UNDERWATER HULL MAINTENANCE OF SHIP UNDERGOING PAINTING PROCESS AT BOUSTEAD NAVAL SHIPYARD

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ABSTRACT

This study is focused on underwater hull maintenance involving the painting aspects of a class A shipyard, namely Boustead Naval Shipyard. The research is about best practices in underwater hull surface preparation and subsequent painting process for a ship undergoing maintenance at the shipyard and whether best practices are adopted in accordance to international standards or otherwise. The methodological approach conducted for this research is through journal, reference analysis, statistics, observation as well as interviews.

Keywords: hull maintenance, surface preparation, painting process.

INTRODUCTION

Ships are classified by displacement, namely small class for a displacement of below 250 tons, medium class of between 250 and 500 tons, and large class for a displacement of more than 500 tones. This research will cover the large class ship with a displacement of more than 500 tones. Ships such as bulk carriers, containers, and specialized ships such as naval ships are normally subjected to planned maintenance routines as well as unplanned breakdown repairs. The maintenance of these ships may include, among others, mechanical, hull and electrical works. A very important common maintenance would be the hull maintenance such as painting and replacing of zinc anodes.

Every ship would normally need to undergo a process that involves painting, either on the superstructures or underwater hull areas. Painting is an important part in shipbuilding or ship repairs. Ships plying the seas are subjected to a lot of resistance and obstructions and this is made worse by the presence of underwater marine growth due to barnacles and other marine organisms that impede its speed and cause drag resistance. It is this very reason that ships require periodic underwater hull maintenance that include the surface preparation and painting process (Kovach and Swain, 1998). Painting is quite costly because it involves a big portion of the ship's surface area such as the hull and other related structures of the ship. Painting is needed to protect the surface from corrosion and to ensure the surface is provided with a good aesthetic quality that contributes towards enhancing its operational life and retain the upkeep cost to a minimum. Hence, the issue of proper surface preparation prior to painting is an important part of a ship's maintenance management in the shipyard. An improperly managed surface preparation works would eventually translate to poor painting works that will reduce the protection that it is supposed to render and cause eventual costly maintenance on the underwater hull. These costly maintenance and repairs, such as hull plating repairs or replacements during subsequent up-slipping routine maintenance may affect a ship's planned operational programme.

LITERATURE REVIEW

The literature that was reviewed for this study covered the various aspects of surface preparation, painting process and the importance to follow standards for a proper surface preparation and painting process. The reviews provided insights into past findings on most relevant theoretical methodologies formulated, gathered that helped provide cross checks with current research being done in order to derive best possible practices for adoption and application in the shipyard. As the subject matter is closely related to repairs and maintenance of underwater hull area prior to painting process, further understanding on ships' maintenance projects was sought and reviewed (Mayoss et al., 1995). Findings were reviewed on issues related to maintenance projects that showed a lack of proper surface preparation could lead to serious

implications, such as cost escalations, that adversely affected profit margins due to unforeseen warranty defects. These findings were in line with research done by Anderson (2000) that had similarly highlighted on aspects of improper surface preparation having a negative impact on quality of underwater antifouling paint application that would ultimately result in higher post maintenance up-keeping costs.

PROBLEM STATEMENT

There is a general lack of compliance to standards of surface preparation process and painting procedures in the shipyard industry that may lead to problems such as pollution, maintenance cost escalation and reduce efficiency in overall ships maintenance upkeep by ship owners. This is evident from occasional cost up-keeping issues that arise from defects due to improper surface preparation prior the application of underwater paint schemes, or even improper application of underwater antifouling paint itself. Some of these defects occur during warranty periods after a routine maintenance cycle, and may even dragged on until the next routine is due on the maintenance cycle. An unattended maintenance problem between maintenance routines would usually result in a more severe and costly repair exercise later on, such as requiring an extensive underwater hull renewal. This issue was highlighted by Anderson (2000) that called for a greater scrutiny on proper underwater surface preparation works to avert costly and unnecessary future hull repairs.

