Journal of
Offshore Structure and Technology

ISSN: 2349-8986
Volume 11, Issue 3, 2024
September–December
DOI (Journal): 10.37591/JoOST

https://journals.stmjournals.com/joost

Research JoOST

An Overview of New Coastal Research Vessel (N-CRV) Dry Dock and Construction

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Abstract

A New Coastal Research Vessel (N-CRV) is a specialized ship designed for scientific research in fields like oceanography, geology, biology, and atmospheric studies, equipped with specific facilities and accommodations for sea missions. This paper discusses the coastal research ship dry-dock, construction, and design process, which involves three stages: concept, preliminary, and contract design. N-CRV must utilize scientific cruise, Exclusive Economic Zone (EEZ) survey, deployment, data collection, and seawater sample collection for the scientific community, considering initial, operating, and future maintenance costs. N-CRV construction and Dry docks are critical shipyard assets because they are essential facilities for ship maintenance and are thus critical assets of a shipyard. Marine vessel performance is crucial in maritime applications, influenced by internal variables like fuel, propulsion type, loading condition, and external factors like fouling, sea state, and currents. The shape of a ship's hull is meticulously crafted, as its geometry affects various aspects such as hydrostatics, layout, structural integrity, and overall appearance. Shipbuilding involves using scientific equipment, deck and engine machinery, materials, and skills. The ship builder needs to consider four inputs from the customer: cargo type, volume, route of operation, and cruising speed. The shipbuilder must also ensure the vessel will deliver at the required speed under loading conditions. The paper also explores ship dry docking and construction, which is often the most labor-intensive stage of shipbuilding. Ships are usually constructed in a dry dock, although some are launched using a ship lift. Efficient use of the construction site is crucial, as it is the most expensive facility, and the speed of construction determines the number of ships built. Dry docks are essential for ship repair and cleaning, with the main types including graving dock, floating docks, marine rail docks, ship lifts, and marine mobile lifts. These types are primarily used for small vessels like recreational yachts, tugs, and pilot boats. In this paper, we study the ship construction and dry dock inspection of N-CRV at a shipyard. It involves decisions on assigning ships to a set of dry docks and sequencing the ships in each dock. The ships have been mounted on the laying blocks and have undergone detailed inspections. Ship construction provides comprehensive guidance for designing and building ships from beginning to end. It covers modern shipyard techniques, safety practices, material properties and strengths, welding and cutting methods, ship structures, computer-aided design and manufacturing, international regulations for various ship types, as well as new materials and fabrication technologies. Ship construction uses a variety of materials, including steel, marine-grade aluminum alloys, and glass fibre-reinforced plastics, to create durable and reliable products. Dry docking is vital for coastal vessels as it ensures safety by allowing experienced professionals to thoroughly inspect the vessel, including checking the hull condition, propulsion system, and safety equipment, preventing potential issues from escalating into major problems. The paper introduces a new coastal research ship construction, fabrication, dry-dock maintenance and repair work. Dry docking improves vessel efficiency by ensuring good working order, reducing fuel usage, and increasing efficiency. This can result in cost savings for owners, particularly in the competitive shipping industry.

Keywords: Dry-dock, Vessels, New- Coastal Research Vessel (N-CRV), Exclusive Economic Zone (EEZ) Atmosphericstudies, ship construction

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Received Date: August 14, 2024
Accepted Date: October 04, 2024
Published Date: October 07, 2024

Citation: G. Nagarajan. An Overview of New Coastal Research Vessel (N-CRV) Dry Dock and Construction. Journal of Offshore Structure and Technology. 2024; 11(3): 1–11p.

INTRODUCTION

A dry dock is a structured area for ship construction, repairs, and maintenance. It allows water to fill the area and features a lock for vessel movement. Once a ship is inside, the gates are closed, and the seawater is drained, revealing the hull and other exposed parts for maintenance and repairs. This design enables vessels to enter and exit the dry dock efficiently. Two main dry-docking methods are gravity and floating dry docks, each tailored to vessel and operator requirements.

