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PWBS Best Practice Analysis of Two Shipyards

Abstract

The product work breakdown structure (PWBS) of a shipyard defines both the interim product breakdown and the work breakdown. Shipyards that have a well defined PWBS can effectively reduce man-hours by applying techniques of group technology and hull block construction method (HBCM). In this paper, a case study of typical double-bottom blocks of both a car carrier and a self-unloading bulker vessel designed in different shipyards, are analyzed. Since each shipyard applies a different interim product breakdown structure (PBS), a best practice tabular comparison demonstrates which PBS is better. The conclusion is that different shipyards under the same corporation should objectively apply best practice methods which recognize and apply what is best from one yard to the other yard and vice-versa. This will raise the competitiveness level of both shipyards.

Keywords: Product breakdown structure-PWBS, shipbuilding, hull-block construction method- HBCM

1. Introduction

The product work breakdown structure (PWBS) derives from the Society of Naval Architects and Marine Engineers (SNAME) research in shipbuilding and related papers [1]. The development of interim products which are assembled at specific workstations and defined with the necessary tools and equipment and necessary man-power according to trade. The purpose of this paper is to analyze the PWBS breakdown of ships from two different shipyards. As a result of the analysis, the shipyard with the superior PWBS should be chosen as a model for the other shipyard, since the two shipyards are part of the same corporation or group. Therefore, it is logical and practical that based upon the conclusions made in this paper, that the management recognize the benefits of both yards in order to adopt a best practice.

The comparison and PWBS analysis of two different shipyards which are under the same management is ideal for best practice analysis and implementation. The

more efficient production methods of each shipyard could and should be stressed and implemented by both shipyards. This will improve the competitiveness of both shipyards, and yield man-hour savings and profit for the corporation.

The case study of this paper analyzed the breakdown of the double bottom section of a 24.900 tons self-unloading bulk carrier vessel and the breakdown of the double bottom of a 7000 vehicle car carrier. This includes the interim products of both vessels.

2. Background

Design for production can be defined as the need to design a vessel which is in compliance with Owner desires and Classification society and International maritime rules, while also being optimized with shipyard production facilities [2]. DFP is in correlation with both group technology and PWBS because it is necessary to develop the detailed production drawings and the interim products according to group technology principles. This way big panels are assembled in one assembly line, whereas smaller panels known as micro-panels are assembled in another assembly line [3-6].

Data mining methods to make predictions in the shipbuilding process is practical for shipyard management to decide to optimize the panel assembly line [7]. This yields significant savings in the core assembly process of any shipyard.

Value stream mapping methodology has been demonstrated to aid in improving panel assembly process [8,9], the built-up panel assembly process [10,11] and the large block erection process [12]. However, the purpose of this paper is to determine and demonstrate how the PWBS of two shipyards should be compared, and the one with the best system should be adopted by the other.

3. Case study

The bulk carrier vessel was designed and built in the 3. Maj shipyard using a product work breakdown structure. The second ship, a car carrier was designed by the Uljanik shipyard which is also the base of the Uljanik group. Depending on the work load of each shipyard, the designs from one yard are sometimes used to build the ship in the second shipyard, in this case study at the 3. Maj shipyard.

There are three main design phases. These include contract design, classification society design and finally production/detail design. While the contract design does have an influence on how the ship may be broken down especially from drawings such as the midship section, the production/detail design phase is the area where PWBS is implemented. Therefore, whereas the contract design and classification design of both shipyards could remain identical, it is certainly a necessity to adapt and transform the detailed design to be in compliance with the different shipyard facilities, since no two shipyards have the same exact facilities. Therefore, the detailed design will also have to be transformed to comply with the different facilities and constraints.

3.1. Self-unloading bulk carrier

The self-unloading bulk carrier has a deadweight of 24.900 tons, a length of 198 meters and a beam of 23.77 meters. It is designed to navigate through the St. Lawrence Seaway which connects the Canadian/US Great Lakes to the Atlantic Ocean.

