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Characteristics of SPOB Ship Hull Block Design Based on the Plate Supply Requirements

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Abstract

The main process of shipbuilding consists of several stages of work, including design, fabrication (cutting, shaping or forming), block assembly, outfitting, painting, erection, and work on the pier. The block assembly system is very efficient to be used in a ship production process in modern shipyards. In this system, the assembly's efficiency and productivity depend on the design of the block division; hence, it requires an appropriate design. Generally, the feasibility of the block division design still relies heavily on the expertise of experienced designers who has extensive knowledge of shipbuilding. The purpose of this study is to describe that the variation in the length of the plate used as the basis for dividing the ship hull blocks will affect the amount of the required supply plate material.This study uses 2 (two) block division designs which are based on a plate length of 20 feet (6069 mm) and 30 feet (9144 mm). Based on the division, the characteristics of the blocks' weight, number, dimensions and the number of supply plate material requirements can be obtained. The results show that the characteristics of the weight, number and dimensions of blocks for each plate reference length are different. The total material needed for each design is 773,028 kg and 907,212 kg. The effectiveness of supply material requirements for the design with 20 feet plate is better than the design for 30 ft plate, which is 0.31 compared to 0.41.

Keywords: Ship hull block design; Plate supply; Shipbuilding; Fabrication; Block assembly; Block erection.

1. Introduction

The main process of shipbuilding consists of several stages of work, including design, fabrication (cutting, shaping), block assembly, outfitting, painting, erection, and work on the pier. In the design stage, the ship is generally divided into some blocks of the right size based on some shipyard constraints. Each block is assembled through several assembly processes or a combination of several [1].

The widely basic principle used in product-oriented shipbuilding or the block method is product work breakdown structure (PWBS). The PWBS method was actually developed by Chirillo in 1985 when he introduced it in the USA's shipbuilding process [2].

The block assembly system is very efficient to be used in a ship production process in modern shipyards. In this system, the assembly's efficiency and productivity depend on the design of the block division; hence it requires an appropriate design [3]; [4]; [5].

Generally, the feasibility of the block division design still relies heavily on the expertise of experienced designers who has extensive knowledge of shipbuilding. Block division can be based on variations of available plate sizes in the market. The plate sizes commonly found in the market are 4 feet, 5 feet, 6 feet, 8 feet, 10 feet, 16 feet, 20 feet, and 30 feet. The use of plate variations in designing ship blocks will produce varied characteristics in terms of number, dimensions, block weight and material supply requirements.

The plate material requirements in a block design can be identified using a cutting design, nesting plan, or cutting path. Cutting design techniques have been widely developed which aim to achieve efficient use of supply materials [6]**;** [7]**;** [8]; [9]**.**

This study illustrates that plate length variations as the basis for breaking down the ship hull into blocks will affect the amount of material required for the supply plates.

2. Methods

The method is designed to show that the amount of supply plate material needed is strongly influenced by the characteristics of the division of the ship's hull into blocks.

In the first stage, block division planning is carried out. At this stage, two types of plate sizes, 20 ft and 30 ft, were selected as the basis for dividing the ship into blocks. The result of this division is the number of blocks for each length of the reference plate. Each block can then be determined in its dimension and weight.

In the next stage, a nesting plan process is carried out to determine the material supply requirements of each block design. This process results in the net weight and gross weight of the material or the weight of the supply material.

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2.1. Ship Data

Self-Propeller Oil Barge (SPOB) is selected as the ship case, with the ship's main dimensions shown in Table 1. The SPOB ship design consists of general arrangement, midship section, construction profile and shell expansion are shown in Figures 1, 2, 3 and 4, respectively.

Table 1. The main dimensions of the Self Propeller Oil Barge (SPOB) ship.

