visina nadvođa manja je od 300 mm tako da još može raditi istim kapacitetom (TLC). Postoje 4 etape u proizvodnoj etapi koje čine pristup pontonu, instaliraju pregrade i dodatna ojačanja, uklanjaju ponton, rastavljaju i intaliraju pumpu te je ponovno povezuju s bočnim zidom. Rezultati analize pokazali su da su troškovi konverzije iznosili IDR 20,051,463,949, a ekonomska analiza koja je provedena također je prikazala uštede pri popravku plutajućega doka, i to u iznosu od IDR 6,559,475,128 na IDR 4,143,346,112. Kad se jedan ponton popravi, ostatak pontona koji se još može upotrebljavati ima prihod od IDR 3,292,265,120, tako da je ukupan trošak IDR 851,080,992. Ušteda koja iznosi IDR 5,708,394,136 koristi se da bi se isplatili troškovi investiranja.

KLJUČNE RIJEČI
samostalni ponton
plutajući dok
višestruki ponton
konverzija

1. INTRODUCTION / *Uvod*

Indonesia's maritime industry, especially the shipyard industry, is demanded to continue to grow to maintain its existence among competitors and to be able to maintain its business opportunities. The demand made several shipyards make changes either by renewing the facilities they owned, expanding

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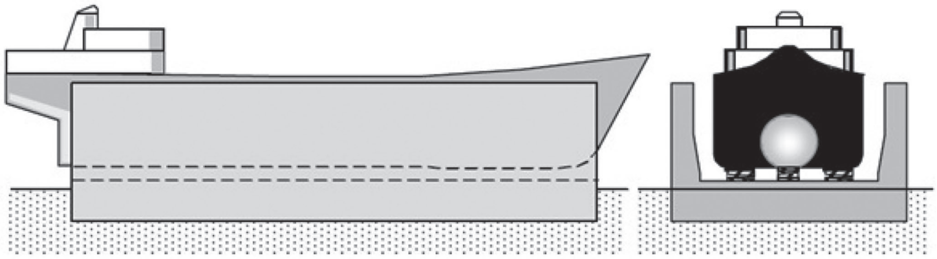

Figure 1 Floating Dock
Slika 1. Plutajući dok

(expanding the land), or completing the facilities. In shipyards, the main facilities that most support the industry are the docks. The docks are required to be able to accommodate ships with the desired capacity and can operate optimally.

Of the various types of docks used in the shipping industry, one of the most widely used is the floating dock. Floating docks are widely used by shipyards that do not have enough land to build graving docks or dry docks. Floating docks have two types according to the number of pontoons namely single pontoon (one pontoon) and multi pontoon (two or more pontoon). In addition to the difference in the number of pontons they have, there are also differences in the time of required maintenance. During the maintenance process, all of pontoon floating docks part must do the docking process. Thus, the floating docks cannot be used

Unlike a single pontoon floating dock, a multi-pontoon floating dock does not need to docking the entire part when it is in the process of maintenance and repairing, simply by removing the pontoon or pontoon section that needs to be maintained or repaired.

The reasons mentioned earlier make some shipyards that have a single pontoon floating dock start thinking about converting the floating dock that originally belonged to a single pontoon into a multi pontoon. One case is the JAYAKERTA V floating dock which has a length of 100 m with a width of 25 m and a height of 10.92 m. The floating dock is going to be converted from the original single pontoon to multi pontoon and it is expected that the results of the floating dock conversion still have the same properties in the sense that the main dimensions are unchanged and there is no reduction from the Ton Lifting Capacity (TLC) of the floating dock JAYAKERTA V.

2. LITERATURE REVIEW / *Pregled literature*

2.1. Floating Dock / *Plutajući dok*

The definition of floating docks is a building construction at sea that is used to dock by sinking and floating in a vertical direction. This floating dock construction generally consists of steel and plates, with different construction systems depending on the design. Construction systems that are commonly applied to floating docks are three, namely longitudinal, transverse, and mixed construction systems. The floating dock has fairly simple piping and pump systems, the piping system is similar to the system on a ballast ship.

Figure 1 shows the condition of the floating dock when operating. Floating docks are floating buildings, thus there must be a need for equipment for mooring. It was conducted to avoid the shift of their position due to currents, waves, or wind. This mooring equipment is evidence by the anchors or chains where sometimes concrete structures or stakes are also used at the bottom of the water as aid. Besides the dock being equipped with equipment to shift the ship to be loaded, the taps also needed for transportation at the time of repair.

Floating docks can be divided into two according to the number of pontoons:

1. single pontoon
2. multi pontoon

The two types of floating docks mentioned above have their advantages and disadvantages. These strengths and weaknesses are a consideration for building a floating dock.