The New-Coastal Research Vessel (N-CRV) is an advanced monohull research ship designed for interdisciplinary oceanographic coastal research in shallow bays and estuaries. The vessel measures 43 meters in length and 9.6 meters in breadth, with a gross tonnage of 500. Registered tonnage is a unit of volume, where one tonnage is equivalent to 100 cubic feet. There are two types of registered tonnage: Gross Registered Tonnage (GRT) and Net Registered Tonnage (NRT). GRT represents the vessel's enclosed volume, excluding certain spaces, while NRT is the GRT minus certain deducted spaces [1–3].

The N-CRV will perform tasks such as surveying, sampling, data collection, launch, towing, and recovery of scientific packages in shallow water, handling and testing small remotely operated vehicle ROVs and autonomous underwater vehicles (AUVs) up to 500 m, deploying and recovering coastal moorings, processing shipboard data, analyzing samples, precision navigation, and station keeping. The coastal research vessel, with a gross tonnage of 495, can sail at 12 knots at a 90% continuous rating, operate at 1000 m depth, and have 15-day endurance. Table 1 provides a comprehensive overview of the new CRV.

N-CRV has two laboratories and equipment for environmental indexing and bathymetric surveys in coastal and offshore waters. The facility is equipped with advanced scientific equipment such as a bacteriological incubator, laboratory water purification system, double beam UV visible spectrophotometer, autosalinometer, zoom stereo microscope, thermosalinometer, gravity corer, motion reference unit, sediment sampler, multiyear echo sounder, automatic weather station, CTD winch, hydrographic winch, CTD (portable), autoclave, centrifuge, portable nutrient analyzer, niskin water sampler, zooplankton net, dosimat, laminar flow, UV cabinet, fume hood explosion proof, carbon dioxide analyzer, auto analyzer, multiple corer, ultrasonic scientific anemometer, and acoustic doppler current profiler 300 kHz.

A CTD device is commonly used on multiple underwater vehicles (ORVs) for conducting temperature and depth measurements, typically utilizing single or cluster arrangements called 'rosettes' and lowered into water using an A-frame. Figure 1 depicts the advanced scientific equipment of the N-CRV [4–6].

Table 1. Main particulars of new CRV.

S.N.	Particulars	Dimension
1	Length overall (app)	43 m
2	Length BP	39 m
3	Breadth molded	9.6 m
4	Depth up to main deck	3.70 m
5	Design draft (molded)	2.5 m
6	Draft (scantling)	2.65 m
7	Speed	12 Knots @ 90 % MCR
8	Frame spacing	500 mm
9	Fresh water	20 m^3
10	Fuel oil	60 m^3
11	GT	< 500

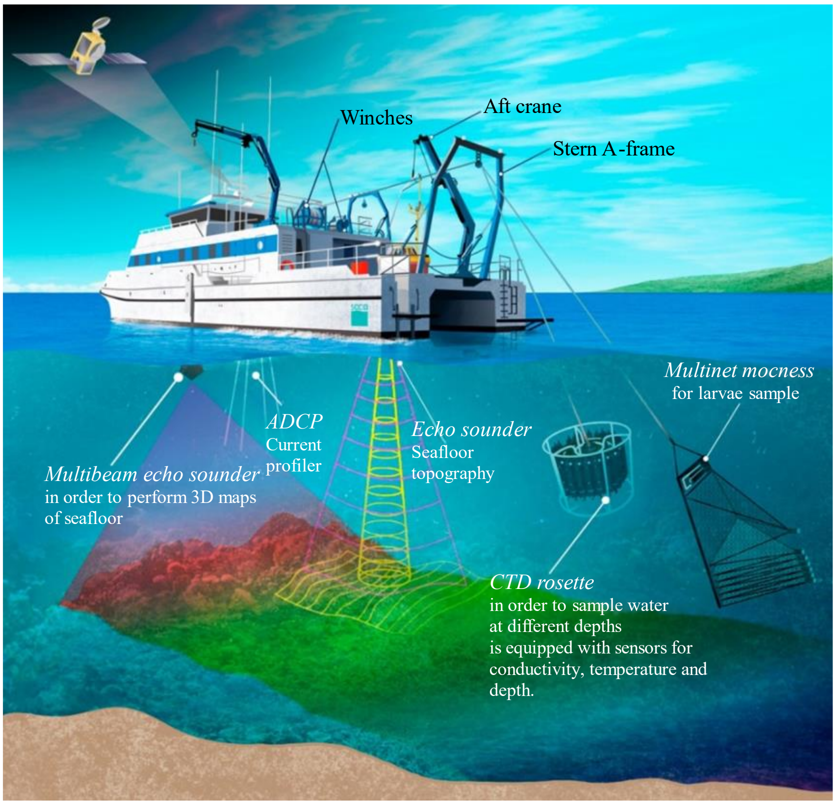

Figure 1. Ship scientific equipment's.