Description	Dimension
Length Over All (LOA)	94.50 m
Length Between Perpendicular (LBP)	89.47 m
Breadth (B)	18. 29m
Height (H)	6.70 m
Draft (T)	4.92 m

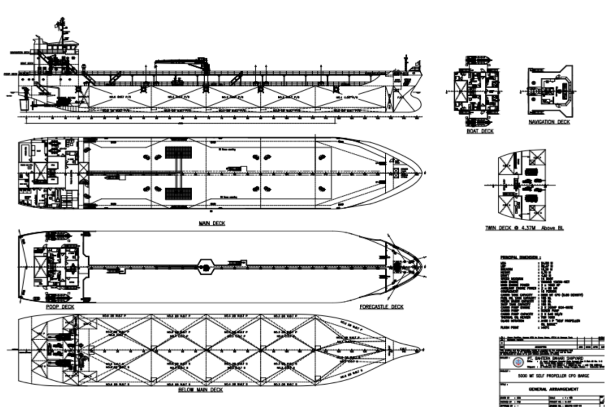

Figure 1. The general arrangement of 5OOO DWT SPOB ship.

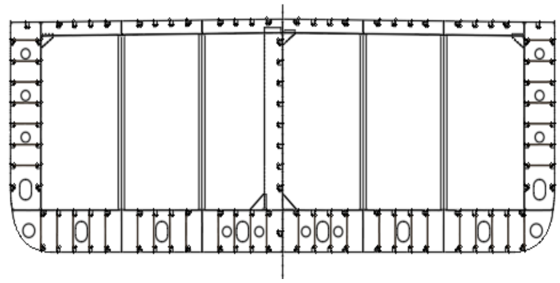

Figure 2. The midship section of 5OOO DWT SPOB ship.

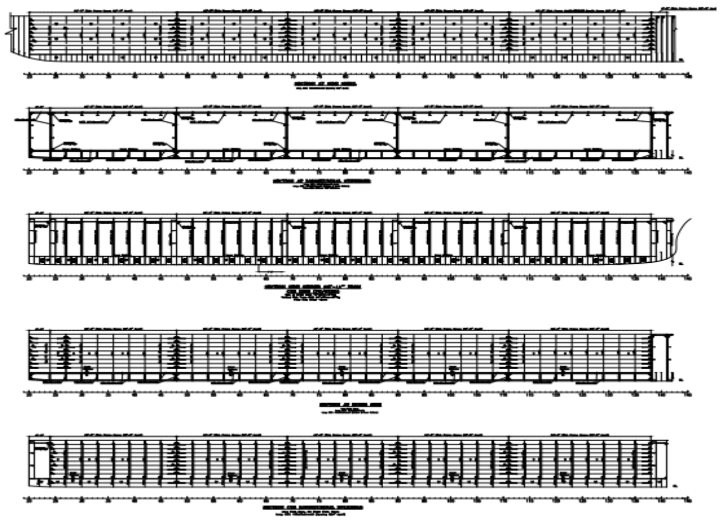

Figure 3. The profile construction of 5OOO DWT SPOB ship.

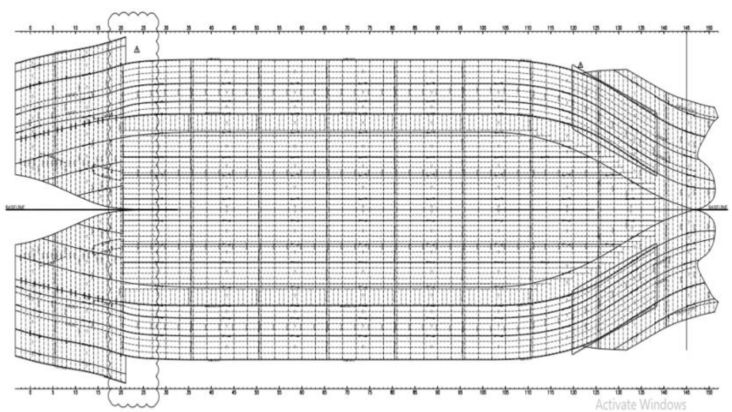

Figure 4. The shell expansion of 5OOO DWT SPOB ship.

2.3. Nesting Plan and Plate Material Supply

The nesting design determines the supply material requirements of each block design. The nesting method used is the heuristic method, which is a method that arranges the cutting pattern from large to small patterns. The quantity used as a nesting parameter is nesting efficiency (ŋ), which is the ratio of the use of available plates. The formulation of nesting efficiency (ŋ) is shown in equation 2 and Figure 5 [10]**.**

$$\text{ŋ} = \frac{W_L}{P_L} X100 \quad (2)$$

where

ŋ = nesting efficiency
W_L = length of the plate that can still be used (workable length)
P_L = available plate length (plate length)

