PS-1 Report

Goa Shipyard Ltd.

College: Birla Institute of Technology and Sciences

Instructor In-Charge : Dr. Ranjit Patil

Duration: 30/05/2023 - 21/07/2023

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ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to Goa Shipyard Ltd. for providing us with the opportunity to undertake our internship at their esteemed organization. This internship has been an invaluable experience, enriching our knowledge and understanding of shipbuilding, the manufacturing process, and various ship machinery.

During our time at Goa Shipyard Ltd., we had the privilege of working alongside highly skilled professionals who generously shared their expertise and mentored us throughout the internship. Their guidance and support played a pivotal role in shaping my understanding of the intricate processes involved in shipbuilding, from the initial design stages to the final construction and outfitting.

We had the chance to witness firsthand the meticulous planning and execution required in shipbuilding projects. We were able to observe the integration of cutting-edge technologies and advanced machinery to ensure the highest standards of quality and efficiency.

Moreover, the hands-on experience we gained with various ship machinery was invaluable. We had the opportunity to work with propulsion systems, navigation equipment, electrical systems, and other critical components that form the backbone of a ship. This practical exposure allowed me to comprehend the complexities and functionality of these systems, and how they contribute to the overall performance and safety of a vessel.

Lastly, we would like to extend our gratitude to the entire staff of Goa Shipyard Ltd. for their warm welcome and unwavering support throughout the internship. Their willingness to share their knowledge and experiences made this learning journey all the more rewarding.

And special thanks to Mr. Polimeta Samuel, Mr. Manor Kumar Mishra, and Mr Nikhil Jeet for taking out time from their busy schedules to teach us about various things with utmost patience.

Also, thanks to Dr. Ranjit Patil, Instructor In-charge, and PSD, BITS Pilani for their encouragement, support, and valuable advice during this project.

ABSTRACT

This study report investigates the intricate field of shipbuilding, analyzing the processes, techniques, and innovations involved in the construction of ships. The report explores various aspects of shipbuilding and the various components being manufactured, such as engines, shafts, propellers, generators, sea tubes, and many more. The report analyses the problems in pipe bending as stated by various workers at the shipyard and with the help of multiple research papers, tries to provide an approximate solution to the problem. This report aims to serve as a helpful resource for anyone entering the field of shipbuilding and provide them with the basic information and knowledge needed for the same.

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INTRODUCTION

About GSL

Goa Shipyard Limited, founded in 1957, is a distinguished organization that holds certifications for Integrated Management Systems on ISO 9001:2015 for Quality Management Systems (QMS), ISO 14001:2015 for Environment Management Systems, and ISO 45001:2018 for Occupational Health & Safety Management Systems by Indian Register Quality System (IRQS), which is accredited by NABCB and RvA. GSL operates under the administrative control of the Ministry of Defence, Government of India. GSL is strategically located on the banks of river Zuari in Vasco Da Gama, Goa, a major international tourist destination well connected by its international airport and major port en route to all important shipping lines.

Initially a small barge building yard under the Portuguese, GSL has evolved into a prestigious shipbuilder renowned for its sophisticated vessels. With over four decades of experience, GSL excels in designing and constructing modern patrol vessels with Steel and Aluminium hull structures, serving various defense and commercial applications.

History

In 1957, the colonial government of Portuguese India established the "Estaleiros Navais de Goa" shipyard to construct barges for the flourishing mining industry in Goa. This growth was spurred by India's blockade of Goa in 1955. After Goa's liberation in 1961, the shipyard's potential to contribute to the nation's development was acknowledged. Consequently, the yard underwent significant development and was renamed Goa Shipyard Limited. It was strategically transformed into a premier defense shipbuilding hub on the west coast of India. In the aftermath of Portugal's defeat and unconditional surrender to India due to the 1961 annexation of Goa, the shipyard was requisitioned for the production of warships for the Indian Navy and the Indian Coast Guard.

GSL has evolved to meet the expanding shipbuilding requirements of the national naval defense sector. With in-house design capabilities, GSL caters to diverse client needs in both defense and commercial sectors. Through intensive research and development efforts, GSL has developed its own range of products, forming the basis for the majority of its shipbuilding projects. Presently, GSL is actively engaged in developing Patrol Vessels ranging from 29m to 110m in length.

Ships Built to date

- **Landing craft Mark II**
    - *L34* – commissioned 28 January 1980
    - *L33* – 1 December 1980
    - *L35* – 11 December 1983
    - *L36* – 18 July 1986
    - *L37* – 18 October 1986
    - *L38* – 10 December 1986
    - *L39* – 25 March 1987[6]
- ***Saryu* class offshore patrol vessel**[edit]
    - INS *Saryu* (P54)
    - INS *Sunayna* (P58)

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    - INS *Saryu* (P54)
    - INS *Sunayna* (P58)
    - SLNS *Sayurala* (P623)
    - SLNS Sindurala (P624)
- ***Vikram* class offshore patrol vessel**[edit]
    - CGS *Varad* (40) – 19 July 1990
    - CGS *Varaha* (41) – 19 July 1990
- ***Samar* class offshore patrol vessel**[edit]
    - CGS *Samar* (42) – 14 February 1996
    - CGS *Sangram* (43) – 29 March 1997
    - CGS *Sarang* (44) – 21 June 1999
    - CGS *Sagar* (45) – 3 November 2003[8]
- ***Tarantul I* class missile corvette**[edit]
    - INS *Vinash* (K47) – 20 November 1993
    - INS *Vidyut* (K48) – 16 January 1995
    - INS *Prahar* (K98) – 1 March 1997 Lost at sea on 22 April 2006[9]
    - INS *Pralaya* (K91) – Missile Corvette 18 December 2002
- **Extra fast patrol vessel**[edit]
    - CGS *Sarojini Naidu* (229) – 11 November 2002
    - CGS *Durgabai Deshmukh* (230) – 29 April 2003
    - CGS *Kasturba Gandhi* (231) – 28 October 2005
    - CGS *Aruna Asaf Ali* (232) – 28 January 2006
    - CGS *Subhadra Kumari Chauhan* (233) – 28 April 2006[10]
- In 1997, GSL built the three-masted barque INS *Tarangini* for use as a training ship for the Indian Navy.
- **Offshore Patrol Vessel**[edit]
    - ICGS *Samarth* – 10 November 2015

The Modernisation Project

In response to the ever-evolving demands of the maritime industry, Goa Shipyard Ltd. (GSL) has embarked on a comprehensive modernization program. This initiative aims to create new facilities and infrastructure while augmenting existing ones, ensuring GSL's readiness to undertake future ship construction projects, including the series construction of high-technology ships for the Indian Navy and Coast Guard.

The four-phased plan includes the establishment of an integrated steel fabrication facility, dedicated building berths with shiplift and transfer systems, improved material handling capabilities, and advanced crane facilities. GSL will also introduce new material stores, a GRP complex for constructing Mine Countermeasure Vessels (MCMVs), outfitting jetties, and revamping electrical and mechanical services. By optimizing resources, leveraging cutting-edge technology, and implementing efficient business methods, GSL seeks to achieve high-quality vessel production, cost competitiveness, shorter construction timelines, faster deliveries, increased capacity, and a diversified product portfolio.

The blueprint for the new construction facilities is based on a "product center concept." This approach streamlines the ship construction process by establishing four distinct multi-functional production complexes. Each complex will be equipped with the necessary trade skills and equipment required for a specific stage of ship production. By minimizing workforce movement within the shipyard and optimizing equipment and tooling efficiency, this approach creates a highly productive work environment while reducing capital investment and operating costs associated with materials handling.

Phases 1 and 2 of the Modernization Project were commissioned on May 21st, 2011, significantly enhancing GSL's infrastructure. The shipyard now boasts a system capable of docking 120-meter vessels weighing up to 6,000 tons, along with a Ship Transfer Area spanning approximately 13,600 square meters. As a result, GSL proudly holds the distinction of being India's first defense shipyard equipped with a modern shiplift facility for launching and docking ships. This development has invigorated repair activities, reinforcing GSL's capabilities in this domain.

Upon completion, the Modernization Project will enable GSL to build vessels according to customer requirements within shorter time frames than previously possible. The shipyard's capacity for fabricating steel, aluminum, and GRP hull vessels will nearly triple, while the . These advancements contribute to India's strategic goal of enhancing its own shipbuilding capabilities.

Strengths

GSL operates as an integrated management system certified under ISO 9001:2015. With its in-house design capability, GSL stands as a company equipped to handle various aspects of shipbuilding and related services. The shipyard boasts a world-class CAD/CAM facility utilizing the Tribon platform, enabling efficient design processes. Furthermore, GSL utilizes an ERP-enabled management system integrated with design and planning applications, facilitating effective database management, project monitoring, and control.

GSL's infrastructure includes a state-of-the-art Shift Lift facility capable of accommodating vessels weighing up to 6000 tonnes, along with dedicated repair berths. To support steel preparation activities, GSL operates a modern steel preparation shop equipped with CNC plate cutting machines, automatic shot blasting equipment, and a CNC pipe bending machine. The shipyard also houses a modern electronic workshop, ensuring the availability of cutting-edge equipment and technologies.