SIGNIFICANCE OF RESEARCH

The study shall significantly provide a deeper understanding of the concept of proper hull maintenance in the surface preparation and painting process of a large class ship. The findings of this research should help the shipyard plan and manage its maintenance and repair strategies to avoid unnecessary costly reworks due to poor maintenance practices and help it gain further advantages when compared to other companies within the shipbuilding and ship repair industry.

RESEARCH OBJECTIVES

This research is aimed to achieve the following objectives;

- To examine the best practices in underwater hull painting process for ship undergoing maintenance at shipyard.
- To determine the proper painting process for underwater hull of ships at the shipyard.

RESEARCH QUESTIONS

To help address the research objectives the following research questions were formulated.

RQ1: What are the standard practices used in underwater hull surface preparation at Boustead Naval Shipyard?

RQ2: What are the standard painting process carried out for ship undergoing hull maintenance at Boustead Naval Shipyard?

RESEARCH METHODOLOGY

The methodological approach adopted for this research is through the collection of information and data from reliable sources with respect to painting process in a class A shipyard involving ship repair. In this research, the methodology is basically through the collection of data and information from various sources such as interviews, questionnaires, observations and calculations. Observations and interviews help derive invaluable information that provide a better understanding of this study.

DATA ANALYSIS AND FINDINGS

Hull pressure wash

Hull pressure wash at the shipyard uses up to 3000 pound per square inch (PSI) at nozzle pressure to remove algae and barnacles. This method is in compliance with the best practice according to classification rules as specified by DNV GL (2016) that hull pressure wash must be between 2000 PSI and 5000 PSI for hull cleaning process. St2 (hand tool cleaning) and St3 (Power tool cleaning) may be used in the process of the hull cleaning.

Hand Tool Cleaning (St2)

The shipyard uses the hand tool cleaning such as wire brushing, sanding, scraping and chipping to remove loosely adhering mill scale and old paint. The use of St2 is very important when the positioning tooling is not feasible.

Power Tool Cleaning (St3)

The shipyard uses the power tool cleaning such as wire brushing, sanding disc and needle guns for removal of loosely adhering mill scale, paint and rust.

Salt test

Salt test is usually carried out to measure the level of salt and to ensure the content of salt is at minimum level (< 50 ppm). This process is very important before the paint coating to prevent coating failure due to effects of salt elements on the surface of hull. The presence of salt prior to painting may render the paint unable to maintain its adhesive qualities.

Condition of ship hull prior to blasting

After the hull cleaning process using water jet spray, the corroded area is identified for blasting based on rust grade and this is discussed between ship owner and shipyard for verification. When all parties had agreed with rust grade and total area to be blasted, it is then endorsed for blasting and subsequent painting using owner's choice of paint. This is to avoid unnecessary ambiguities that would arise later if no prior agreement and endorsement is made between both parties as it involves a great deal of cost.

Grit Blasting

Grit blasting is normally used for making ready a surface prior to the application of paint. When properly done it will remove old paint, rust, salts, fouling etc., and provide a good mechanical blast profile for the new coating. The shipyard uses the garnet abrasive media for blast area on underwater hull surface. It uses the garnet abrasive media for underwater hull blasting rather than slag. The advantages of garnet blasting media are namely, the absence of health issues such as silica sand, more eco-friendly and meets all Occupational Health and Safety requirements. In addition, garnet abrasive media meets the stringent requirements for current industry standards for chloride and free silica content. The entire automated production processing includes 4 times crushing, 6 times washing, 3 times magnetic separation and 4 times screening, and promising the highest standard of quality in respect of mineral purity and meeting stringent requirements for chloride and free silica content production (ISO 11126-10:2000E)

Paint Application

The paint application provides a film that gives protection and aesthetic aspects to the ship hull. The success of paint application depends on some variables such as surface profile, paint film thickness, method of application and conditions during application.

Generally, manufacturer of paint will provide a technical data sheet about the paint application. Technical data sheet will provide information about minimum surface profile needed before application of paint, dry film thickness of paint, and many other information that painter needs in order to do a paint job. The shipyard uses one of the popular brands of paint for this particular ship under study. The popular brand provides a technical data sheet to the shipyard as a guide for its painting application.