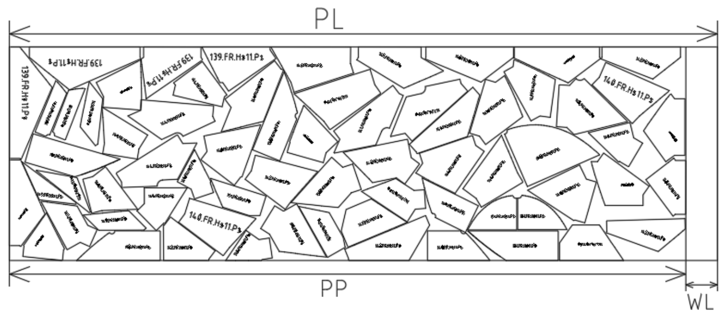

Figure 5. Nesting efficiency parameters

The results of the nesting design are the net weight and the gross weight of the material or the weight of the supply material. Net weight represents the total weight of the ship's construction elements installed on the ship. Gross weight is the weight for one sheet of the plate provided as a place to arrange construction elements with a nesting plan. For example, the gross weight of 20 feet x 5 feet x 0.315 inches or equivalent to 6096 x 1524 x 8.00 mm is equal to 6096 x 1524 x 8.00 x steel density.

3. Results and Discussion

The selection of hull block division design can be made in various ways depending on the resources of the shipyard. For the case in this paper, the basis for dividing the hull block is the plate length of 20 feet and 30 feet. The direction of block development is carried out vertically or as the assembly section method. The results of the hull block design using the assembly section method are shown in Figures 6 and 7.

Characteristics of the number, weight and dimensions as the result of the ship hull division design can be seen in Table 2 and Table 3.

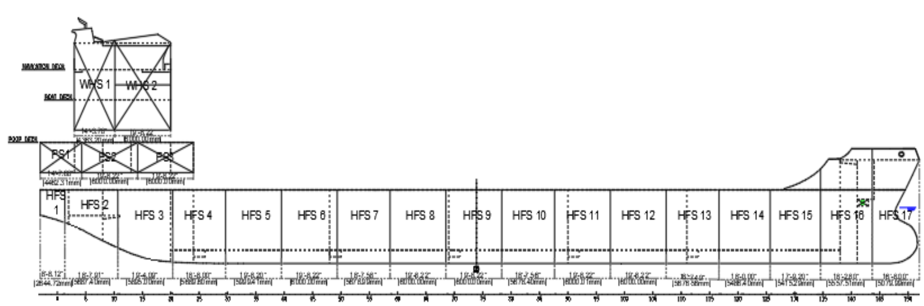

Figure 6. Block Division Plan for a 20 feet plate length.

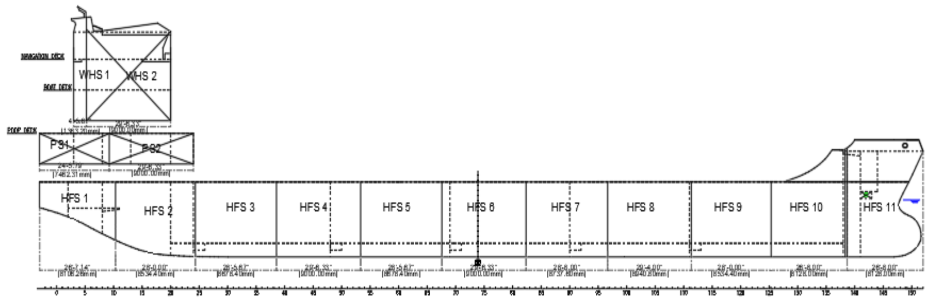

Figure 7. Block Division Plan for a 30 feet plate length.

Table 2. Characteristics of the number, weight and dimensions of blocks for a 20 feet design.