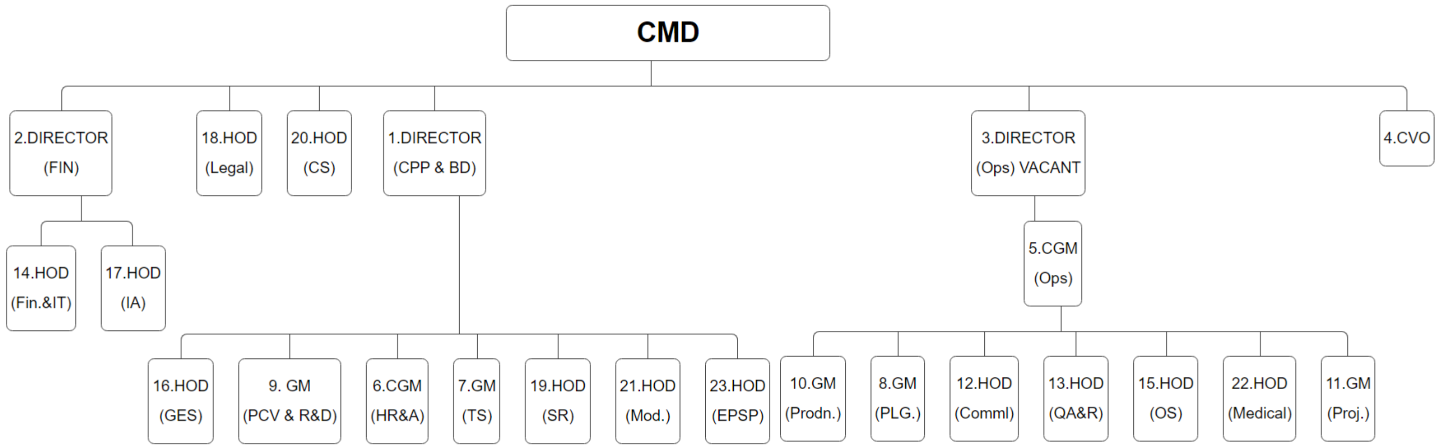
With a focus on ship repair and general engineering services, GSL offers comprehensive solutions to meet industry demands. Additionally, GSL is committed to the development of simulated training facilities, providing a practical and immersive learning environment. The shipyard takes pride in its skilled workforce of over 1700 personnel, including a team of more than 265 qualified engineers and naval architects who contribute their expertise to the successful execution of projects and the overall growth of GSL.

Services Offered

GSL takes pride in offering a wide range of services, including vessel design and construction, simulated training facilities, vessel repair and modernization, and the supply of stern gear. With in-house design capabilities, GSL is known for efficiently constructing vessels for both defense and commercial sectors. The shipyard's state-of-the-art facilities and skilled workforce enable them to handle diverse repair and modernization projects, ensuring vessel longevity and efficiency.

Additionally, GSL provides reliable and high-performance stern gear components essential for the propulsion system of vessels. As a trusted partner in the maritime industry, GSL meets the evolving needs of customers and contributes to sector growth and development.

Organization Chart



Abbreviations			
1.	Director (Corporate Planning, Projects & Business Development)	13.	Head of Department (Quality Assurance & Reliability) [AGM]
2.	Director (Finance)	14.	Head of Department (Finance & Information Technology) [AGM]
3.	Director (Operations) [Position Vacant]	15.	Head of Department (Outsourcing) [AGM]
4.	Chief Vigilance Officer	16.	Head of Department (General Engineering Services) [AGM]
5.	Chief General Manager (Operations)	17.	Head of Department (Internal Audit) [AGM]
6.	Chief General Manager (Human Resources & Administration)	18.	Head of Department (Legal) [AGM]
7.	General Manager (TS)	19.	Head of Department (Ship Repairs) [AGM]
8.	General Manager (Planning)	20.	Head of Department (Company Secretary) [AGM]
9.	General Manager (PCV & R&D)	21.	Head of Department (Modernisation) [AGM]
10.	General Manager (Production)	22.	Head of Department (Medical) [AGM]
11.	General Manager (Projects)	23.	Head of Department (EPSP) [DGM]
12.	Head of Department (Commercial) [AGM]		

Corporate Objective

1. To design and build warships for the defense forces of the Nation, sea-faring platforms for the Commercial sector, and export to friendly foreign Nations, meeting project timelines and quality standards.
2. To carry out repairs and refits of defense and commercial ships.
3. General engineering services related to designing and manufacturing products relevant to shipbuilding and Naval applications.
4. Endeavor to expand/diversify the business of the Company through concerted marketing efforts.
5. To enhance global outreach and increase footprints through exports to friendly foreign nations by offering comprehensive solutions, thereby enhancing export revenue.
6. To continuously enhance production capabilities by adopting emerging technologies, improved internal processes, innovative practices, and infrastructure augmentation.
7. To strive for maximizing indigenization in line with Govt. policies to achieve self-reliance in shipbuilding.
8. To make sustained efforts to encourage domestic vendors to onboard the GeM portal to achieve the objective of mandatory procurement.
9. To help build up a strong industrial base by developing ancillaries.
10. To ensure commitment towards environment protection & conservation and integrate into production processes.
11. To formulate corporate policies on employment, promotion, reservations, and workers' participation consistent with the Government's efforts in promoting social justice to the people at large. Promote the use of Hindi as a medium of communication.
12. To improve productivity by harmonious industrial relations.
13. Promote welfare activities to raise the morale of the employees and up-skill human resources through training and engaging the workforce in learning and development programs.

14. To create a conducive, clean, and safe working environment.
15. Maintain a high standard of quality through strict quality assurance measures at each stage, from design to delivery process, and continuously improve the production processes to ensure high efficiency of production and to increase customer satisfaction Index.
16. Make sustained efforts for self-reliance through continuous R&D on an extensive basis to develop viable in-house designs for complex and weapon-intensive platforms to meet customer requirements.
17. Generate and maximize internal financial resources for enhancing growth, maximizing the return on investment, and creating wealth for shareholders.
18. Enhancement of the Company's share in total National Industrial output.
19. Fostering inclusive growth & development of the society and actively participating towards maintaining ecological balance through implementing sustainable CSR activities, projects, and programs.
20. To support and implement various government schemes & programs issued from time to time.
21. To promote integrity, fairness & transparency through various pieces of training and to root out corruption & malpractices through confidence building and awareness programs.

OUTFITTING DEPARTMENT

The outfitting engineering department deals with installation of machinery on the ship, their inspection, conducting trials and commissioning. Some of the various machineries that are installed are

- Main engine
- Gear Box
- Shaft Generators
- Bow Thrusters
- Diesel generators
- Fuel oil separator
- Propeller
- Fresh water generator
- Fin stabilizer
- Air compressor

Activities Performed by the department are:

1. Piping and seatings for machinery manufacturing and installation in ships

2. Installation of propulsion machineries: It includes stern gear systems, gear boxes, main engines, boost engines, rudders, stabilizers and their control systems.

Divided mainly into two categories:

a) Prelaunch (when ship in yard)
b) Post launch (after ship is launched into water)

3. Installation of Auxiliary machinery: These machines help the propulsion system, crew's daily requirements, maintenance operations, fire fighting etc.

4. Trials and commissioning

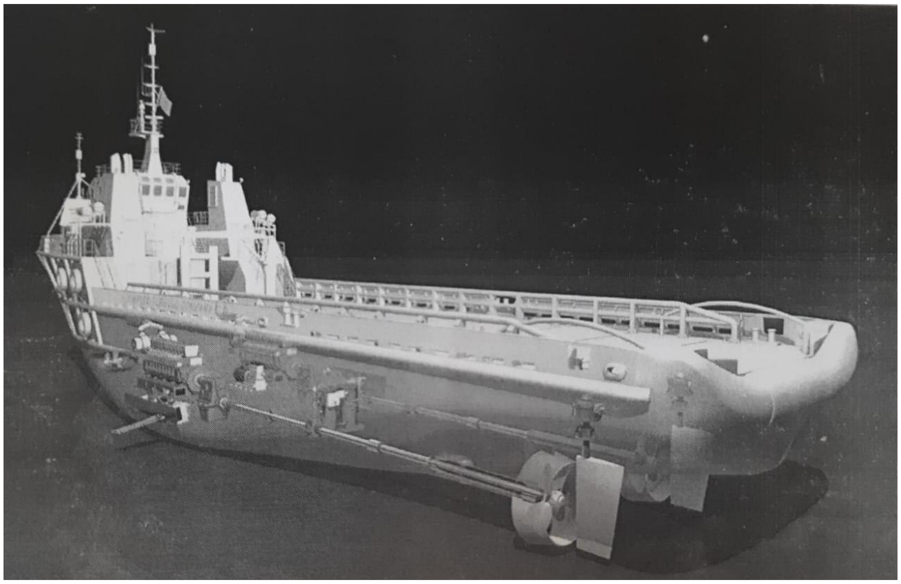
PROPULSION SYSTEM

The propulsion system of a ship is responsible for generating the necessary power to move the vessel through the water. It has three main components: the engine, shafting, and propeller.

Engine: The engine serves as the power source for the ship's propulsion system. Traditionally, ships have used internal combustion engines, either diesel or gasoline, to drive their propulsion. However, alternative propulsion systems like gas turbines, steam turbines, and even electric motors are also utilized in certain types of ships. The engine generates rotational energy that is transferred to the propeller through the shafting system.

Shafting: The shafting system is a mechanical arrangement of shafts, couplings, and bearings that transmits power from the ship's engine to the propeller. The primary shaft connects directly to the engine's output shaft and runs through the ship's hull to reach the propeller. Intermediate shafts and bearings are sometimes used to reduce the length of the main shaft or to support its weight. The shafting system ensures a smooth transfer of rotational energy from the engine to the propeller.