Figure 2 shows a floating pontoon-type single dock. The floating pontoon-type has several advantages not shared by the floating pontoon-type. These advantages are as follows:

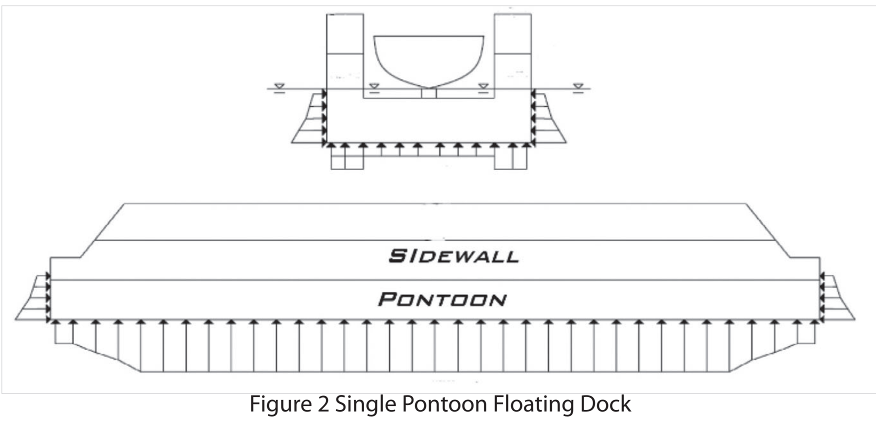

Figure 2 Single Pontoon Floating Dock
Slika 2. Samostalni pontonski plutajući dok

1. Longitudinal strength is borne by all parts of the floating dock including the sidewall and the pontoon
2. The number of pumps needed to fill the ballast tank is less, because the pontoon is only one. It is enough to use one pump with pipes along the floating dock.

In addition to the advantages of the single pontoon floating dock mentioned above, this type of floating dock also has disadvantages compared to the floating pontoon type multi-pontoon:

1. Repairing each side of the pontoon cannot be done in the floating dock itself (does not have the ability to self-repair).
2. Necessity of docking for maintenance and repair processes.
3. The construction time is relatively longer than multi pontoon floating docks.

Figure 3 shows a multi-pontoon floating dock. Compared to a single pontoon floating dock, a multi pontoon floating dock has the advantage of a single pontoon floating dock as follows:

1. Repair of each pontoon section can be carried out by the floating dock itself by removing the pontoon section that must be repaired, then floating it above the floating dock itself.
2. The construction can be applied in a building berth that is less than the length of the entire floating dock. It should be connected to each other on the water.
3. The progress time is relatively faster.

In addition to the multi pontoon floating dock advantages mentioned above, multi pontoon floating dock has disadvantages. However, the disadvantages of this type of floating dock are as follows:

1. Longitudinal strength power is only borne by the sidewall thus the pontoon is not included in the stiffener's elongated strength stiffener.
2. The number of pumps needed to fill a ballast tank is greater than a single pontoon floating dock, because each pontoon must have at least one ballast pump. [1]

2.2. Finite Element Method / *Metoda Finite Element*

In the process of determining the node points called discretization, a system is divided into smaller parts. In order to solve the problem, it is performed on these parts and then recombined to obtain a comprehensive solution. [3]

It is possible to use a computer program to perform analysis with the finite element method known as FEA (Finite Element Analysis). It is possible to analyze the entire floating dock with an accurate calculation of the voltage response of the floating dock using this method. Several levels in finite element modeling can be used in the analysis as follows:

- Global stiffness mode
- Cargo hold model
- Frame and girder models
- Local structure models
- Stress concentration model

In this study, the level of the finite element model used is the global stiffness mode

2.3. Production Step / *Proizvodna etapa*

The construction of the floating dock is an activity conducted starting from the planning to the delivery of the floating dock product to the owner.

The manufacture of floating docks required several stages of the production process which consists of:

1. Preparation

This stage is the initial stage in the production process. At this stage, the straightening process and the blasting process begin on the ship plate material. Moreover, the primary coating process is carried out to keep the plate from corroding during the production process.

2. Fabrication

This stage produces the components that make up the floating dock such as frames, plate floors, brackets, etc. The types of work at this stage of fabrication include marking, cutting, forming, and bending activities.

3. Sub-assembly

In the Sub-assembly stage, the work that has been completed in the fabrication section is continued with the joining process. The results of the cutting / shaping in the fabrication workshop in the form of brackets, plate floor, face plates, and others, are combined into a single part of the construction into a component block. The work activities at this stage include: fitting, welding, and grinding.

4. Assembly

After the previous stage, assembly is combining into a larger block or commonly called as grand block. The work performed in the assembly process includes fitting, leveling, welding, grinding activities.