Coating Code

The shipyard normally uses a five (5) coat scheme for painting of underwater hull area of ship. The first coat is the short primer, followed by a primer coat and a tie coat, then the first anti-fouling coat followed by another anti-fouling coat. This may vary according to customer preference.

Short Primer

The shipyard uses one of the popular brands as short primer. The paint needed a minimum SA 2.5 for surface profile before it can be applied to the substrate. The popular brand is a pure epoxy two components system. Epoxy two components means that the coating does not need the hardener to dry.

Primer

After the short primer is applied to the substrate, the paint inspector normally checks the surface of the substrate to ensure surface profile Sa 2.5 is achieved before the primer can be applied. St2 and St3 are used to achieve the desired surface profile. The shipyard uses a popular brand of marine paint as primer for painting the surface area of hull. The paint is epoxy two components and can directly be applied after first coat of short primer. The coat covers the surface area of substrate with a coverage of over 8-metre square per liter.

Tie coat

The tie coat is used between epoxy anti-corrosive coatings and some types of anti-fouling paints. Incompatibility between both types of coating can be overcome using tie coat. The shipyard uses a popular brand of paint as tie coat. The coat is a two component type and is applied after the primer coat. The coat covers a surface area of substrate with a coverage of over 12-meter square per liter.

Anti-fouling Paint

Ship's underwater hull is painted to guard the substrate and stop undue roughness. The most important explanation for hull roughness is fouling. Anti-fouling paint is applied for the final coat to ensure the hull surface is protected from fouling and to maximize the effectiveness of hull roughness. The shipyard uses the popular brand of paint as anti-fouling paint for painting the ship's underwater hull area.

Film thickness measurement

The coating application involves two types of thickness measurement, namely the wet film thickness (WFT) and dry film thickness (DFT). The wet film thickness is the thickness of coating when in wet condition, and the dry film thickness is the thickness of coating in dry condition. Wet film thickness is usually determined by the dry film thickness. Specific wet film thickness is needed to achieve the desired dry film thickness. The basic formula to measure WFT is as follows:

$$WFT = \frac{DFT \times (100 + \%Thinning)}{\%V.S.} \quad [\mu m]$$

Table 1: Hull Coating Systems and Allocation
Hull coating systems and allocation

Hull coating systems and allocation			
Allocation	Coating Type	Total Average DFT microns	Number of coats
External hull, underwater including boot-top area • Between loaded and ballasted water line	Epopxy or Epoxy coal tar + Anti-fouling paint	300-350 250-350	2-3 2-3

Different ship's area has different dry film thickness. Table 1 above shows the recommended dry film thickness according to DNV GL.

Table 2: Dry film thickness used by Bousted Naval Shipyard Sdn Bhd on KD Jebat

Surface Area (m^2)	Paint Type	Vol. solid (%)	Dry Film Thickness
1997.00	MUKI EPS, Red	25	50
	Jotamastic 90, Dark Red	82	150
	Safeguard Universal ES, Grey	62	150
	Seaquantum Plus S, Light Red	50	125
	Seaquantum Plus S, Darkt Red	50	125

Table 2 indicates the dry film thickness used by Boustead Naval Shipyard Sdn Bhd on KD Jebat. Dry film thickness used by the shipyard is as recommended by DNV GL.

Table 3: Drying and curing time

Coating Type	Muki	Jotamastic	Safeguard	Seaquantum
Surface touch to dry	20 sec	90 minutes	90 minutes	30 minutes
Walk-on-dry	1 min	3 hours	6 hours	NIL
Dried to over coat, minimum	3 hours	90 minutes	6 hours	6 hours
Dried/cured for service	3 days	2 days	2 days	NIL
Dried to immersion	NIL	NIL	NIL	8 hours

Table 3 shows the drying and curing time for each coat as used in Boustead Naval Shipyard Sdn Bhd to paint ship's underwater hull surface area. For surface touch to dry, it is between 20 seconds and 90 minutes.

According to the popular anti-fouling paint brand the coating has a maximum of 1 month for safe exposure to the air. If the hull that is coated with the paint is exposed to the air for more than one month, the effectiveness of the coat will decrease as the main purpose of the coat is designed for immersion in water.