Propeller: The propeller is a crucial component of the propulsion system that converts the rotational energy provided by the engine into thrust. It consists of a set of blades, usually made of metal, attached to a central hub. As the propeller rotates, the blades push against the water, creating a force that propels the ship forward or backward. The design of the propeller, including the number of blades, their shape, and pitch, is optimized to maximize efficiency and performance. Modern propellers often have adjustable pitch to optimize performance under different operating conditions.



Cross section view of the propulsion system

Together, these three components work in harmony to propel a ship through water. The engine generates power, which is transmitted through the shafting system to the propeller. The propeller then converts the rotational energy into thrust, effectively pushing the ship forward or backward. The efficiency and performance of the propulsion system depend on various factors, including the ship's design, engine power, propeller design, and the operating conditions in which the ship operates.

ENGINES

Introduction

Ship engine systems are critical components of maritime vessels, providing the power and propulsion required to navigate the world's oceans. These systems are the result of intricate engineering, designed to withstand the harsh marine environment while optimizing performance and efficiency. From the main propulsion engines to advanced control systems, ship engine systems play a pivotal role in enabling global trade and transportation.

Types of Engines:

Diesel Engines:

Diesel engines are the most widely used type of ship engines due to their reliability, fuel efficiency, and high power output. These engines work on the principle of internal combustion, igniting fuel oil injected into the cylinders. Diesel engines can be classified into two categories: two-stroke and four-stroke engines, depending on the number of strokes required to complete a combustion cycle. They are commonly found in various ship types, from small fishing boats to large cargo vessels.

Gas Turbine Engines:

Gas turbine engines, also known as turbine engines or gas turbines, utilize the combustion of liquid or gaseous fuel to drive a turbine, which in turn powers the ship's propeller. These engines are known for their high power-to-weight ratio and quick response time. Gas turbine engines are often found in naval vessels, high-speed ferries, and fast patrol boats that require rapid acceleration and maneuverability. However, their fuel consumption can be relatively high compared to other engine types.

Steam Turbine Engines:

Steam turbine engines use steam generated by boiling water under high pressure to drive a turbine, which converts thermal energy into mechanical power. These engines were widely used in the past but have become less common in modern ships due to the advances in diesel and gas turbine technologies. Steam turbine engines are typically found in older vessels, such as steam-powered ships and certain types of cruise liners.

Stirling Engines:

Stirling engines are unique heat engines that operate on the cyclic compression and expansion of a working fluid, typically air or other gases. These engines can use any external heat source, making them versatile and adaptable. Stirling engines are known for their quiet operation, low emissions, and high fuel efficiency. They are often employed in specialized applications, such as research vessels and icebreakers operating in environmentally sensitive areas.

Electric Motors:

Electric propulsion systems have gained popularity in recent years due to their environmental benefits and technological advancements. These systems use electric motors powered by batteries or fuel cells to drive the ship's propellers. Electric engines offer zero-emission operation, reduced noise levels, and enhanced maneuverability. They are commonly found in smaller vessels, hybrid ships, and ferries operating in environmentally protected areas.

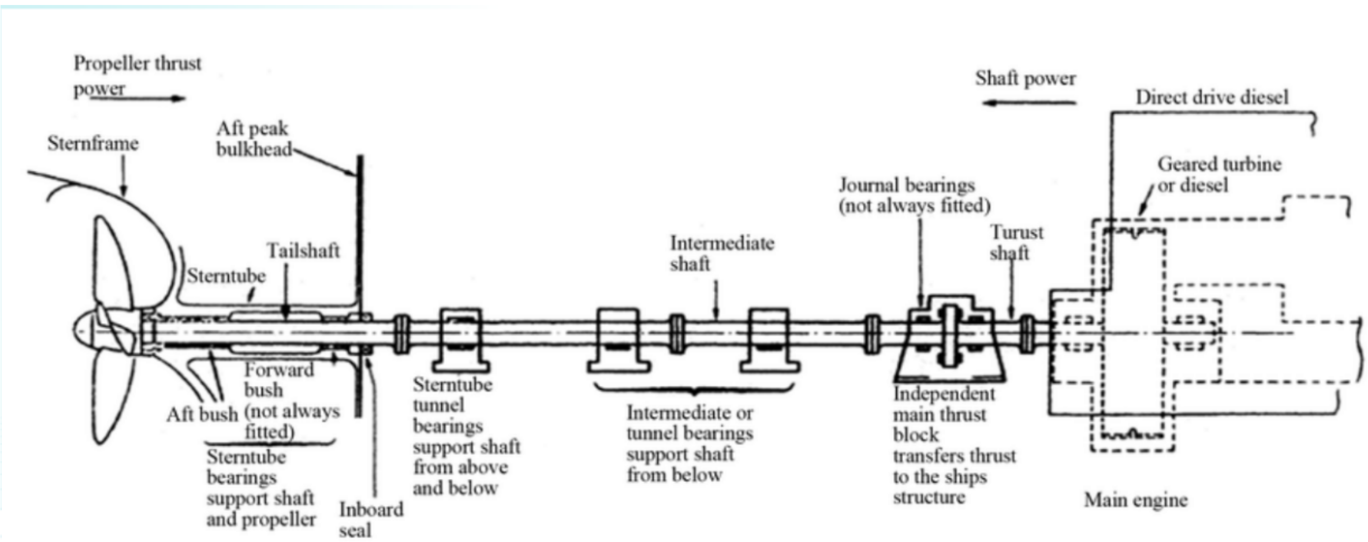
Nuclear Reactors:

Nuclear-powered ships utilize nuclear reactors to generate heat, which produces steam to power a steam turbine engine or directly drives electric motors. Nuclear reactors offer a virtually unlimited power supply and long endurance without the need for frequent refueling. They are primarily used in nuclear-powered submarines and aircraft carriers due to their exceptional endurance and ability to operate for extended periods without refueling.

SHAFTING

Introduction

The shafting system is a vital component in ship propulsion, responsible for transmitting power from the engine to the propeller. It consists of the shafts, bearing, stern tubes, hydraulic lines for CPP, bearings, and couplings.

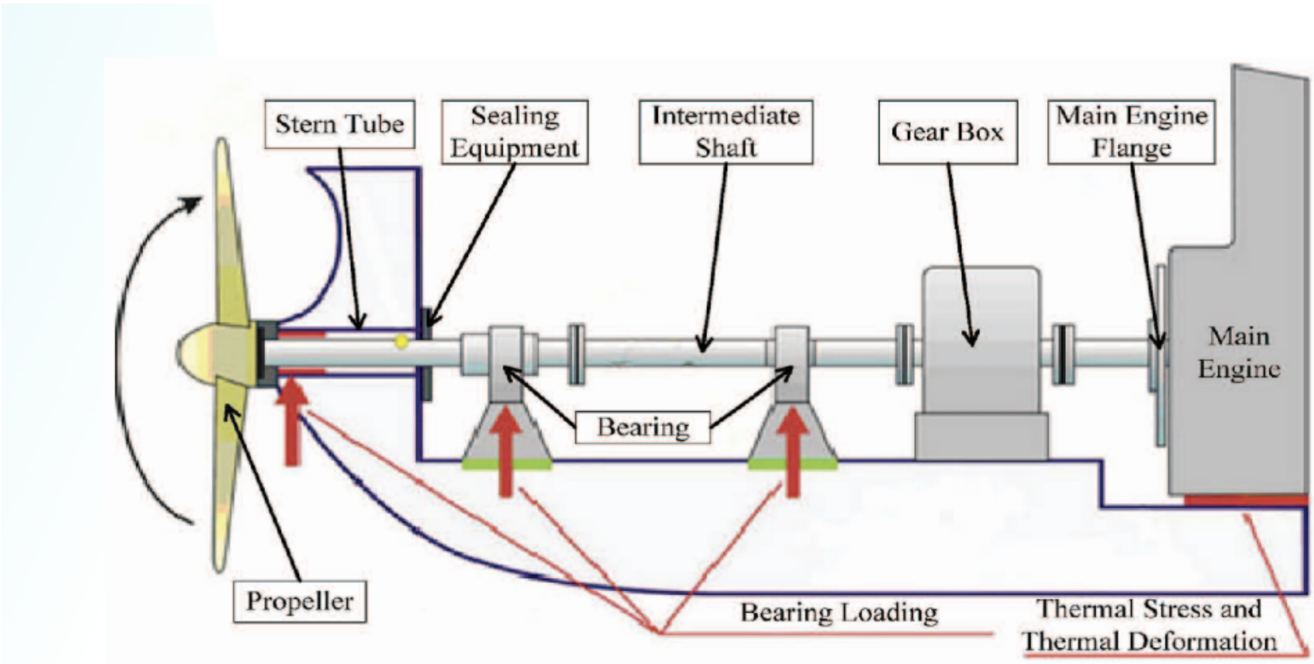


The main 3 components are -

- **Shafts:** A shaft is a mechanical component that transmits rotational motion and power from the ship's engine to the propeller. It is typically a long, cylindrical metal rod designed to withstand torque and bending forces.
- **Bearings:** Bearings are mechanical devices installed along the shafting system to support and reduce friction between the shaft and its housing. Common types of bearings used in ship propulsion systems include journal bearings, thrust bearings, and sleeve bearings. They ensure smooth rotation and proper alignment of the shaft.
- **Couplings:** Couplings are mechanical connectors used to join two shafts together, allowing the transfer of rotational motion and torque. In ship shafting, couplings help to compensate for misalignment between the engine and propeller shafts and absorb shock and vibration. Flexible couplings are often utilized to minimize misalignment-related issues.