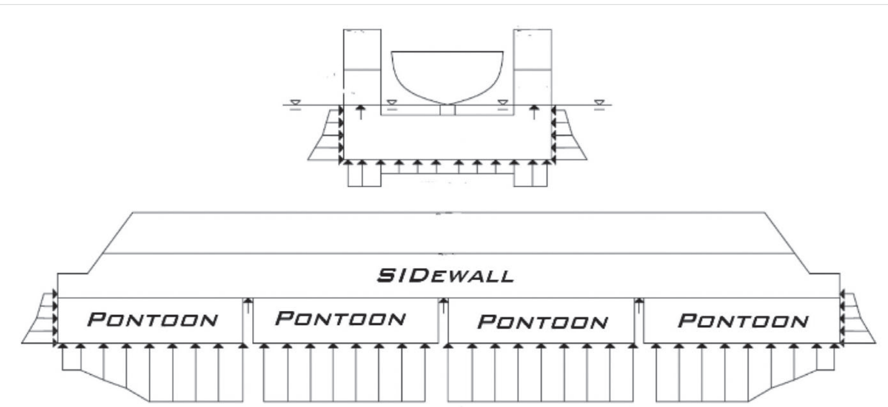

Figure 3 Multi Pontoon Floating Dock
Slika 3. Višepontonski plutajući dok

2.4. Costs / *Troškovi*

Costs are value which should be equivalents with the needs of goods or services that are expected to provide current or future benefits to the organization.

Cost is the acquisition price that is used in order to obtain income or revenue that will be used as a deduction from income.

Before the construction of the project is completed, a large amount of cost or capital is needed which is grouped into fixed capital and working capital, in other words investment = fixed capital + working capital. This grouping depends on the time of study of economic and financial aspects [6].

1. Fixed Capital

Production or fixed capital costs are costs used to build the installation or produce the desired project product, starting from the expenditure of feasibility studies, engineering design, procurement, fabrication, construction until the installation or product is fully functional. Capital is divided into direct costs and indirect costs [6].

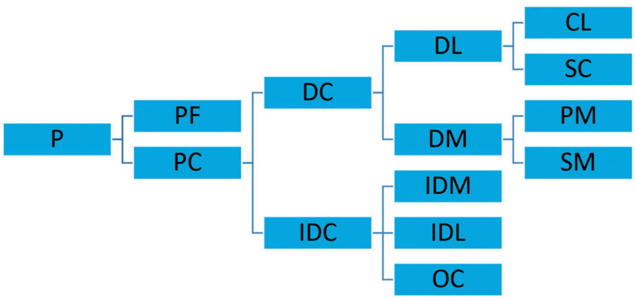

Figure 4 Costs Component
Slika 4. Sastavnica troškova

Note:

P : Price
PM : Primary Material
PC : Production Costs
SM : Secondary Material
PF : Profit
CL : Company Labor
DC : Direct Costs
SC : Sub-contractor
IDC : Indirect Costs
IDM : Indirect Material
DM : Direct Material
IDL : Indirect labor
DL : Direct Labor
OC : Other Costs

a. Direct Costs

Direct costs are cost components that have a direct bearing on the volume of work stated in the payment item or become a permanent component of the project's final output. Direct costs are [7]:

1. Direct costs of material
2. Direct costs labor

b. Indirect Costs

Indirect costs or indirect costs are expenses for management, supervision, and payment of materials and services for the procurement of parts of the project that will not be a permanent installation or product, but are needed in the framework of the project development process [8].

3. DESCRIPTION OF RESEARCH / *Opis istraživanja*

At the beginning of the conversion process, the first thing to do is analyze whether the floating dock can be converted. The analysis is conducted by calculating whether the lengthening strength of the floating dock still fulfills after conversion, how is the condition of the piping system and pump inside the floating dock after conversion and the ballast filling ability after conversion, also whether there will be a decrease in TLC after conversion or not. Then, it also analyzed how production techniques are suitable to be applied in the conversion process and analyze the costs required and also other benefits derived from the conversion carried out.

4. RESEARCH RESULT / *Rezultat istraživanja*

4.1. Longitudinal Strength of Floating Dock / *Longitudinalna čvrstoća plutajućega doka*

The first analysis was the calculation of the ship's longitudinal strength. It aimed to find out whether the longitudinal strength of the ship was still fulfilling or not after the conversion process is finished. Moreover, it was conducted to examine whether additional construction was needed to strengthen the longitudinal strength of the floating docks or not. It was the same as when the floating dock has not been converted. After the conversion process, the strength test was conducted using the same boundary conditions when the floating dock had not been converted. It was found that the converted floating dock stress was 14,652 Mpa. The stress was smaller than the permissible stress which was 160 MPa. Hence, it can be concluded that the floating dock can be converted with the note that an additional stiffener needed to be added to the sidewall.

The load on the keel block and side block in Figure 5 is combined with the load from the ballast on the pontoon and the buoyancy of the floating dock when working with a draft of 2.05 m. After loads and lift forces are applied to the model as well as the desired boundary conditions, the test can be conducted.

This longitudinal strength test uses the aid of a computer application FEA analysis with a static structural analysis method. The test is applied using several loadings, including the buoyancy of the floating dock in working draft conditions, the load of the ballast tank, the load due to the lifting capacity of the floating dock, and the weight of the floating dock construction itself.