No	Block Code	Number of Blocks (units)	Weight (tons)	Dimensions (mm)		
				p	l	t
1	*2*	*3*	*4*	*5*	*6*	*7*
1	BLOK 1	1	22.79	2645	17004	3170
2	BLOK 2	1	52.63	5687	12246	5282
3	BLOK 3	1	62.51	5895	18287	6573
4	BLOK 4	1	78.63	5690	18287	6700
5	BLOK 5	1	72.09	5999	18287	6700
6	BLOK 6	1	78.91	6000	18287	6700
7	BLOK 7	1	67.92	5679	18287	6700
8	BLOK 8	1	70.61	6000	18287	6700
9	BLOK 9	1	78.91	6000	18287	6700
10	BLOK 10	1	67.97	5678	18287	6700
11	BLOK 11	1	78.91	6000	18287	6700
12	BLOK 12	1	71.18	6000	18287	6700
13	BLOK 13	1	76.60	5677	18287	6700
14	BLOK 14	1	63.36	5486	17716	6700
15	BLOK 15	1	62.98	5415	17046	6700
16	BLOK 16	1	60.76	5558	14692	8624
17	BLOK 17	1	26.68	5080	9595	10465
18	PS1	1	14.23	4462	17556	2743
19	PS2	1	14.38	6000	18288	2743
20	PS3	1	16.56	6000	18288	2743
21	WHS 1	3	20.91	4363	9754	2743
22	WHS 2	3	22.63	6000	9754	2743
Total number		29	1182.15			
Maximum			78.91	6000	18287	10465
Minimum			14.23	2645	9595	2743

Based on tables 2 and 3, the total weight of the ship's structure or the total weight of the block is the same, 1182.15 tons, because the sizes of the structural elements are the same. The difference between the two is only the block length.

The characteristics of the number of blocks are different, with 29 and 22 blocks for the design of 20 feet and 30 feet, respectively. It means that the number of blocks produced will be higher with a shorter block length of 10 feet with the same ship size. Using the same logic, the characteristics of the weight per block and the dimensions of the block will also be different.

The maximum and minimum block weights for each reference plate are 78.91 tons and 14.23 tons for the 20 feet design and 112.57 tons and 6.81 tons for the 30 feet design. The maximum and minimum dimensions are 6000 x 18287 x 10465 mm and 2645 x 9595 x 2743 mm for the 20 feet design and 9000 x 18289 x 10465 mm and 1363 x 9754 x 2743 mm for the 30 feet design, respectively.

Table 3. Characteristics of the number, weight and dimensions of blocks for a 30 feet design

No	Block Code	Number of Blocks (units)	Weight (tons)	Dimensions (mm)		
				p	l	t
1	BLOK 1	1	75.47	8131	17905	4875
2	BLOK 2	1	108.82	8534	18289	6584
3	BLOK 3	1	107.49	8678	18289	6700
4	BLOK 4	1	112.57	9000	18289	6700
5	BLOK 5	1	107.49	8678	18289	6700
6	BLOK 6	1	112.57	9000	18289	6700
7	BLOK 7	1	111.14	8738	18289	6700
8	BLOK 8	1	112.57	8941	18289	6700
9	BLOK 9	1	106.54	8534	18287	6700
10	BLOK 10	1	87.86	8128	16587	9550
11	BLOK 11	1	50.92	8128	84123	10465
12	PS1	1	21.16	7462	18174	2743
13	PS 2	1	24.01	9000	18289	2743
14	WHS 1	3	36.73	1363	9754	2743
15	WHS 2	3	6.81	9000	9754	2743
Total Number		22	1182.15			
Maximum			112.57	9000	18289	10465
Minimum			6.81	1363.2	9754	2743

Further, the material supply needs are identified if the net weight is constant. The nesting parameters and the amount of material needed are obtained using a nesting design approach or cutting path heuristic method. An example of designing a cutting pattern for 20 ft and 30 ft of plates using this method can be seen in Figure 8. Meanwhile, the nesting parameters and the number of supply plates required for the 20 ft and 30 ft designs can be seen in Tables 4 and 5.

a.

b.