Shafts

The system consists of 3 shafts basically -



1. Intermediate Shaft

    The intermediate shaft is located between the engine and the stern or tail shaft. It serves as a connection point between the primary engine and the propulsion system. The primary purpose of the intermediate shaft is to reduce the length and weight of the main propulsion shaft and provide additional support to the shafting system.

2. Stern/Tail Shaft

    The stern or tail shaft is the section of the shafting system that extends from the end of the intermediate shaft to the ship's stern, passing through the stern tube. It is responsible for transferring power from the intermediate shaft to the propeller.

3. Propellor Shaft

    The propeller shaft is the final section of the shafting system and connects directly to the ship's propeller. It extends from the stern or tail shaft into the water, transmitting rotational energy from the engine to the propeller.

These shafts are of 2 types Hollow and Solid, Hollow shafts are basically used in larger ships and also where CPP is used and solid shafts are for smaller/low torque applications for smaller vehicles.

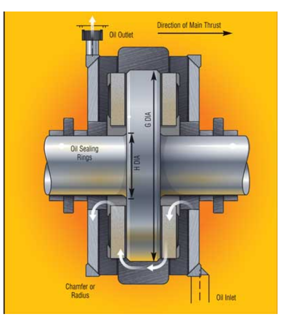
The length of the entire shaft is roughly 30-40% of the total length of the ship. In the case of the 105m OPV, the total shaft length was 30m weighing a total of 35 Tonnes.

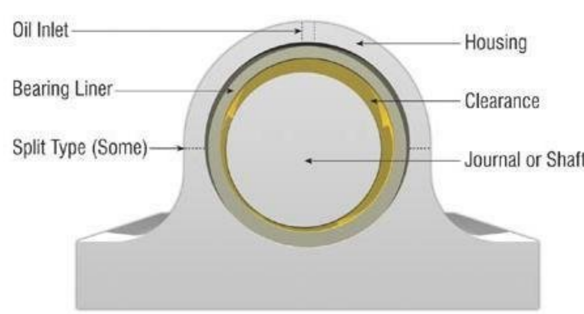
To avoid bending and sagging of the shafts, bearings are used to provide support to the shafts at various locations and a stern tube is used at the last bulkhead to avoid water getting into the ship.

Bearings

The three main types of bearings used are -

1. Journal bearings, also known as plain bearings or sleeve bearings, are commonly used in ship propulsion systems. They consist of a cylindrical sleeve (bushing) made of a low-friction material, such as bronze or a polymer, which surrounds the shaft. The bearing's inner surface forms a low-friction interface with the rotating shaft.
2. Thrust bearings are designed to handle axial forces exerted on the shaft, such as the propeller thrust or the weight of the shaft. They are used to support the shaft along its axial direction and prevent it from moving in the axial direction.
3. Roller bearings consist of cylindrical or tapered rollers held between inner and outer races. They are designed to accommodate both radial and axial loads. Roller bearings offer higher load-carrying capacity than journal bearings and can handle higher speeds.





Alignment Procedure

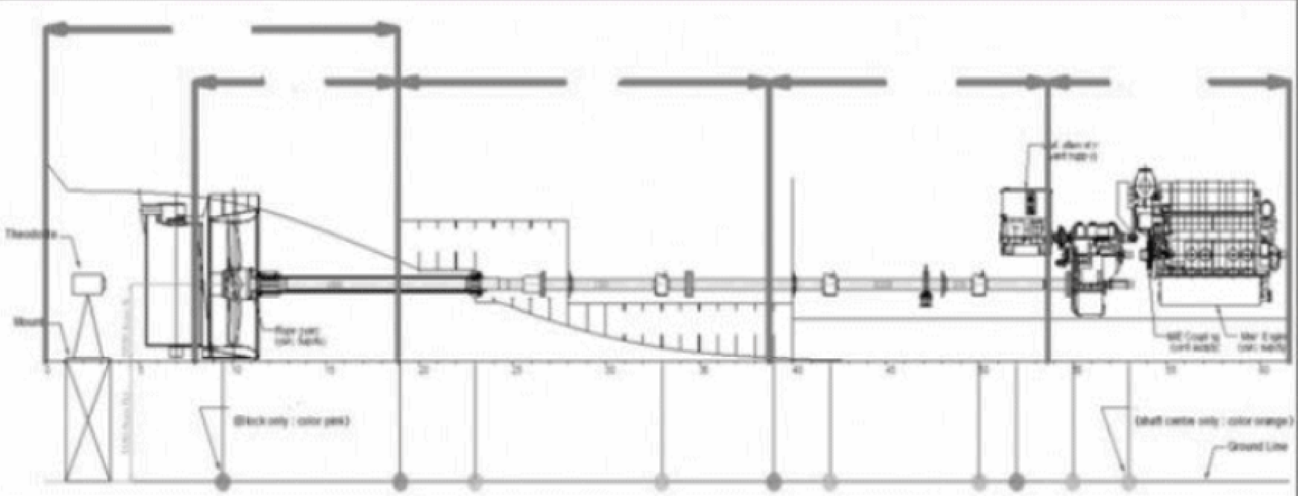


Figure – 2 (a) – Prime mover without a high speed shafting with the engines directly coupled to the gear box.

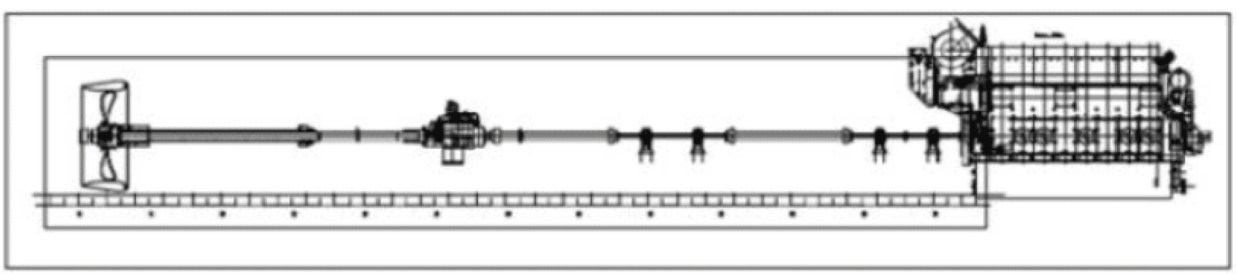


Figure – 2 (b) – Prime mover with a high speed shafting between the engine and the gear box.

The alignment procedure is a critical process in ship propulsion systems to ensure that the various shafts, bearings, and couplings are properly aligned. Proper alignment minimizes mechanical stress, reduces wear and tear, and optimizes the performance and lifespan of the system. Here is a general description of the alignment procedure:

Preliminary Inspection:

Before starting the alignment procedure, conduct a preliminary inspection to assess the condition of the shafting system, including the shafts, bearings, couplings, and alignment components. Look for signs of wear, damage, or misalignment that may need to be addressed.

Initial Alignment Check:

The shafting line is established in the ship with a rough eyeballed alignment and then the misalignments are checked and corrected.

Using precision measuring tools such as dial indicators or laser alignment systems, measure the relative positions and misalignment between the engine, intermediate shaft, and propeller shaft. Check for angular misalignment, parallel misalignment, and vertical or horizontal offsets. Record these initial measurements for reference.

Adjusting the Couplings:

If misalignment is detected, adjust the couplings between the shafts to achieve proper alignment. Rigid couplings may require physical adjustments by shimming or moving the components, while flexible couplings may allow for angular and axial misalignment without requiring physical adjustments.

Recheck Alignment:

After making initial adjustments to the couplings, recheck the alignment measurements using the same precision measuring tools. Ensure that the misalignment has been reduced and that the shafts are moving closer to the desired alignment.

Fine-Tuning Alignment:

Fine-tune the alignment by making incremental adjustments to the couplings or shaft positions to bring the shafts into precise alignment. Continuously monitor the alignment measurements during these adjustments and aim to minimize any remaining misalignment within acceptable tolerances.

Secure and Lock Components:

After achieving the desired alignment, secure and lock the couplings, bearings, and other components in their final positions. Ensure that all fasteners are properly tightened and secured to prevent any movement or shifting that could affect the alignment.

Post-Launch Activities:

Conduct a thorough inspection of the entire shafting system after alignment to check for any signs of stress, interference, or misalignment. Inspect bearings, couplings, seals, and other components to ensure they are in good condition and functioning correctly.

When the ship is afloat, the dynamic forces due to rotation and the hydrostatic and hydrodynamic forces on the propeller can change the stresses on the shafts, so a post launch alignment is done to relieve the shaft line of all the stresses arised.

Ongoing Monitoring:

Regularly monitor the alignment of the shafting system during routine maintenance intervals or dry-docking to detect any changes or deviations. Periodic alignment checks and measurements help to maintain optimal alignment and prevent issues from developing over time.

PROPELLER

Introduction

There are mainly two types of propellers used on marine vessels, Fixed pitch propeller (FPP) and the Controllable pitch propeller (CPP). The main difference is that the angle of attack on the Fixed pitch propeller remains constant while the angle of attack of the propellers can be changed in the case of a Controllable pitch propeller.\

Controllable Pitch Propeller

A Controllable pitch propeller enables a vessel to operate with maximum fuel efficiency, making it energy-saving, environmentally friendly, and economical.