The load arising from the lifting capacity of the floating dock is distributed evenly to the keel block and side block in the floating dock. The total keel blocks in the floating dock are 90 keel blocks where each keel block supports a load of 31.25 tons. Likewise, each side block supports a load of 31.25 tons with the side blocks of floating docks totaling 18 pieces. The keel block and side block are neatly arranged to support the ship when maintenance and repairs are performed on the floating dock. The conditions of the tests carried out were made as closely as possible to the original state on the ground, with the boundary conditions of the translational motion in the direction of the x-axis and y-axis [9]. The load used was the burden when the floating dock works with a maximum workload of 3850 tons TLC divided by 90 keel blocks with each bearing a load of 276.652 N and also a side block of 18 units with each side block bearing the load of 699.131 N. In addition to the test load, the construction

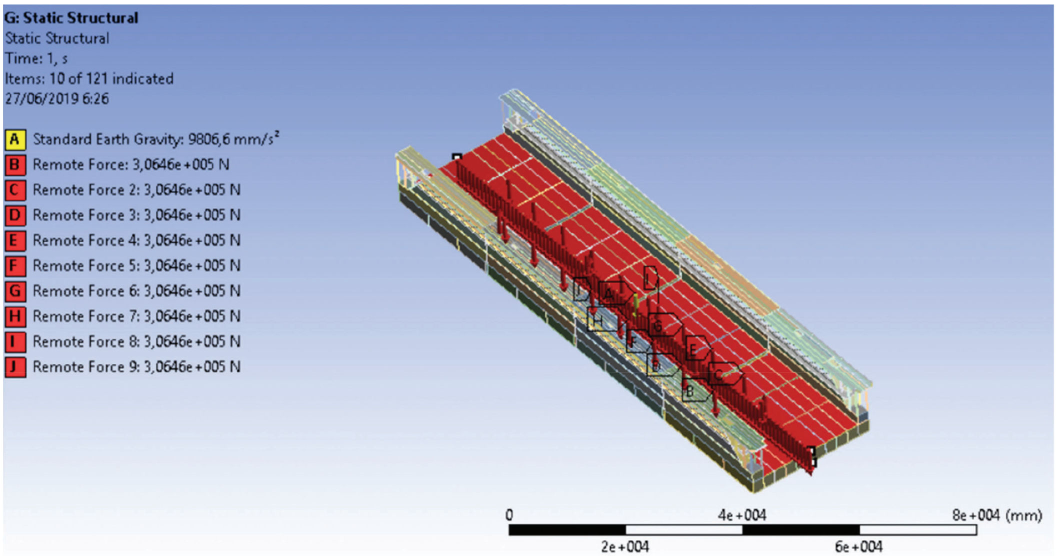

Figure 5 Load simulation
Slika 5. Simulacija opterećenja

load of the floating dock itself also becomes a problem on the tests performed by adding a load on the construction of each pontoon of 31.81 tons and also on the sidewall.

4.2. Pipe and Pump System / *Sustav cijevi i pumpi*

The analysis conducted after analyzing the longitudinal strength of the floating dock was the state of the pump and the pipe system after conversion. The first thing to note was the location of the existing piping system (see Figure 6).

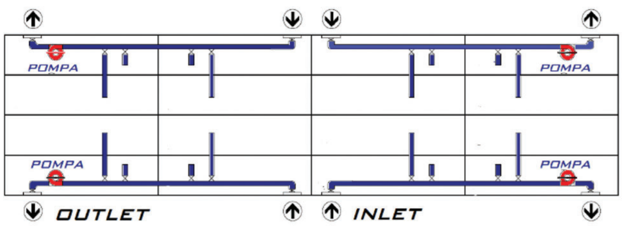

Figure 6 Pipelines existing
Slika 6. Postojeći cjevovodi

Figure 6 portrayed the state of the pipeline from the floating dock before conversion. The location of the pump before being converted was in compartments 1 and 4. After being converted into a multi pontoon the floating dock has a new pump and pipe system where each pontoon now has one pump. Changes that occur in the floating dock after being converted were only the location of the pump (See Figure 7)

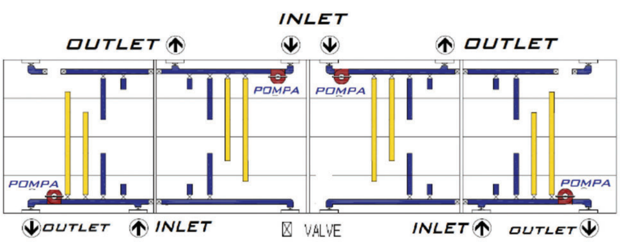

Figure 7 Pipe and Pump System after Conversion
Slika 7. Sustav cijevi i pumpi nakon pretvorbe

Figure 7 indicated floating dock pipelines after conversion. The number and capacity of pumps were still the same. The pump's ability was still the same, to fill the floating docks ballast in full took 54.16 minutes.

4.3. Decreased TLC (Ton Lifting Capacity) / *Smanjeni kapacitet nosivosti u tonama*

The initial displacement of the floating dock was 5316.438 tons. From the displacement value, it was known that the working draft is 2.07 m. The working draft changed after the floating dock conversion process was carried out. It has increased to 2.11 m by using the same Dwt which was 3850 workloads from floating docks.