Paint Estimation

Paint estimation is for one of Malaysian Navy ship, KD Jebat. Every data given by Bousted Naval Shipyard Sdn Bhd is calculated to define the paint estimation and cost for the paint.

Table 4: Paint Estimation for KD Jebat

	Paint Type	Vol Solid %	Dry Film Thickness	Loss %	Practical Coverage	Paint Est { Liter}	Price (RM) Per {Liter}	actual price (RM)
surface Area 1997.00 m2	MUKI EPS,RED	25	50	30	3.5	570.57	27.89	15913
	Jotamastic 85, Dark Red	82	150	30	3.8	521.86	65	33921
	Safeguard Universal ES, Grey	62	150	30	2.9	690.21	47	32440
	Seaquantum Plus S, Light Red	50	125	30	2.8	713.21	215	153340
	Seaquantum Plus S, Light Red	50	125	30	2.8	713.21	215	153340
		Total	**600**				**Total**	**388954**

Table 4 shows the paint estimation for KD Jebat. Total dry film thickness for painting of underwater hull surface area of 1997-meter square is 600 microns. The calculation includes the losses for every coating as mentioned from technical data sheets from the popular paint brand which is 30% for every coating due to environmental conditions during the application of the paint.

Price for every coating is not mentioned by Boustead Naval Shipyard Sdn Bhd due to confidential issues of the company. Therefore, the price was taken from the website of eBay to get the estimation cost for every coating. The total estimation cost for every coating to paint the underwater hull surface area is RM388,954.

CONCLUSION

Boustead Naval Shipyard Sdn Bhd uses the popular paint brand products for every coating scheme starting from short primer, primer, tie coat and antifouling coats for painting the ship's underwater hull area. The paint manufacturer gives a technical data sheet for every coating that they produce, and every company needs to follow the guide and procedures from the technical data sheet to get the best results from the products.

IMO Antifouling System Convection stated that every antifouling paint applied to vessel must not contain metallic component such as organotin Tributylin (TBT) that can slowly kill marine sea life and may even enter our food chain (Anderson, 2000).

The paint manufacturer considers the harmful effects of metallic compounds and has come out with a new technology known as non-toxic alternatives to TBT systems such as silicon-type foul release AF that is used in the anti-fouling paint.

All coatings from the paint manufacturer as used by Boustead Naval Shipyard Sdn Bhd comply with the IMO and the technical data sheet provided by JOTUN and had proven that Boustead Naval Shipyard Sdn Bhd has complied with the best practices for their painting process.

RECOMMENDATION

Salt test is important to prevent coating failure due to effects of salt elements on the surface before coating. Salt test must be considered during the surface preparation process. Boustead Naval Shipyard Sdn Bhd does not use the salt test in its surface preparation process for ship undergoing painting maintenance at their shipyard.

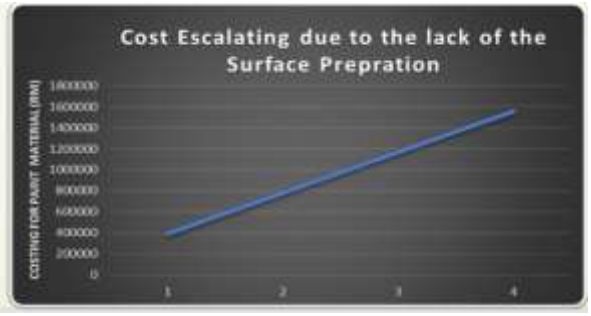

Figure 1. Cost Escalation Due to Lack of Surface Preparation

Figure 1 indicates the cost escalation due to the lack of surface preparation. The graph shows the total cost for paint is RM388954 and it may increase due to lack of a proper surface preparation and subsequent reworks. It is strongly recommended that Boustead Naval Shipyard Sdn Bhd considers the use of the salt test for every ship undergoing maintenance for repainting process at their shipyard. This is to ensure that the painted underwater surface remains sustainable throughout the ship's operational duration and needing another up-slip only when next routine is due based on maintenance cycle, not having to be up-slipped due to some unnecessary and costly emergency reasons such as underwater hull failures due to paint peeling or damage by barnacles due to poor surface preparation and anti-fouling paint application.

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