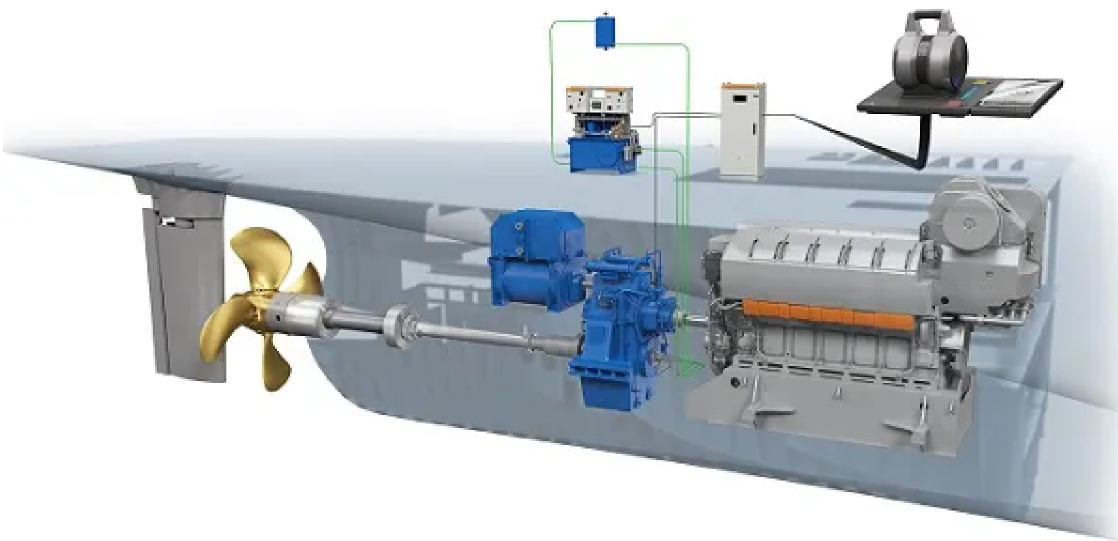
The thrust of a vessel can simply be changed by changing the angle of attack of the propeller blades rather than changing the rpm of the engine, this prevents wasting the engine's energy and making the vessel more efficient.

Some Important Components

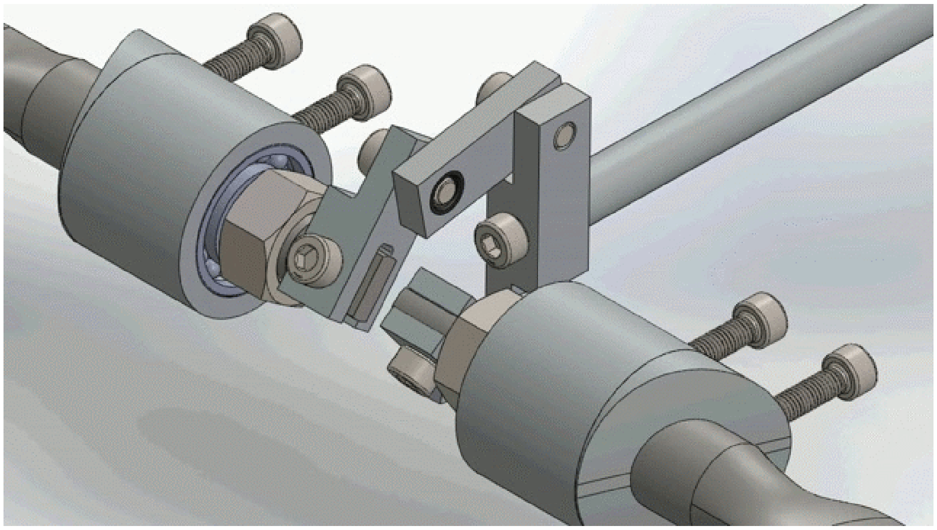
- Controllable-pitch propeller (CPP):
  A propeller whose pitch can be altered by blade rotation via a control mechanism installed in the hub.
- Hub:
  A component where the blade of CPP and the blade rotating mechanism are installed
- Oil distributor:
  The oiler of hydraulic CPP supplies pressure oil to the rotating shaft for the purpose of pitch control. If the oil distributor is installed on the intermediate shaft, then there is a short shaft with an oil-filling port.
- Power pack:
  The subunit consists of an oil storage unit and a motor. It is mainly used to drive the hydraulic systems to change the propeller pitch via the hub.
- Propeller pitch:
  The theoretical advance of CPP, which rotates a revolution under the working condition without slip.
- Design pitch:
  The geometrical pitch measured on the section when the CPP has the same geometrical characteristics such as radial pitch distribution, section offset, blade outline, and propeller diameter as specified in the construction plan.
- Pitch angle:
  The arc tangent of the ratio of the pitch to the distance traveled by a point in the measuring radius when it revolves about the propeller center for a revolution.

Working principle

- The controllable pitch propeller consists of a hub with separate blades mounted onto it.
- The blades can be moved together in an arc to change the pitch angle and adjust the pitch.
- When a pitch demand signal is received, a spool valve is activated.
- The spool valve controls the supply of low-pressure oil to the auxiliary servo motor.
- The auxiliary servo motor moves the sliding thrust block assembly.
- The thrust block assembly positions the valve rod, which extends into the propeller hub.
- The valve rod allows high-pressure oil to enter either side of the main servo motor cylinder.



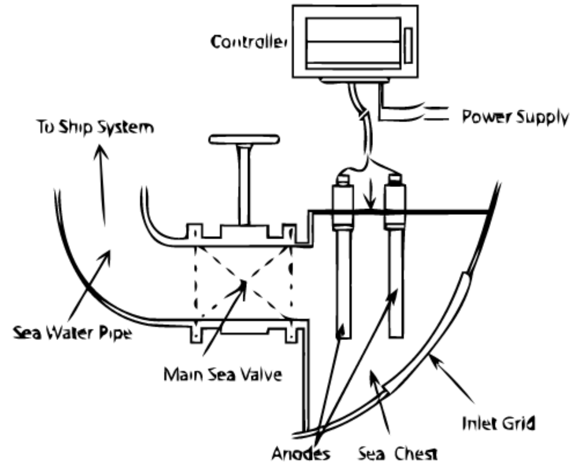
- The movement of the cylinder is transferred to the propeller blades through a crank pin and ring mechanism.
- All propeller blades rotate together until the feedback signal balances the demand signal.
- Once balanced, the supply of low-pressure oil to the auxiliary servo motor is cut off.
- In the event of a power loss, the spool valves can be manually operated to control the propeller pitch.
- The oil pumps are often driven by the propeller shaft.
- The control mechanism, usually hydraulic, passes through the hollow tail shaft
- The operation of the control mechanism is typically carried out from the bridge
- Changing the pitch of the propeller will vary the thrust provided.
- Since there is a zero pitch position, the engine shaft can rotate continuously.
- The blades can also rotate to provide astern thrust, eliminating the need to reverse the engine.



SEA CHEST AND SEA TUBES

Sea Chest

Sea Chest refers to a chamber located inside the hull of a ship that can be flooded for the intake of water. Any of the ship's equipment that requires the intake of sea water uses the sea chest for water supply.



Sea Water Pipe/ Sea Tube:

Sea Pipes are responsible for intake of water from the sea chest via pumps. Sea tubes provide for various functions inside the ship.
Sea Chest and Sea Tubes are attached with grates to remove debris and organisms before entering the ship's systems.

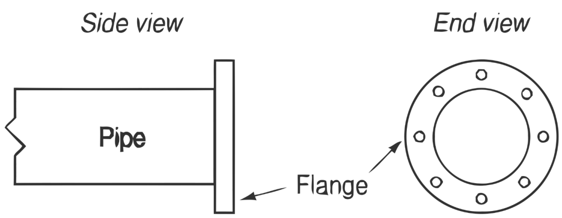
Applications

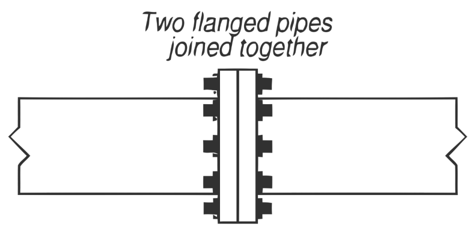
1. Engine Cooling: The seawater drawn from the sea chest is typically circulated through heat exchangers to cool down the ship's engines. The heat exchangers transfer the excess heat generated by the engines to the seawater, helping to maintain optimal operating temperature
2. Machinery Cooling: In addition to engine cooling, seawater from the sea chest may be used to cool other machinery and equipment in the ship's engine room, such as generators, compressors, pumps, and hydraulic systems.
3. Heat Recovery: Seawater can also be utilized in heat recovery systems, where the heat extracted from the ship's engines or exhaust gases is transferred to the water. This recovered heat can then be used for various purposes, such as preheating boiler feed water or heating other onboard systems.
4. Firefighting: The seawater from the sea chest can be used for firefighting purposes in case of emergencies. It can be pumped to the fire hydrants or sprinkler systems throughout the ship to extinguish fires.
5. Ballast Operations: In certain situations, seawater from the sea chest may also be used for ballast operations. Ballast water is taken into dedicated tanks within the ship's hull to enhance stability, trim, and draft as needed.