Table 1 Recapitulation of Single Pontoon TLC Calculation
Tablica 1. Sažimanje izračuna TLC samostalnoga pontona

Name	Value	Unit
L	100	m
B	25	m
H	10.93	m
H (Pontoon)	2.6	m
T (Working)	2.074708	m
T (Empty)	0.572268	m
LWT	1466.438	t
DWT	3850	t
Displacement	5316.438	t
Tmax-Tmin	1.502439	m
TLC	3850	t

Table 1 showed the state of the TLC from the floating dock before the conversion process was performed. It can be seen in the table above that the displacement of the floating dock amounted to 5316.438 tons with workload or when the ship was loaded at 2.074 m.

Table 2 Recapitulation of Multi Pontoon TLC Calculation
Tablica 2. Sažimanje kalkulacije TLC višestrukoga pontona

Name	Value	Unit
L *pontoon 1,2,3,4*	24.5	M
B	25	M
H	10.93	M
H (Pontoon)	2.6	M
T (Working)	2.114	M
T (Empty)	0.589	M
LWT	1487.365	Ton
DWT or TLC	3850	Ton
Displacement	5337.365	Ton
TLC	3850	Ton
H(pontoon)-Tmax	0.485	M
	485	Mm

Table 2 showed the state of the TLC from the floating dock after the conversion process was conducted. The table above presented that the displacement of the floating dock amounted to 5337.365 tons, a difference of 20.92 tons occurred. By using the same Dwt as the floating dock before conversion, the workload of the floating dock changed from the original 2.07 m to 2.11 m. ladder changes of 0.04 m.

To prove whether floating docks were still declared safe when working on the same TLC, it was known that the floating draft work value was 2.11 m while the height of the pontoon was 2.6 m. Thus, the freeboard value of the pontoon was 485 mm. Since the value of the freeboard was greater than the permitted freeboard value of 485 mm> 300 mm, thus it can be stated that the floating dock after conversion still has the same TLC as before conversion.

4.4. Production / *Proizvodnja*

The production process was carried out in stages to minimize the possibility of failure and ensure all parts were produced properly [10]. The conversion of floating docks from single pontoon to multi pontoon was conducted in 4 stages of production where the whole process was iterative. The process was only distinguished by the pontoon work order, while the pontoon work order was pontoon 1,2,4 and 3.

In Figure 8 can be seen that access was made on the pontoon deck, making access was created alternately in each compartment of the floating dock only on compartment 4 does not need to be made access because the installation of additional insulation was not required. The bulkhead installation was done in stages and with small pieces given limited access to the inside of the pontoon.

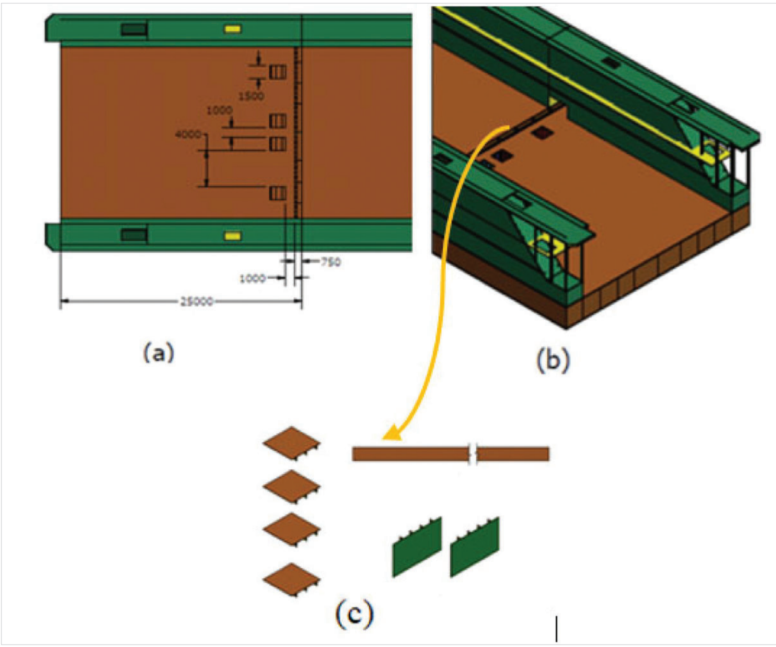

Figure 8 Access materials and workers during conversion on the pontoon deck
Slika 8. Pristupni materijali i djelatnici tijekom pretvorbe na palubi pontona

Note:
(a) Location and size of the cut section on the pontoon deck as access to materials and workers
(b) View of the pontoon deck
(c) Cuts on the pontoon deck