The double bottom section of the parallel middle-body section was analyzed (See Figure 1). It is designated as VT which stands for very large three dimensional section and it has a mass of 148 tons and is made up of the following interim products: panels, built-up panels, sections, three-dimensional sections and three different types of micro-panels. A large panel (P) is made up of butt-welded steel plates stiffened with longitudinal profiles. A built-up panel (KP) is made up of a big panel (P) fitted with multiple micropanels. Micropanels are designated as robotically assembled (CR), semi-automatically assembled (CA) and manually assembled (MP) micropanels. The product breakdown structure is as follows (See Figure 2).

- P111 and P211 (Large panels)
- KP11 and KP21 (Built-up panels)
- T01, T11, T21 (Three dimensional sections)
- S14, S15, S24, S25 (Sections)
- MP003, MP032, MP033
- CR003, CR004
- CA070-CA079

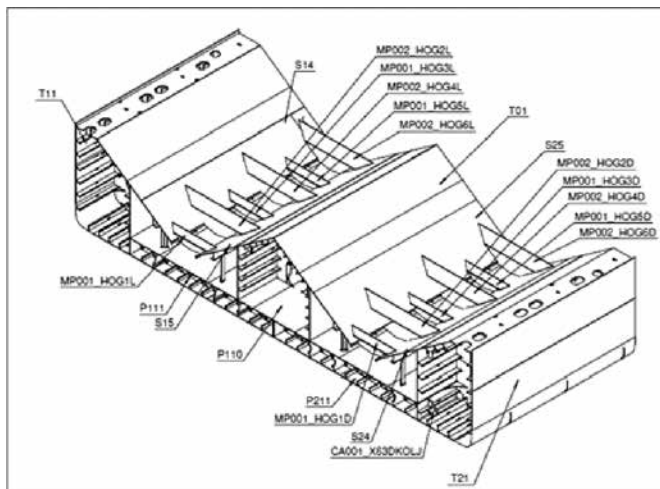


Figure 1. Double bottom erection block of the bulker vessel

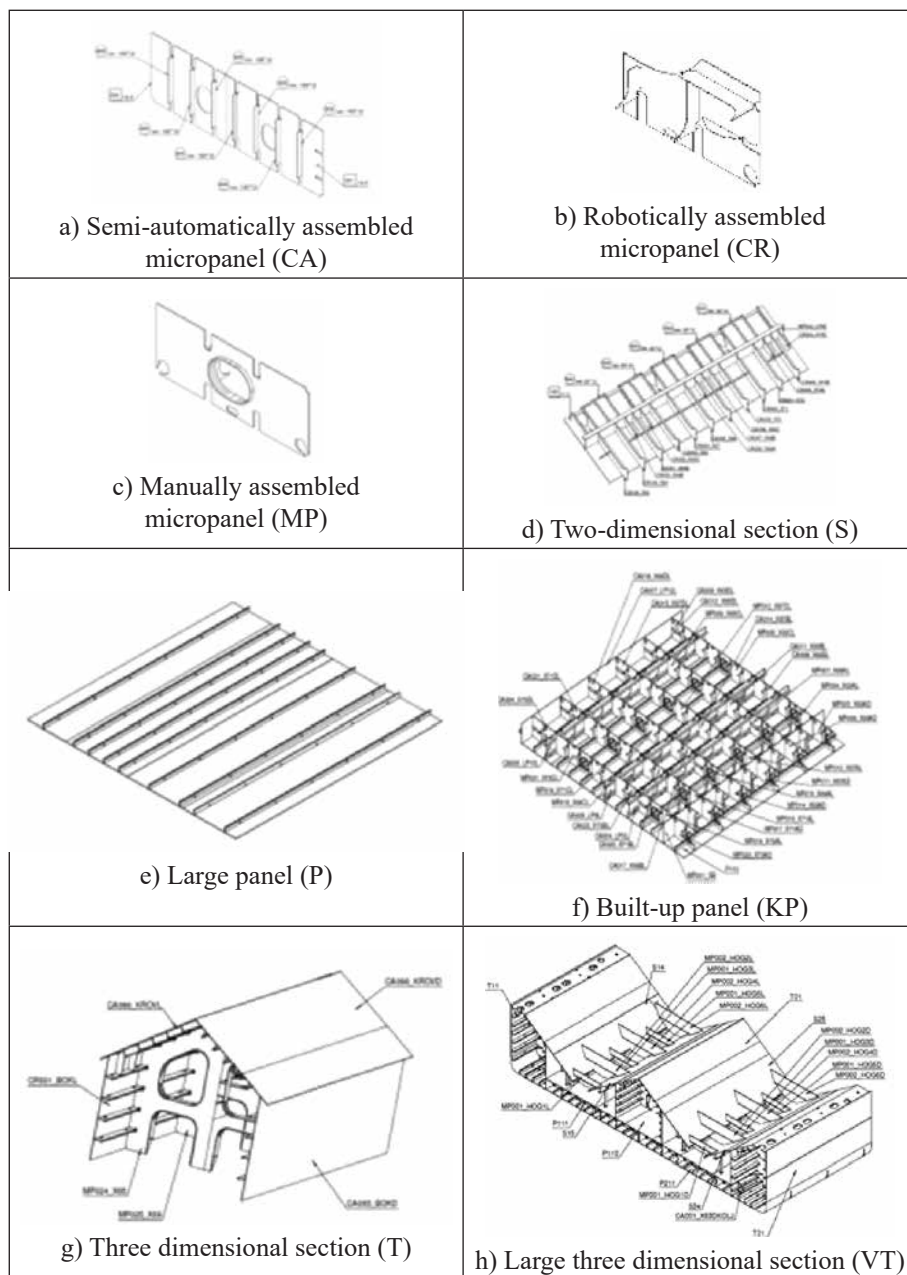