Installation of Sea Tubes

The installation of sea tubes in ships is a 7-step process:

- Marking
    - The designated locations for making the holes are marked physically on the ship by cross-referencing multiple diagrams. The inclination of pipes has to be considered as and where needed since such pipes require an elliptical hole to pass through.

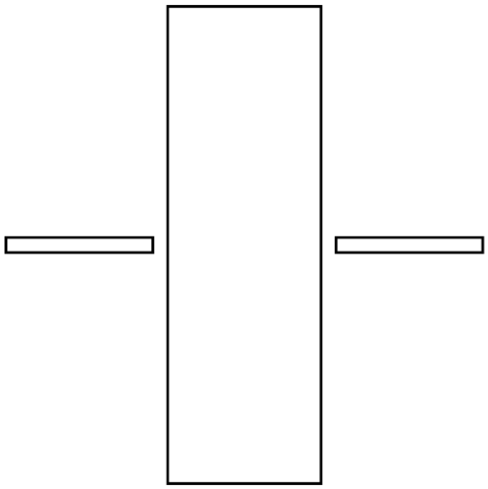




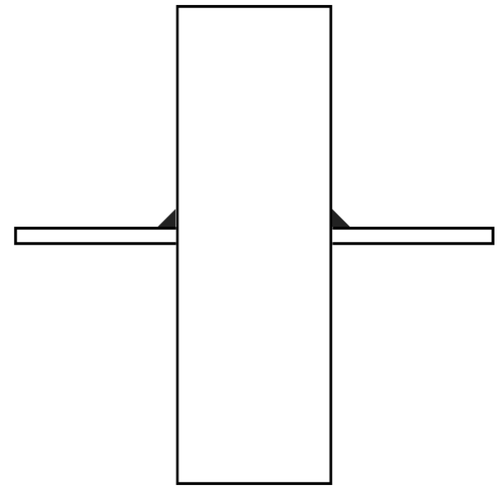
- Hole cutting
    - The holes are cut into the ship body as per the marking. Generally, holes cut are minutely larger for easy passage of the pipes.
- Pipe cutting/preparation/flanging
    - The pipes are cut to the required length, considering any angular cuts to be made, depending on where the pipe is to be welded.
    - The ends of the pipes are cleaned in preparation for welding.
    - Flanges are added at the ends where connections are to be made via bolts.
- Pipe welding
    - Pipes are then welded to each other and to other parts before installation into the ship.
- Pickling
    - Pipeline pickling is a process that uses acid or alkali solutions with corrosion inhibitors to chemically clean the inner surface of a pipe. It removes oxides and grease, preparing the pipe for inspection, maintenance, or product transportation. The solution circulates through the pipe, dissolving or loosening contaminants for improved cleanliness and corrosion prevention.
- Fitup in ship
    - Fitup refers to the specific arrangement of the various parts in preparation for joining. In this case, it's arranging the pipes in the required positions before they are permanently welded in position.
- Complete welding
    - When all connections are made and checked, the pipes are completely welded and sealed air-tight for completion.

Different Types of Weld Joints in Sea Tubes

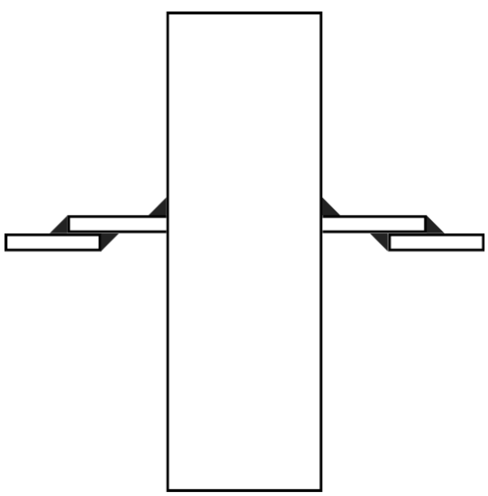
There are multiple types of joints possible between pipes or pipe and sheet metal.



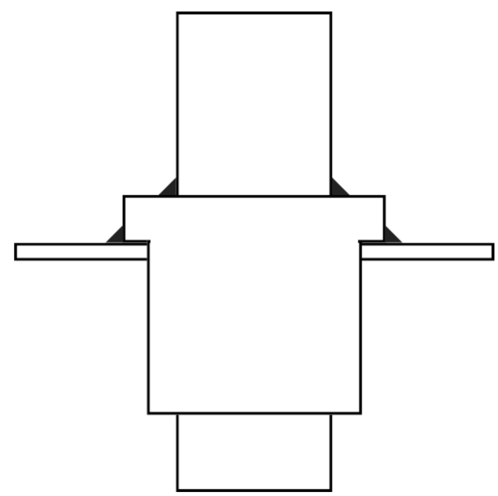
No weld pass through



Simple Weld



Doubler Weld



Socket WelD

DIESEL GENERATOR

Introduction

Diesel generators are powerful and reliable machines that provide a dependable source of electricity in various settings. These generators utilize diesel fuel to produce mechanical energy, which is then converted into electrical power. Renowned for their robustness and efficiency, diesel generators are commonly used in industries, construction sites, remote areas, and as backup power solutions. Their ability to deliver consistent performance, even under heavy loads, makes them a preferred choice for applications where a stable power supply is crucial. With their durability and long lifespan, diesel generators have established themselves as indispensable assets in meeting energy demands across various settings.

Components

IC Engine

The engine is the key component of a diesel generator, providing the mechanical energy that is converted into electrical power. The power output is directly proportional to the engine size, meaning a more powerful engine generates higher electricity.

Alternator

The alternator is a vital component of a diesel generator, responsible for converting the engine's mechanical input into electrical output through induction. It consists of a primary component called the rotor, which generates a magnetic field to produce alternating electricity.

Fuel System

The fuel system of a generator stores and distributes fuel, playing a crucial role in its operation. Fuel is the key factor in getting the engine running, as its chemical energy is converted into mechanical energy, which is then transformed into electrical energy by the engine. The fuel system typically includes a tank, which can be built inside the generator housing for smaller portable generators or exist as a separate external structure for larger, permanent installations. In addition to the tank, the fuel system consists of components such as pipework to deliver fuel, a fuel pump, a fuel filter, and a fuel tank ventilation pipe or valve to maintain pressure. An overflow connection ensures that excess fuel is safely directed away from the engine or alternator's surface in case of overfilling.

Lubricating (oil) System:

It plays a vital role in preventing issues by providing constant lubrication to the generator's various moving parts. With numerous spinning components, a reliable lubrication system is essential to protect these parts from friction and maintain their optimal temperature. Regular monitoring and maintenance of the lubricating system are vital to ensure the generator operates efficiently and remains in good working condition.

Voltage Regulator

The voltage regulator is a critical component that ensures a stable power supply in a diesel generator. Without it, the voltage and amperage of the AC produced would fluctuate based on the engine's speed. However, the inner workings of the voltage regulator are complex and beyond the scope of this content to explain in detail. Nevertheless, its presence is necessary to maintain a consistent and reliable power output, which is essential for powering modern electrical equipment.

Cooling System:

In a diesel generator, the engine generates waste heat along with mechanical energy. This heat is absorbed by a coolant fluid, usually but not always water. The coolant absorbs the heat and is then directed through a heat exchanger, where it releases the heat into the air or, in some cases, into a secondary coolant fluid. This process helps regulate and dissipate the excess heat generated during the operation of the generator.

Exhaust System:

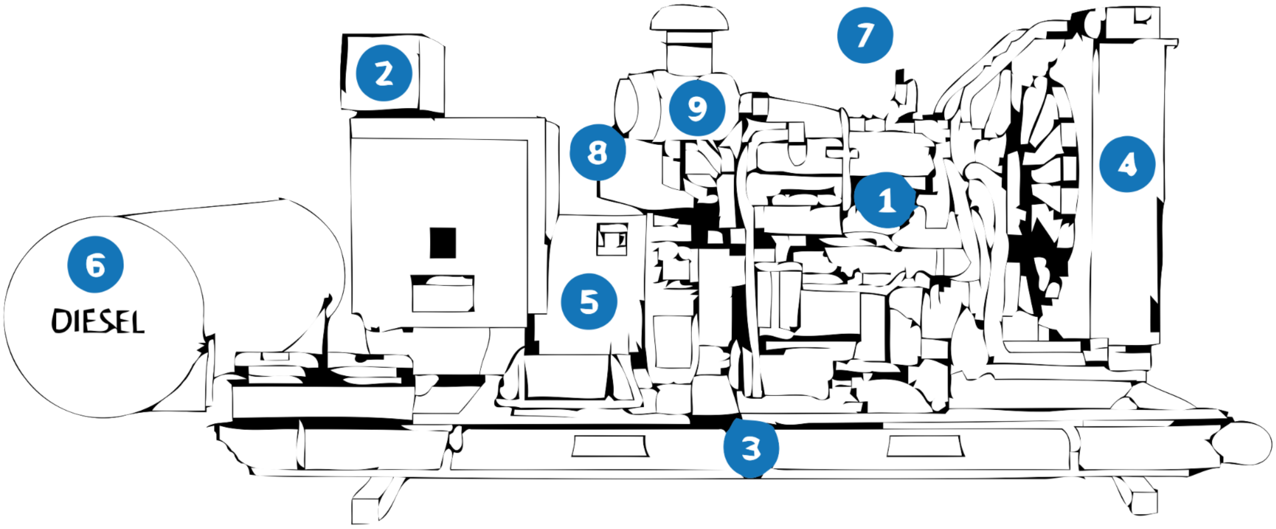
Exhaust gases, produced by internal combustion engines like diesel generators, are toxic and must be safely channeled away from the engine and people nearby. Compliance with local health and safety standards is crucial for determining the proper exhaust system installation, ensuring the safe release of these gases into the atmosphere.