N-CRV DRY-DOCKING GENERAL

Dry-docking is an essential part of the shipbuilding process, conducted when the vessel is nearly complete, outfitted, and ready for the sea. The layout of the shipbuilding process is illustrated in Figure 2. The ships discussed in this paper were constructed on a slipway, made of steel, launched longitudinally, and then moved to the outfitting pier for final outfitting and commissioning. Dry-docking occurs when the vessel is largely finished and seaworthy. This process includes various activities related to the ship's outer hull and inspections, such as scraping off fouling, steelwork (including chipping of launching support structures), high-pressure washing, spot sandblasting, sand sweeping, and applying coating systems, including antifouling coatings.

Additionally, checks on appendages and equipment involve measuring propeller shaft wear, checking seals, and measuring rudder stock bearings and jumping bar clearances. Dry-docking also provides an opportunity to install underwater sensors, such as speed logs, echo sounders, and draft sensors. During this period, the vessel undergoes final system commissioning and testing to ensure it is ready for sea trials upon completion of the dry-docking process**.** The result of the new building dry-docking is a seaworthy vessel with a clean and coated outer shell prepared to proceed to sea trials, particularly speed and maneuvering trials, and after the vessel’s delivery to the buyers, she is ready for a five-year service before the subsequent dry-docking [7–9].

The docking plan also details the number of blocks and the minimum load-carrying capacity for each block. As the entire weight of the ship in the docking condition has to be borne by the keel blocks, it is also necessary to limit the weight of the ship while she is being docked. The extra ballast weight, which must be kept at a minimum to ensure stability while the vessel is afloat or sailing, needs to be reduced as much as possible before the vessel enters the dry dock. Since the weight of ballast required for the vessel to stay upright in afloat condition may be more than the weight acceptable by the keel block, it may be necessary to take the vessel into the dock with that much ballast and then de-ballast the vessel when she is inside the dry dock but is still afloat. The construction flow diagram depicted in Figure 3.

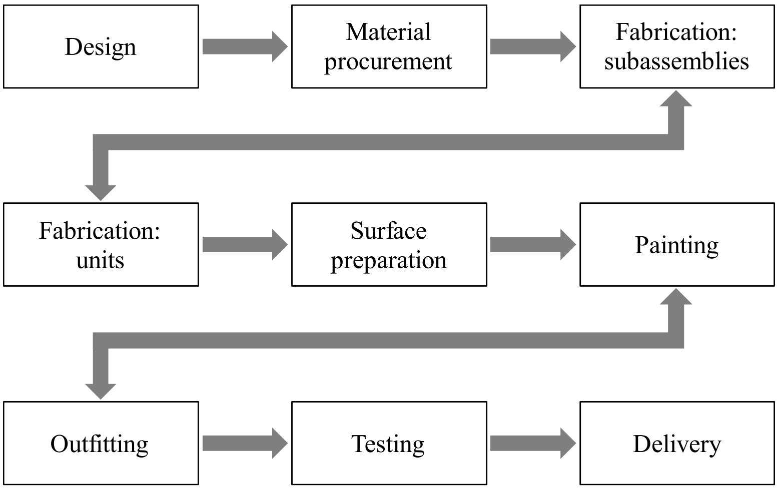

Figure 2. Shipbuilding process layout.