Figure 2. Illustration of interim product types

The different interim products once assembled in their specialized production lines are then transported and assembled in the gigantic assembly hall as demonstrated in Figure 3 below.

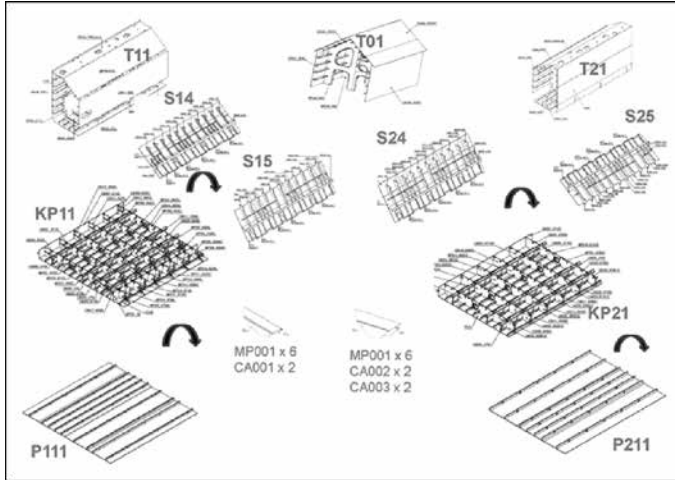


Figure 3. Interim product breakdown of a large erection block

The masses of each interim product is listed and summed up in Table 1 below, which yields a total of 148523 kg or 148.523 tons.

Table 1. Erection block interim product breakdown PBS

Interim product	Mass (kg)
T01	17869,79
T11	24239,85
T21	24239,85
S14	16559,02
S15	4757,67
S24	4299,07
S25	11690,94
KP11	19570,5
KP21	14483,6
P111	13817,6
P211	10139,3
Misc. elements	2502,96
Misc. micropanels	5356
	148523

3.2. Car carrier

The dimensions of the car-carrier built in the Uljanik shipyard are 199,90 m long, 32,3 m wide, with a capacity of over 7000 cars. The designations of the interim products have similarities to the interim products of 3. Maj (See Table 2). The parallel middle body breakdown is illustrated in Figure 4.