Starter and Battery System:

The diesel motor is started by a small electrical motor. This electrical starter motor is powered by a battery that is charged either by a separate charger or by the generator’s output.

Control Panel: The Control Panel houses the Start/Stop button as well as indicators for various parameters such as Start/shutdown controls, Phase selector switch, Engine mode switch, Engine speed, fuel, output voltage, output current, frequency, etc.

The Housing/Frame: The structure that houses all the components of the diesel generator.



1. Engine
2. Control Panel
3. Base frame
4. Radiator
5. Alternator
6. Fuel system
7. Lubrication system
8. Voltage regulator
9. Exhaust system

Working Principle

Diesel generators go through four combustion processes: Suction, Compression, Power, and Exhaust. The cycle of processes causes the generation of rotational mechanical energy. This energy is transferred to a rotor in the alternator via a crankshaft. The alternator houses conductive copper wiring which spins inside a housing of magnets. This generates a voltage that alternates as per the rotation speed of the shaft

Usage on ships

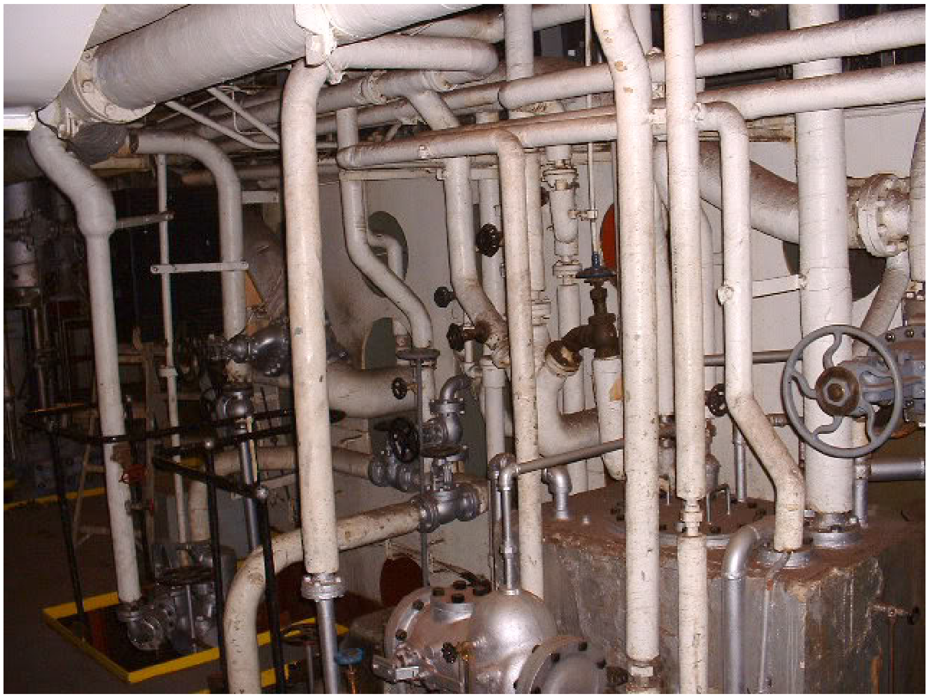
Generators are extensively used on ships for various purposes. Some common usages are:

- Generators are crucial for supplying electrical power to different systems and equipment on the ship, including lighting, navigation systems, communication systems, refrigeration, ventilation, and various machinery.
- Ships are equipped with emergency generators to provide backup power in case of a main power failure. These generators ensure critical systems like emergency lighting, communication, and essential equipment continue to operate during power outages. Sometimes they can also be used for propulsion in case of emergency.
- Generators are utilized for refrigeration systems on ships to maintain the required temperature in cold storage areas, such as for perishable goods, provisions, and medical supplies.
- Generators are often used to provide power for welding and maintenance activities onboard ships. They enable the operation of welding machines, power tools, and other equipment needed for repairs and maintenance work.

PIPE BENDING

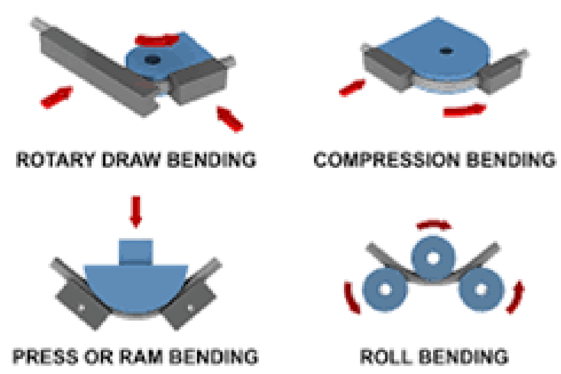
Introduction

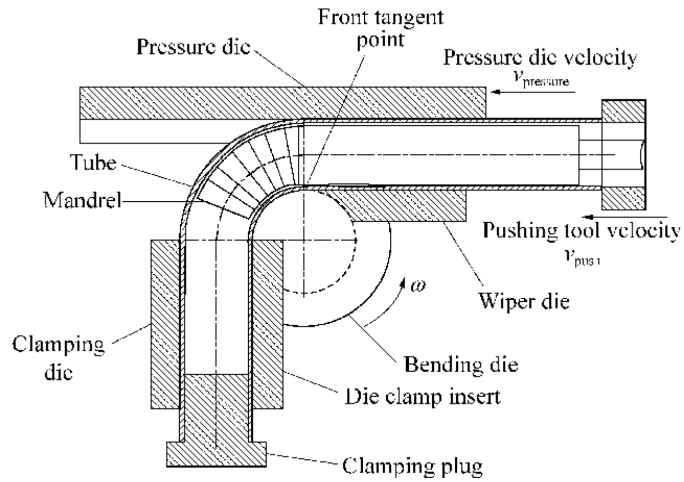
Pipes play a crucial role in the efficient functioning of ships, serving as vital conduits for various systems and operations on board. These sturdy channels, often made of durable materials like steel or copper, enable the safe transportation of essential fluids throughout the vessel. From supplying fresh water for drinking, cooking, and sanitation purposes to facilitating the circulation of cooling water for engines and machinery, pipes form the lifelines of a ship's infrastructure. They also facilitate the transfer of fuel, lubricants, and other chemicals required for propulsion and maintenance. Additionally, pipes are instrumental in managing ballast systems, enabling the filling and emptying of tanks to ensure stability and maneuverability. In summary, pipes in ships are indispensable components, providing a reliable network for fluid transfer and contributing to the seamless operation and safety of maritime vessels.



Piping in ships gets very complex due to the large number of pipes and they have to be carefully routed to fit in the desired space. This requires precise bending and joining of pipes. Joints are time-consuming and possible failure points, so it's best to reduce them to a minimum and rely on bending to accomplish the requirements of complex plumbing.

Bending Methods

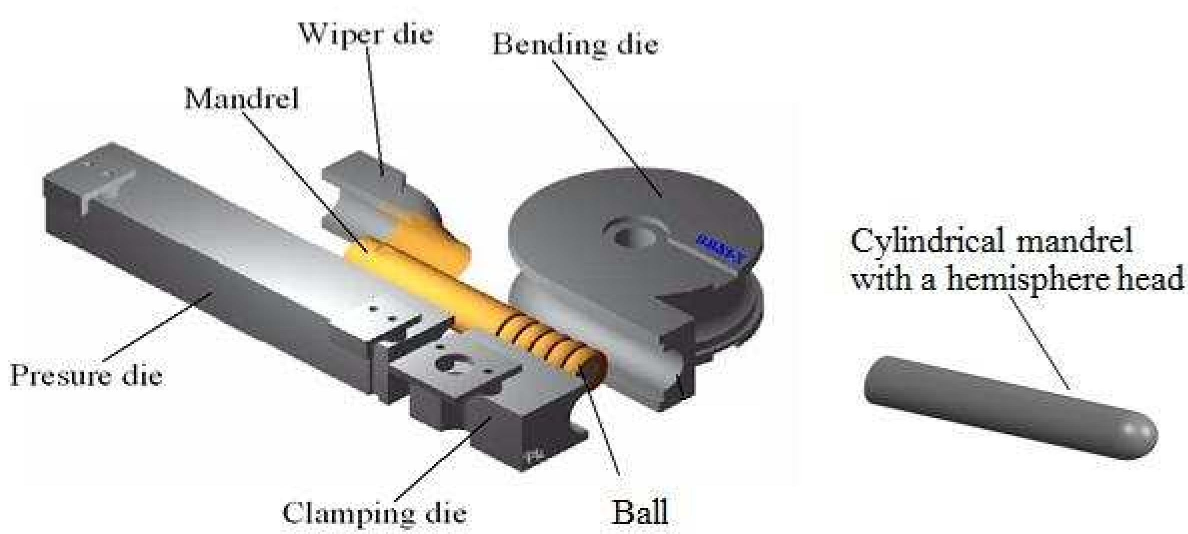




There are mainly 4 methods of pipe bending -

1. Rotary Draw Bending
2. Compression Bending
3. Press/Ram Bending
4. Roll Bending

Rotary draw bending with 1 axis and 3 axis semi-automatic and automatic CNC machines is mainly done here. With support for pipes up to 60mm.