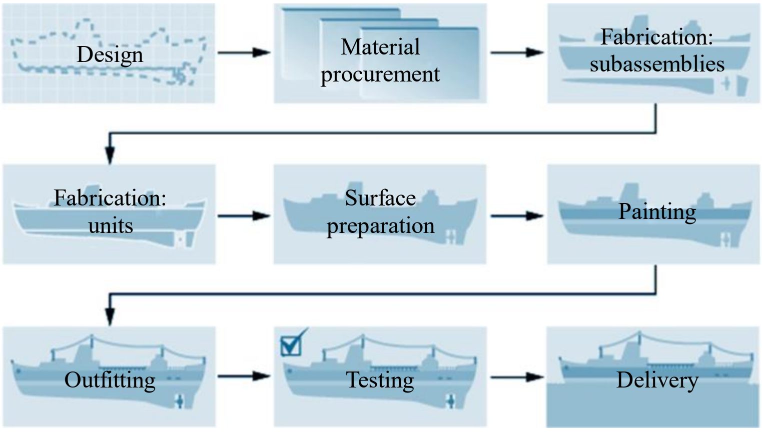

Figure 3. N-CRV Manufacturing process flow diagram.

Figure 4. The ship hull construction at the shipyard.

The ship must have the least ballast and no cargo on board. Divers are sent to check the accuracy of the blocks. The dock master pumps water out of the dock, and the ship sits on the keel blocks slowly. The ship's contact with keel blocks should not be outside the vessel's center line to prevent tumbling, and the cleaning and repairing process commences once the ship is docked. The ship hull construction at the TWL shipyard is depicted in Figure 4. The dry docking procedure can be understood by following the following sequence.

Dry Docking Scheduling

Every vessel has its own routine schedule for dry docking. The shipyard will also need the repair list and design of the vessel from the shipowner. Once both parties agree, then the dry docking can proceed. The ship block fabrication at the shipyard TWL is depicted in Figure 5. Regular dry docking of N-CRV is crucial for efficient and safe ship operation, with the following two main objectives:

1. The ship's hull will be cleaned, scrubbed, de-scaled, and painted to restore speed and fuel consumption to their original state.
2. The task involves a comprehensive examination of all underwater critical components and the entire hull for defects and the necessary action.

The shipyard will devise a docking plan based on the ship-owners data, arranging vessel blocks. Blocks are typically made from one material to maintain similar stiffness. Different materials used in construction can cause more force on smaller blocks, potentially causing damage to the block or the ship's hull. Common materials include concrete with steel and timber blocks. at the bottom. When combined with concrete or steel bases, timber blocks can take a smaller load.

First, the vessel will be washed using a high-pressure washer. Second, blasting is necessary to remove rust, coral, or defect paint from the vessel. The blasting can be a swift blasting or spot blasting, depending on the ship owner’s request. Last, the vessel will get its new paint. Sandblasting, a high-velocity process of propelling fine particles to clean or etch surfaces, was once used to remove paint and rust from ship hulls. However, due to silicosis, other materials are now used, making sand dust inhalation less common.

Dry Dock Repair and Maintenance Process

Dry docking repair and maintenance processes are meticulous processes that ensure safety, efficiency, and quality in the construction of N-CRV vessels. These vessels are designed for scientific missions, analyzing seawater's characteristics and marine ecosystems. Dry docking helps identify and repair issues, ensuring optimal performance and longevity. Additionally, it offers opportunities to upgrade a vessel, such as increasing fuel efficiency, leading to long-term cost savings and improved performance. Implementing this strategy enhances the efficiency of a vessel.

During this period, the shipyard will implement a repair and maintenance procedure based on the shipowner's repair list. The repair and maintenance include replating, maintenance work, and changing the spare parts if necessary. Starting with the engine, pumps, piping system, sea chests, even rudder, and propeller.

Sea Trials and Departure

After undergoing repair and maintenance, the vessel passes quality control and is released from the dry dock, allowing it to float for trials and departure. Tugs are used to transport the vessel to a safe area for sea trials.

Figure 5. Ship block fabrication at shipyard.

During the completion of a vessel, several tests are conducted to ensure its stability and loading. The naval architect assesses the ship's weight, stability, and loading details using data from inclining experiments. Dockside trials are held for preliminary testing of main and auxiliary machinery before official sea trials. Formal speed trials are conducted to fulfil contract terms, often preceded by a builder's trial. Contract terms require speed to be achieved under specified conditions of draft and deadweight, achieved through runs over a measured course. Progressive speed trials measure the vessel's performance over a range of speeds, with essential requirements such as adequate depth of water, freedom from sea traffic, sheltered waters, and clear marking posts.