Table 2. Interim product designations at Uljanik and 3. Maj shipyards

Uljanik shipyard designation	3 Maj shipyard designation	Description
SU	VT	Large erection block
S (3D)	T	Three dimensional section
S (2D)	S	Three dimensional section
P	P	Panel
N	KP	Built-u panel
M	MP	Manually assembled micropanel
R	CR	Robotically assembled micropanel
A	CA	Semi-automatically assembled micropanel

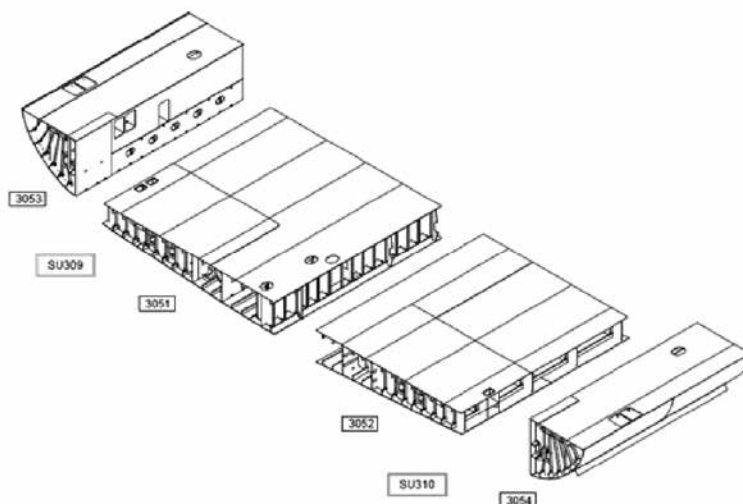


Figure 4. Interim product breakdown of a large erection block of a 7000 vehicle car carrier at shipyard B

The SU erection blocks 309 and 310 consist of four interim products labeled as sections S1 to S4. SU 309 has two sections as does SU 310. See Table 3 and Figure 5. The SU abbreviation of Uljanik shipyard is synonymous to the VT designation used by the 3. Maj shipyard.

Table 3. Erection block interim product breakdown PBS

SU Erection block number designation	Block S	Mass (tons)
309	1+3	101,168
310	2+4	87,587

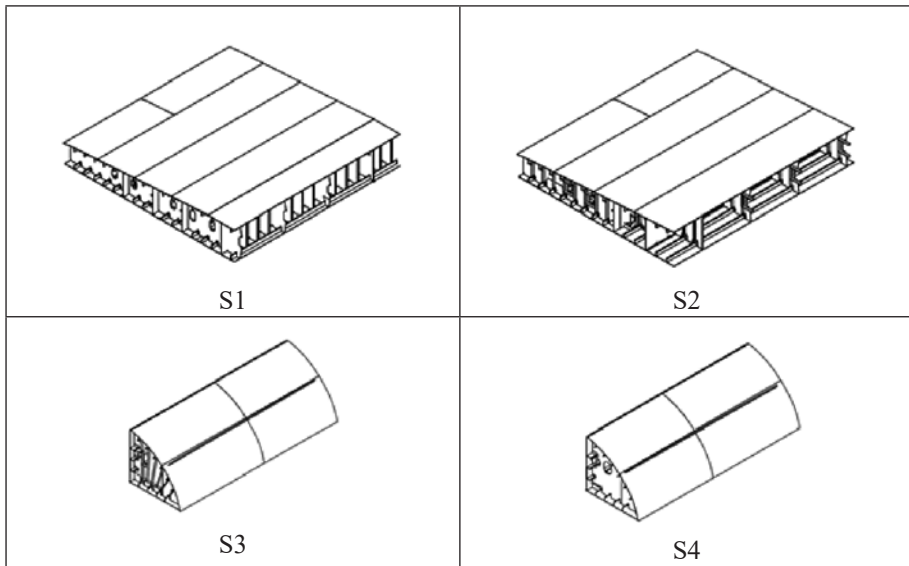


Figure 5. Close-up illustration of the interim product breakdown

The erection block 309 consists of two three-dimensional sections with a PBS shown in Table 4. Likewise, Table 5 shows the PBS of Erection block 310.