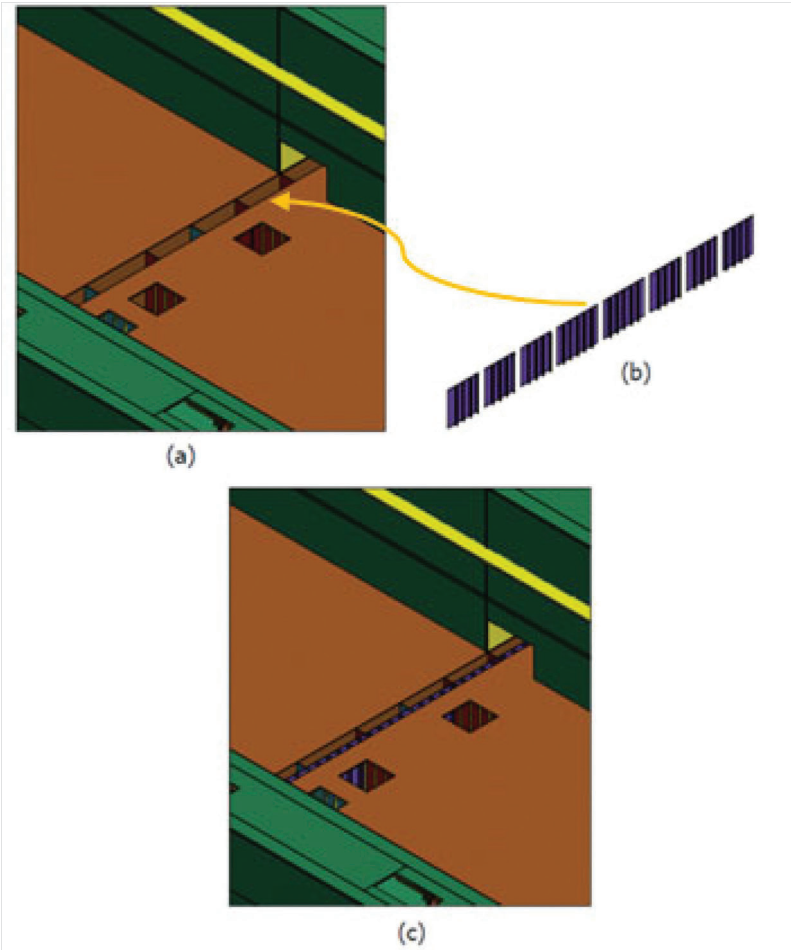

Figure 9 Addition of a partition during conversion
Slika 9. Dodavanje pregrade tijekom pretvorbe

Inf:
(a) Detail of the pontoon and sidewall plates before the partition is added
(b) Bulkhead
(c) Detail pontoon plates and sidewall plates after bulkhead addition.

Figure 9 displayed that additional insulation will be installed in the floating dock compartment before cutting to separate the compartment into pieces of the pontoon. Installation of additional insulation was carried out in conjunction with the installation of additional construction for the sidewall access stiffener that was used to enter additional construction in the form of longitudinal was access that was previously made in the sidewall.

Figure 10 indicated the location of the cutting of the pontoon with the sidewall that was carried out during the conversion process. After the pontoon is separated from the sidewall, it is then taken to the airbag to disassemble the pump in compartments 1 & 4, while for compartments 2 & 3 the pump is installed. Cutting was performed by using flame cutting. The cutting process can be applied on the water with calm waters and with the ballast condition of the pontoon empty. The addition of a bulkhead was conducted to ensure the pontoon cut results are in a tight condition. The dismantling of the pump carried out above the airbag aimed to change the location of the floating dock pump which is in compartments 1 & 4 changed to each pontoon having one pump. The process of changing the location of the pump was done by making access first to the inside of the compartment, then the process of dismantling the pump was carried out after that the installation of new pipes on the existing pump that was still installed (See Figure 11).

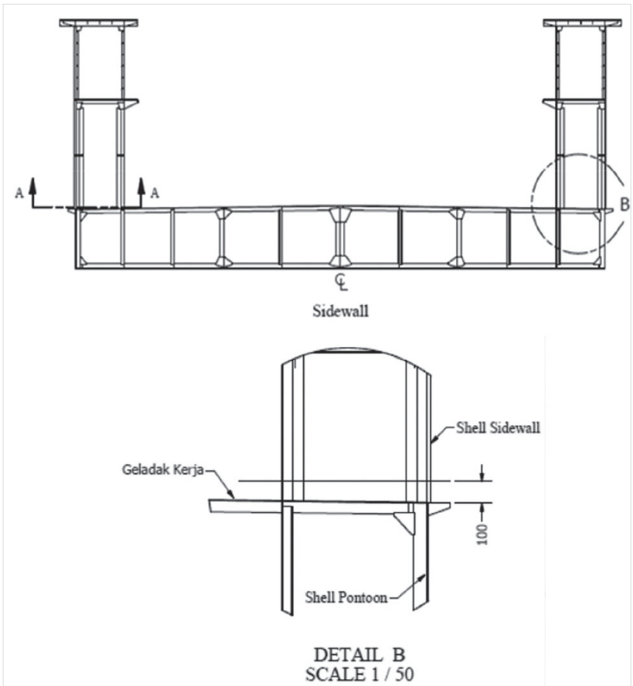

Figure 10 Location of Cutting Pontoon with Sidewall
Slika 10. Lokacija rezanja pontona s bočnim zidom