The N-CRV underwent extensive testing and trials to evaluate its performance in real-world situations, ensuring optimal functionality and safety regulations through sea trials and comprehensive inspections. A coastal research vessel is preparing for its return to the sea after removing support and refloating, symbolizing its renewed strength and readiness for its voyage. The N-CRV sea trail underwent successful trials, including machinery and speed trials, as depicted in Figure 6.

The new vessel has been commissioned to return to service after completing sea trials. Every ship-owner has to plan their docking schedule since there is limited available space. The sea trial test is a crucial test conducted to assess the effectiveness of various technologies and processes in the marine environment.

WELDING PRACTICE AND TESTING OF WELDS

WPS and Structural Material

A Welding Procedure Specification (WPS) is a mandatory document that outlines accepted, reliable, and repeatable welding techniques for certified welders. It is developed for each material alloy and welding type used, often driven by specific codes or engineering societies. A WPS provides direction to welders or welding operators for producing sound and quality production welds according to code requirements.

The butt joint is the strongest welded joint, produced when two plates are in the same plane. It is recommended to use butt joints in all welded structures. Figure 7 illustrates the ability to buttweld various thickness plates at different locations.

The bulbous bow has been constructed in accordance with approved drawings and the welding of bulbous blocks has been inspected by the Quality Assurance (QA) process adheres to the class rules as illustrated in Figure 8.

Figure 6. N-CRV at sea trial test.

Journal of Offshore Structure and Technology
Volume 11, Issue 3
ISSN: 2349-8986

Figure 7. Block Fabrication work in progress at yard.

Figure 8. Ship Bulbous welding.

Fusion welding is a crucial shipbuilding technique that utilizes high-intensity heat sources to melt plate edges to be joined. Gas welding, arc welding, and resistance welding are the most common heat sources for fusion welds. Gas flame serves as a heat source for fusion welding, and other fuel gases with oxygen can be utilized to produce high flame temperature. Acetylene is the most commonly used gas, providing an intense, concentrated flame when burned with oxygen. The N-CRV has been designed in various parts in accordance with the approved drawings. Figure 9 displays the parts of the ships.

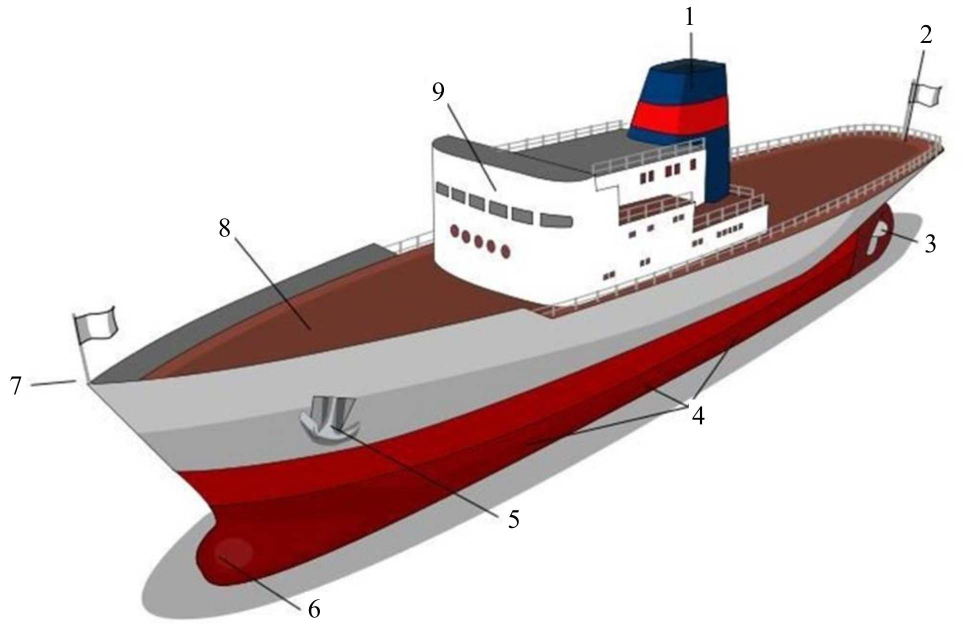

Figure 9. Parts of the ships (1) Funnel, (2) Stern, (3) Propeller and rudder, (4) Port side and Star, (5) Anchor, (6) Bulbous bow, (7) Bow, (8) Deck, (9) Super structure.