Table 4: PBS of Erection block 309

3D section	Erection block designation	Mass (tons)
S1	309	70,792
S3	309	30,376
Total		101,168

Table 5: PBS of Erection block 310

3D section	Erection block Designation	Mass (tons)
S2	310	57,18
S4	310	30,407
Total		87,587

A further breakdown of the micro-panel types are illustrated in Figure 6. In Uljanik shipyard, the micropanels labelled a and b are both done manually, whereas in 3. Maj shipyard, b would be performed by the robot, which results in less manual work, thereby yielding man-hour savings.

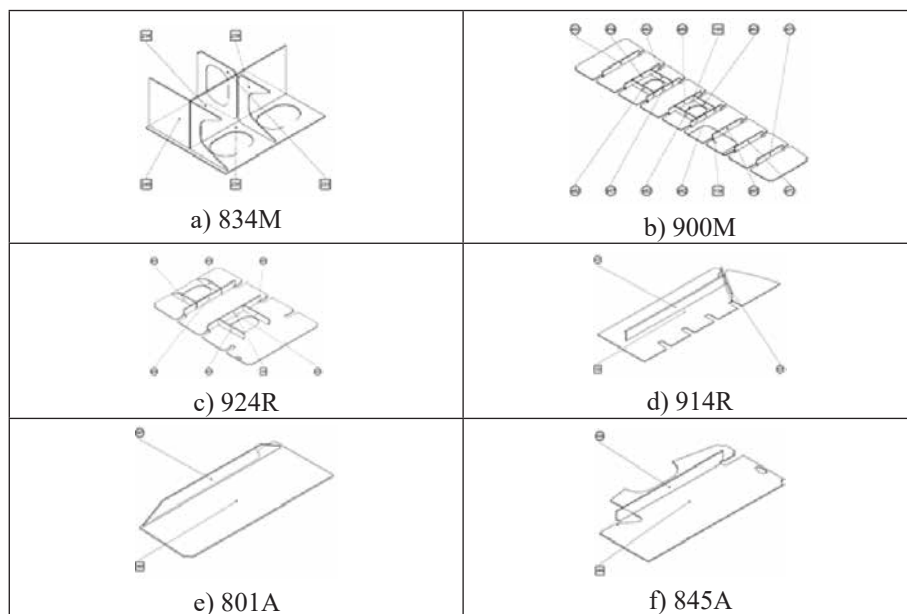


Figure 6. Micropanels a,b)manually assembled c,d)robotically assembled, e,f) semi-automatically assembled

Figure 7 below shows the large erection blocks at both 3. Maj shipyard and Uljanik shipyard. Uljanik shipyard has a greater breakdown due to having a smaller crane capacity, 150 tons vs 300 tons at 3. Maj shipyard.