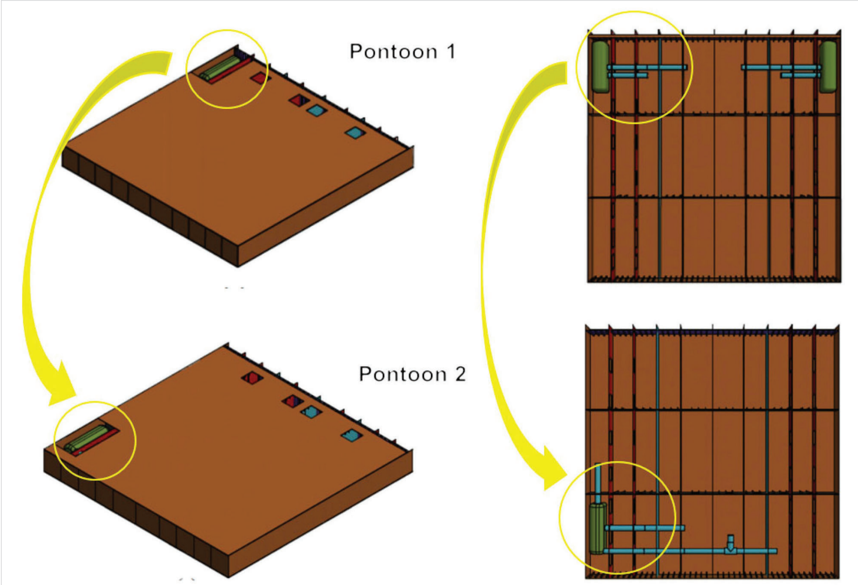

Figure 11 The pump in pontoon 1 is moved to pontoon 2
Slika 11. Pumpa s pontona 1 premješta se na ponton 2

Figure 11 portrayed the disassembly of the pump carried out. The pump which was in the pontoon 1 & 4 starboard parts are removed and installed in the starboard pontoons 2 & 3. After that, the repainting process was performed, as long as the work on the water bag was finished. There was work that can also be completed on the floating dock which was in the form of a connection replacement, The pontoon with a sidewall which was originally a welding connection was now replaced by a bolting connection to make it easier to repair later, because for the process of installing pairs it was easier to use bolting than welding connections.

Figure 12 was the final process that reconnected the pontoon with the sidewall. This process was the last process of each stage of production, which distinguished only the order pontoon installed only, the order of pontoon installation following the order of work that was pontoons 1,2,4 & 3.

4.5. Economic Analysis / *Ekonomska analiza*

Economic analysis was conducted to determine the conversion costs needed. It was also to reveal the benefits that can be obtained after the conversion. Besides that, other costs such as warranty and insurance and undocking, docking processes need to be considered. [11] Based on the analysis, it was found that the conversion fee was IDR 20,051,463,949.

It was known that the cost of a single pontoon floating dock repair is IDR 6,559,475,128 with a working time of 36 days. When the pontoon floating dock was repaired, the floating dock did not generate income. The cost of multi-pontoon floating dock repairs resulting from conversion was IDR 1,035,836,528 per pontoon with 9 days of work time. Total reparation costs and workmanship was in the process of a reparation fee was IDR 4,143,346,112. However, when the floating pontoon was repaired, the floating dock can still work with the TLC reduced

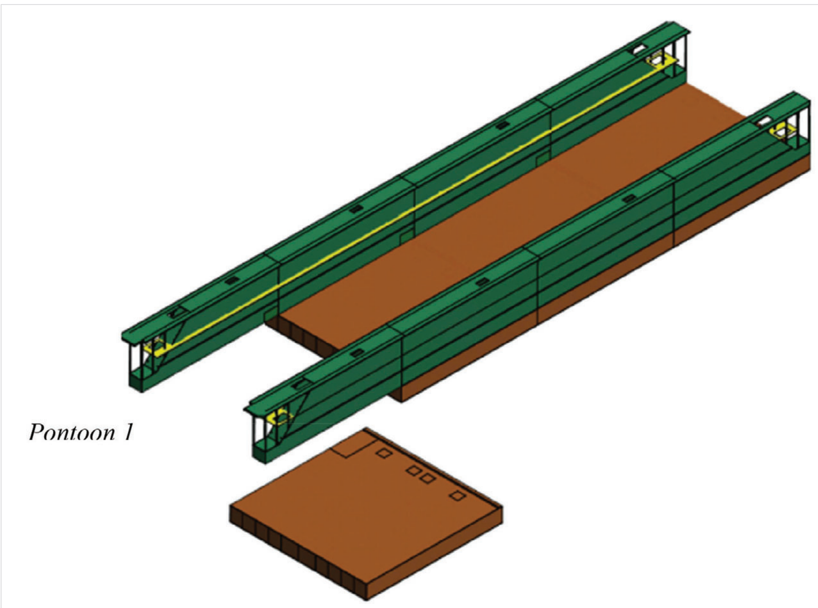

Figure 12 Connection pontoon with sidewall
Slika 12. Povezivanje pontona bočnim zidom

from 3850 tons to 2737 tons. But with this condition, there was an income of IDR 823,066,280. Thus, it can be said that the cost of a single pontoon floating dock repairs was reduced by the each pontoon amounting to IDR 212,770,248.