Classification Societies

A vessel is considered "in class" if it holds a current certificate of classification from a recognised classification society, such as the American Bureau of Shipping, (ABS), Lloyds, (LR), Bureau Veritas, (BV), or other members of the International Association of Classification Societies (IACS), indicating conformity to structural strength, machinery, and equipment standards, ensuring seaworthiness and safety in marine insurance. With over 50 ship classification organisations worldwide, these societies publish rules and regulations focusing on ship strength, structural integrity, equipment provision, and machinery reliability. Ships can be constructed in any country under specific classification society rules, and are not limited to the relevant society of the country where they are built.

The Indian Register of Shipping (IRS) is an international organization that provides classification, certification, and inspection of all ships. The class requires two docking surveys in each five-year special survey period, with a maximum interval of three years. One of the two surveys must coincide with the Special Survey, and in exceptional circumstances, the interval may be extended by three months. An in-water survey (IWS) can be utilized as an alternative to intermediate docking between specific types of surveys. Special surveys differ from routine surveys, with a more extensive inspection scope and timing covered by class rules.

Mid Ship (MS)

The longitudinal strength of a hull girder is determined by the section modulus of the midship section, which is influenced by the scantlings and layout of structural members in the MS region. The section extends one-fourth of the ship's length forward and aft of the MS, and its scantlings remain constant. The maximum longitudinal bending moment occurs within this zone, making the midship section crucial for longitudinal strength and determining the structural layout based on the cargo type. Consequently, different types of ships have different MS sections.

Engine vs. Propeller curve

The main engine, with a make of SCANIA, has an output of 552 kW and a RPM of 1800.The light running margin (LRM) is the percentage of the propeller curve below the engine curve, calculated by subtracting the relative length of the horizontal end of the engine curve from the Figure 10.

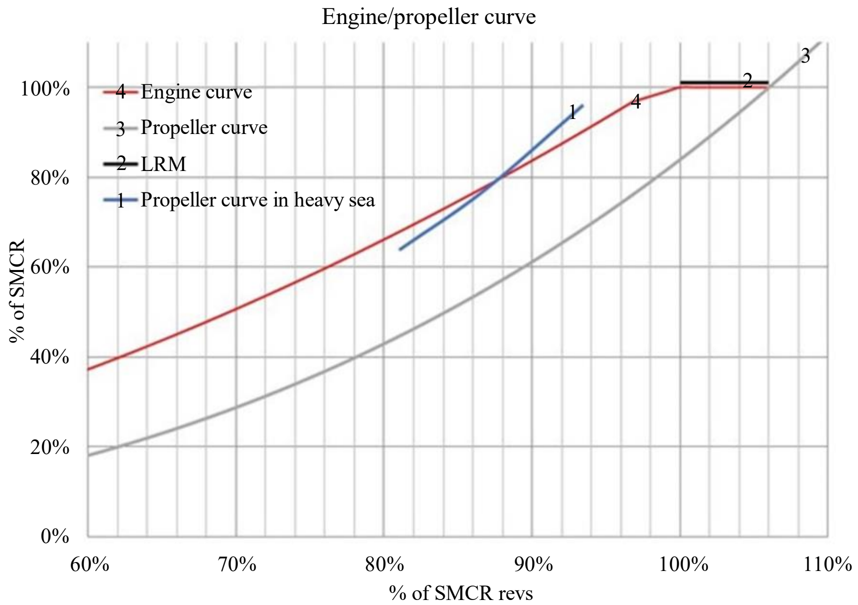

Figure 10. Illustrates the calculation of the light running margin (LRM) for engine and propeller curves.
(Ref: https://forcetechnology.com/en/about-force-technology/news/news-archive/model-test-reveals-propellers-influence-on-ship-performance)

Figure 11. Fabrication of Aluminium super structure.