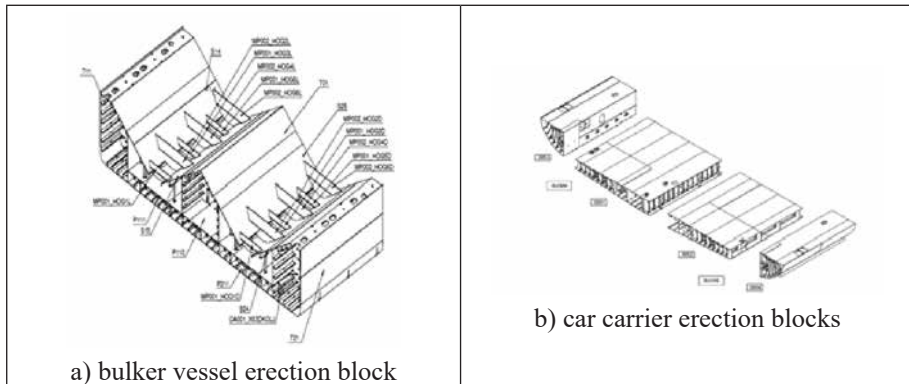


Figure 7. Double bottom erection blocks of the a) bulker vessel and b) car carrier - SU309 and SU310 erection blocks

4. Discussion

The main difference is that even though the two large erection blocks have great mass, 148 tons for the bulker erection block and 188 tons for the car carrier, the car carrier is divided into two erection blocks SU309 which has a mass of 101 tons and SU310 with a mass of 87,6 tons. This is due to the fact that the crane capacity at shiyard B is smaller and therefore is not able to assemble larger erection blocks.

The designations of all of the interim products at the 3. Maj shipyard follow a clearer logic. For instance, from walking around the 3. Maj shipyard, it is very easy to differentiate which sections and elements were designed by the engineering/design office of 3. Maj shipyard from the Uljank shipyard designs. Each interim product designed by 3. Maj is readily identifiable from the labelling method. By looking at either a fabricated longitudinal stiffener or a steel plate, it is identifiable by the hierarchical structure. Each steel element tells a story about how it will evolve in the downstream production process. For instance whether it will be assembled as a micropanel or a panel. Likewise, half of all assembled panels remain as panels and the other half transform to built-up panels. Then the assembly of a panel and a built-up panel result in a very large three-dimensional section. This clear labelling and PWBS system means that less time is spent in detemring where to transfer the interim products in the downstream shipbuilding processes. For instance, some micropanels are sent of the built-up panel assembly, while others may need to be sent to the large erection hall as was the case in this paper for the bulker larger three-dimensional seciton analyzed in this paper.

5. Conclusions

There are similarities and differences in the product work breakdown structures of both shipyards. The key differences are that 3. Maj shipyard has a much more logical PWBS system which is clearer for everyone, and does not look like esoteric bar-code labelling system which Uljanik shipyard uses. When 3. Maj shipyard uses Uljanik production drawings instead of transforming them to be in full compliance with its own facilities, then the production man-hours become significantly higher. Therefore, since both 3. Maj and Uljanik shipyards are part of the same holding corporation, when it comes to PWBS, it would be proper to adopt the 3. Maj shipyard system. This would drive down the man-hours thereby yielding major savings for the entire Uljanik group.

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PWBS analiza najbolje prakse dvaju brodogradilišta

Sažetak

Detaljna tehnološka raščlana međuproizvoda (PWBS) jednog brodogradilišta definira podjelu prouzvoda i podjelu rada. Brodogradilišta koja imaju dobro definiranu detaljnu tehnološku raščlanu međuproizvoda učinkovito smanjuju broj radnih sati koristeći blokovsku metodu gradnje trupa (HBCM). U ovome su radu analizirani tipični blokovi dvodna broda za prijevoz automobila i broda za prijevoz rasutog tereta s automatiziranim istovarom projektiranih u različitim brodogradilištima. Budući da svako brodogradilište koristi različitu raščlanu međuproizvoda (PBS), tabličnom usporedbom će se prikazati koja je raščlana bolja.

Zaključak je da različita brodogradilišta pod istom upravom trebaju objektivno primjenjivati metode najbolje prakse koje prepoznaju i, ono što je najbolje u jednom brodogradilištu, primjenjivati u drugome i obrnuto. To će povećati razinu konkurentnosti oba brodogradilišta.

Ključne riječi: Detaljna tehnološka raščlana međuproizvoda - PWBS; brodogradnja; blokovska metoda gradnje trupa - HBCM