The reduction in reparation costs for the entire pontoon, which was originally IDR 6,559,475,128 after being converted to IDR 851,080,992, was another advantage gained by the time of multi pontoon floating docks for 36 days. However, it can be conducted separately for 9 days per pontoon in multi pontoon, if scheduling maintenance can be completed. The reduction in reparation costs was IDR 5,708,394,136 per a single pontoonwhich can be called to be a saving cost to pay off the conversion costs which carried out in 4 times. Hence, the saving cost collected was sufficient to pay off the conversion costs.

5. CONCLUSION / *Zaključak*

Based on research that has been conducted, the following conclusions are obtained:

1. In the process of floating dock conversion, it is known that the longitudinal strength of the floating dock still fulfills, the floating dock stress is obtained after being converted and the stiffener is added to obtain a yield of 14.653 MPa smaller than the permitted stress of 160 MPa thus it is still safe. The ability to charge the ballast after being converted is still the same, namely for 54.16 minutes. The floating dock TLC after the conversion was still equal to 3850 tons, there was a change in the working draft from 2.07 m to 2.11 m, freeboard height after being converted is 485 mm so it is still said to be safe because> 300 mm in accordance with class rules.
2. The production phase is divided into 4 stages of production namely stages 1,2,3 and 4. At each stage, work which was carried out was the same such as cutting pontoon deck plates as additional bulkhead access and sidewall stiffener construction, after that cutting pontoon with sidewall then proceed with dismantling the pump which is carried out on the air bag and for work on floating docks namely the change of the sidewall connection with the pontoon from the welding connection to bolting. The work above air bag was also repainting. Each stage ends with reinstalling the pontoon with the sidewall. The difference in work is only in dismantling the pumps performed in compartments 1 & 4, and installing the pumps in compartments 2 & 3. Whereas the order of workmanship starts from compartments 1, 2, 4, and 3.
3. The conversion fee needed is IDR 20,051,463,949 cost savings due to a reduction in the cost of repairs by IDR 5,708,394,136 if used to pay the conversion costs, in 4 repairs the total conversion costs can be paid. Another advantage gained from the conversion made is that the reparations made can be done scheduling system with reparation time for each pontoon for 9 days with a total 36 days for reparation all pontoons.

REFERENCES / *Literatura*

[1] Soeharto, I. (1997). *Manajemen Proyek Dari Konseptual Sampai Operasional*. Jakarta: Erlangga.

[2] Santosa, B. (2013). *Diktat Kekuatan Kapal*. Surabaya: Instittut Teknologi Sepuluh Nopember.

[3] Hutton, D. V. (2004). *Fundamental of Finite Element Analysis*. New York: McGraw-Hill.

[4] Storch, R.; Hammon, C. P.; Bunch, H. M.; Moore, R. C. (1995). *Ship Production*. Second Edition. Maryland: Cornell Maritime Press. https://doi.org/10.5957/jsp.1995.11.2.81, https://doi.org/10.5957/jsp.1995.11.3.133

[5] Wahyuddin. *Teknik Produksi Kapal*. Makassar: Universitas Hasanuddin.

[6] Wahidi, S. I.; Virmansyah, V. M.; Pribadi, T. W. (2021). "Study on Implementation of Activity-Based Costing (ABC) System on". *Journal of Marine Science and Technology*, Vol. 18, No. 1, pp. 1-7. https://doi.org/10.14710/kapal.v18i1.33000

[7] Wahidi, S. I.; Pribadi, S. R. W.; Pribadi, T. W.; Wardhana, N. L. A.; Arif, M. S. (2021). "Fixed Manpower Reduction Analysis to Reduce Indirect Cost of Ship Production". *The 5th International Conference on Marine Technology (SENTA 2020)*. Surabaya. https://doi.org/10.1088/1757-899X/1052/1/012048

[8] Wahidi, S. I.; Pribadi, T. W.; Pribadi, S. R. W.; Megawati, S. (2021). "Implementation Study of Activity Based Costing System to Define Indirect Costs on Ship Repair Industries". *The 5th International Conference on Marine Technology (SENTA 2020)*. Surabaya. https://doi.org/10.1088/1757-899X/1052/1/012049

[9] Midhun, K. G. (2009). *Structural Design and Stability of a 6,000 ton Capacity Floating Dock as per DNV-GL Rules*. Master Thesis.

[10] Widjaja, S. (1996). *Manajemen Produksi Untuk Industri Perkapalan*. Surabaya: Instittut Teknologi Sepuluh Nopember.

[11] Kharis, M.; Pribadi, T. W. (2014). "Analisis Teknis dan Ekonomis Konversi Kapal Tanker Single Hull Menjadi Double Hull". *Jurnal Teknik Pomits*, Vol. 2, p. 5.

[12] Supriyono, R. A. (2000). *Akuntansi Biaya*. Yogyakarta: BPFE.

[13] Henry, S. (2002). *Akuntansi Manajemen*. Jakarta: Salemba Empat.

[14] Soejitno (2002). *Mata Kuliah Teknik Reparasi Kapal*. Surabaya: Institut Teknologi Sepuluh Nopember.