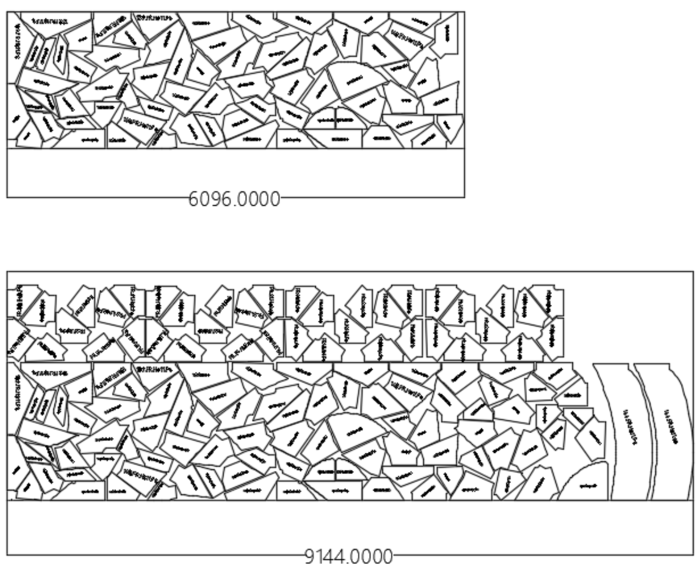

Figure 8. Nesting pattern a) plate length 20 feet, b) plate length 30 feet

Tables 4 and 5 show the nesting parameter, which is the plate utility. Both tables shows that the arrangement pattern for each design is satisfying and solid. The net weight of the assembled components is the same, which means that the arrangement pattern is proper because all the assembled construction components are complete.

Table 4. Nesting parameters and the number of plates supply required for a 20 feet design

No.	Plate Thickness (mm)	Plate Utility Average	Nesting Efficiency Average	Net weight (kg)	Gross weight (kg)	Number of supply plates (sheets)
1	8	0.89	0.11	24276.52	37089.98	53
2	9	0.93	0.07	168656.41	181863.41	231
3	10	0.93	0.07	55809.27	96224.04	110
4	12	0.86	0.14	287490.59	456626.71	435
5	14	1.00	0.00	967.08	1224.67	1

Table 5. Nesting parameters and the number of plates supply required for a 30 feet design

No.	Plate Thickness (mm)	Plate Utility Average	Nesting Efficiency Average	Net weight (kg)	Gross weight (kg)	Number of supply plates (sheets)
1	8	0.89	0.11	24279.55	35005.87	4
2	9	0.98	0.02	168655.69	177217.19	90
3	10	0.73	0.27	55804.29	158962.50	75
4	12	0.97	0.03	287492.87	532964.30	203
5	14	0.67	0.33	967.08	3063.01	1

Gross weight and the number of plates representing the amount of required material for supply plates are different for each design. The effectiveness of the number of material supply requirements in terms of the gross weight of the two designs can be seen in Table 6.

Table 6. Effectiveness of supply plate requirements for 20 feet and 30 feet designs

Material	Total Net Weight (kg)	Total Gross Weight (kg)	Effectiveness
	(1)	(2)	(3) = ((2)-(1))/(2)
20 feet plate	537199	773028	0,31
30 feet plate	537199	907212	0,41

The effectiveness of the supply material requirement (gross weight) on net weight is acceptable; it is close to 0 (zero), which means that the pattern of construction components arrangement in the available plates is solid, and there is not much residual area.

In Table 6, it is found that the effectiveness of the supply plate requirement for the 20 feet design is 0.31, which means that, on average, 31% is still the remaining area of the available plate or supply plate. As for the 30-feet design, the effectiveness is 0.41, meaning that, on average, 41% is still the remaining area of the available plate or supply plate. If viewed from the effectiveness of the supply plate requirement, the 20 feet design is preferred compared to the 30 feet design.

Based on the analysis of the two designs, some interesting findings can be described, among others.

1. The difference in the plate length used as the basis for dividing the hull block indicates the difference in the blocks' number, dimensions and weight. The number, dimensions, and weight directly affect the availability of lifting and transport facilities, construction areas and shipbuilding birth. Hence, it is important to assess and select the hull block design carefully. It means that the design selection depends on the shipyard's resources.

2. The difference in the plate length used as the basis for the division of the hull block indicates the difference in the supply material requirements. Care must be taken into account when selecting and applying the block design.

4. Conclusions

The difference in the plate length used as the basis for dividing the hull blocks indicates differences in the number, dimensions and weight of the blocks and indicates differences in the supply material requirements based on either the weight requirement (kg) or sheet (piece) approach. In this study, it was found that the effectiveness of the supply plate requirement for the 20 feet design was 0.31, which means that an average of 31% is still the remaining area of the available plate or supply plate. For the 30 feet design, the effectiveness of 0.41 means that an average of 41% is still the remaining area from the supply plate. If viewed from the effectiveness of the supply plate requirement, the 20 feet design is better than the 30 feet design

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