Large vessels typically use a fixed pitch propeller (FPP) directly connected to the main engine drive. However, the propeller must be designed to be below the engine curve, ensuring sufficient power for still water trials with some margin for added resistance. This resistance can come from fouling of the hull and propeller or environmental factors like waves and wind. Model tests enable objective evaluation of the propeller's light running margin (LRM) and allow for necessary pitch modification.

MATERIAL FOR N-CRV CONSTRUCTION

The aluminum welding quality is excellent, with consistent width throughout and straight parallel lines between the two edges. The 5083 type of Al-alloys are commonly used in shipbuilding for plates and 6082 for extrusions, providing reliability in marine service and manufacturing. Al-Mg type alloys offer potential for at least 10% lower costs in heat-treatable applications, making them favorable for shipbuilding applicability. The work on Y 283 Aluminums Fabrication is currently in progress as depicted in Figure 11.

Aluminum alloys can replace carbon steels, reducing weight, improving ship stability, enabling narrower ship designs, and enhancing fuel efficiency. Rudder stock, made of cast or forged steel, is determined by its diameter based on its bending moment and torque. The plating and stiffeners are IRS Grade-A/IS-2062 and E250 Grade BR/BO Steel.

The Process of Preparing Steel Materials

A ship's structure consists of both flat and curved steel plate panels. Its hull structure must meet watertight integrity, separate internal spaces like cargo and fuel oil, and resist forces, particularly waves. Steel material preparation is a crucial process in fabrication, involving the removal of residual stress and a hard layer of oxides called mill scale. This stress and oxide layer must be removed before the plates and sections are taken for further production. The handling of materials from the mill to the shipyard steel stockyard may also cause surface deformation, necessitating straightening. Steel material preparation includes straightening, stress-relieving, and mill scale removal. Plates are fed from the stockyard to the straightening machine and then to the surface dressing station. Surface dressing removes mill scale, a layer of ferric and ferrous oxides formed during the hot rolling operation of steel plates. Shot blasting and chemical pickling processes are the most efficient methods for surface dressing.

Plate Cutting

Shipbuilding requires precise cutting of plate parts with varying thicknesses. This can be done through mechanical or thermal processes. Mechanical methods involve shearing force, while thermal processes involve oxidation, fusion, or sublimation. Mechanical methods use guillotine shear or high-pressure water jets, while thermal processes use oxy-flame cutting, plasma arc cutting, or laser cutting. The plate cutting work for Y 283 is underway as depicted in Figure 12.

Basic Structural Components

A ship is composed of various structural components that provide the ship's shell structure with basic strength and support. These components can be longitudinal or transverse, and they can be basic structural members or prefabricated components. Ship construction follows an orthogonal stiffening arrangement, ensuring they are never arranged in an arbitrary or oblique direction. Prefabricated structural components are aligned and welded in place. Brackets play a crucial role in connecting components and providing load paths. Buckling is the primary failure cause of these brackets, and to prevent failures, flanged brackets, curling, a higher corrosion margin, and various cutouts in highly loaded areas are used. The shipbuilding process is divided into indoor and outdoor methods, including cutting, forging, sub-assy, unit assy, grand assy, outfitting, painting, pre-erection, and erection.

Figure 12. Y-283 Plate cutting work in progress.

CONCLUSIONS

This paper examines N-CRV ship construction and dry dock scheduling for coastal ships, providing a detailed analysis of dry dock systems, procedures, scheduling, welding practices, ship parts, steel material preparation, classification societies, shipbuilding process layout, ship repair, and maintenance. A review of New-Coastal Research Vessel Dry Dock (N-CRV) and construction aids academicians, ship operators, and owners in monitoring and analyzing coastal research vessel performance and efficiency, particularly in construction, by introducing a new building dry-docking performance to improve decision-making processes.

The shipyard demonstrated its commitment to the government's 'Make in India' vision by successfully launching the N-CRV vessels. The first New Coastal Research Vessel was delivered to the ministry in August 2019. Since then, it has conducted over 15 scientific cruises, praised for its comfortable sailing environment and extensive scientific instruments. The N-CRV, a 43-metre-long vessel, is currently sailing under the Indian flag, with a width of 9.6 meters. Advancements in science and technology have significantly advanced research vessels, with the concept of investigating ships set to continue demonstrating significant advancements in the future.

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