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Challenges in Pipe Bending

- **Thinning:** Thin spots or thinning occur when excessive material is stretched during the bending process, leading to a reduction in wall thickness. This can weaken the structural integrity of the pipe and may result in failure under stress. Proper selection of bending techniques, tooling, and material properties is crucial to minimize thinning.

- **Folding:** Folding happens when the inner wall of the pipe collapses or buckles during bending, creating undesirable folds or creases. It occurs when the compression forces exceed the material's yield strength, causing plastic deformation. To prevent folding, proper bending techniques, appropriate mandrel support, and careful material selection are important.

- **Wrinkling:** Wrinkles are unwanted surface imperfections that appear as ridges or folds on the outer surface of the bent pipe. They are typically caused by compressive forces that exceed the material's elastic limit, leading to localized deformation. Adequate support and control of material flow during the bending process can help minimize or eliminate wrinkling.

- **Roundness:** Maintaining the roundness of the pipe after bending is essential for ensuring proper fit, functionality, and aesthetic appearance. However, due to the deformation forces involved in bending, pipes can experience ovality or out-of-roundness. Careful selection of bending parameters, tooling, and mandrels can help maintain the desired roundness.

- **Springback:** Springback occurs due to the elastic nature of the material being bent. When the bending forces are removed, the material springs back and tries to regain its original shape. Springback can lead to deviations from the desired bend angle and affect dimensional accuracy. It becomes more pronounced in materials with higher elastic modulus and yield strength.

To overcome these challenges, various strategies can be employed, including:

- Proper selection of bending equipment, such as mandrels, dies, and supports, to minimize material deformation.
- Choosing the right bending technique, such as rotary draw bending, mandrel bending, or heat induction bending, depending on the pipe material, size, and application.
- Applying appropriate lubrication or mandrel coatings to reduce friction and improve material flow.
- Using high-quality materials with suitable mechanical properties for bending applications.

- Conducting thorough pre-bending analysis and simulation to identify potential issues and optimize the bending process.

It is important to note that the specific challenges and their solutions may vary depending on factors such as the pipe material (e.g., steel, aluminum, copper), wall thickness, diameter, and the complexity of the bend.

Even after overcoming all the challenges of thinning, wrinkling, roundness etc. the challenge of managing **springback** is crucial for achieving precise and accurate pipe bends. Here are some strategies to address this challenge:

- **Over-bending:** One common technique is to over-bend the pipe slightly beyond the desired angle to account for the anticipated springback. This compensates for the material's elastic recovery, resulting in the pipe returning to the desired angle after the springback occurs.

- **Compensation in tooling and setup:** Adjustments can be made to the bending tooling or machine setup, such as accounting for the material's elastic properties and the desired bend angle. Proper calibration of tooling and machine parameters can help reduce the effects of springback.

- **Material selection:** Choosing materials with lower elastic modulus or higher ductility can help minimize springback. Materials with greater plastic deformation capabilities are less likely to exhibit significant springback.

- **Heat treatment:** Applying heat treatment techniques, such as annealing or stress relieving, to the pipe before or after bending can help reduce springback. Heat treatment alters the material's internal stresses and improves its flexibility, making it less prone to springback.

- **Multiple-step bending:** For complex bends or tight radii, performing the bending process in multiple steps can help reduce springback. This involves bending the pipe incrementally, allowing for intermediate adjustments and compensation for springback at each step.

Predicting Springback

Various analytical techniques have been researched and developed to predict the springback to compensate it with overbending, but most of them don't offer results of more than 5-7% accuracy due to the large number of factors involved in the process namely:

1. Bending Method
    a. Ram Bending
    b. Arc Draw Bending
    c. Three Point Bending
    d. Die Bending
2. Material Properties
    a. Young's Modulus
    b. Hardness Coefficient
3. Cracks in material
4. Wall thickness
5. Hardening Method
6. Temperature
7. Bending Speed
8. Lubrication
9. Mandrel Type
    a. Bead Mandrel
    b. Ball Mandrel
10. Die/Mandrel Material
11. Coating/Paint on pipes

Involvement of all these factors make it very hard to get general analytical solutions, the only way to predict accurately is via FEM simulations.

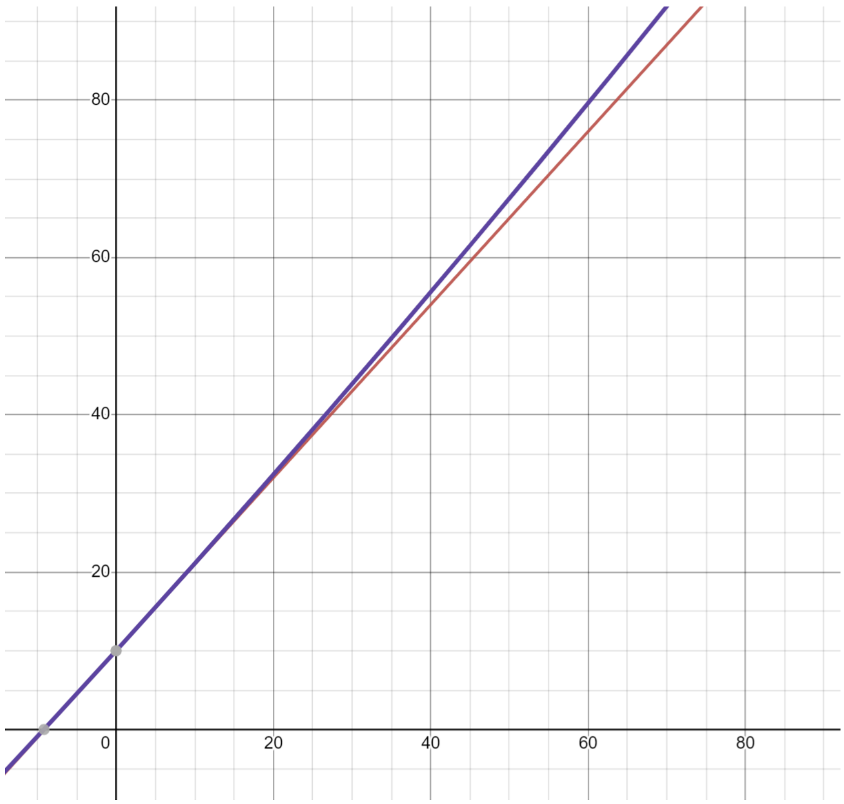
In Industrial applications, automatic machines take advantage of feedback mechanisms to use with a linear/quadratic regression model to get accurate predictions for a pipe type.

Our goal was to develop a solution for the semi automatic machines to calculate the compensation angle in advance to prevent springback.

The springback angle is almost linearly related to the bending angle and this property can be used to predict the springback angle for compensation.

Method to determine the springback -

Bend the pipe by about 30-60 degrees and then measure the final angle, and then repeat the process for a couple of times. This data can be used to calculate the empirical formula to calculate the springback angle for each type of pipe.



The formula that would be obtained will be -

$$\mathbf{BA = C(RA) + SC}$$

Where,
BA = Bending Angle
RA = Required Angle
SC = Springback Constant (5-15)
C = Proportionality Constant (1.025-1.075)

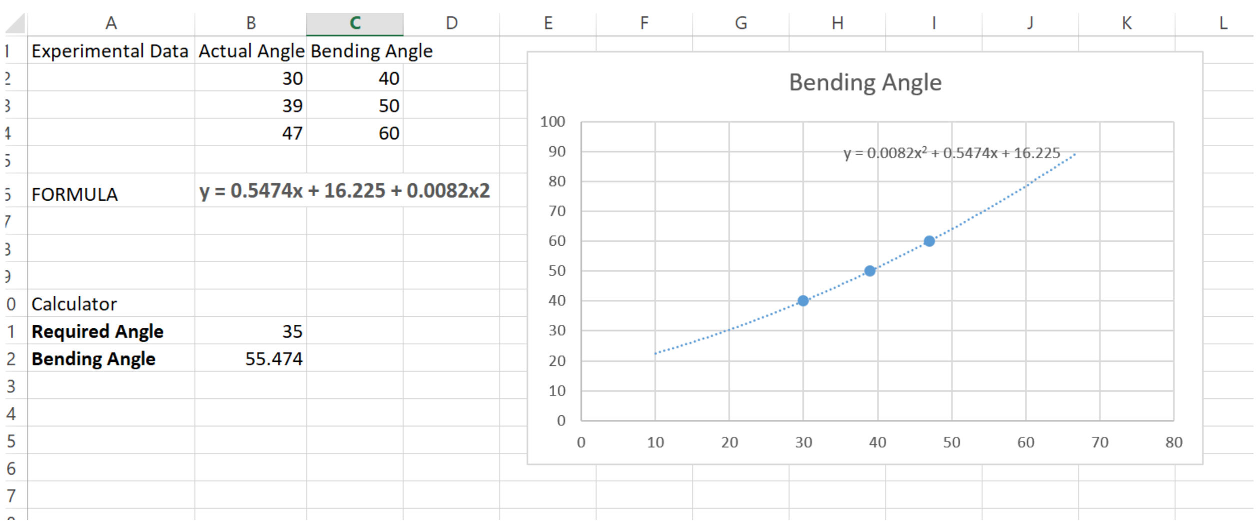
This formula can be used to get compensation angles and can achieve results upto 2% accuracy, way higher than theoretical methods. And this just requires 2 test values to begin with.

To get even higher accuracy, quadratic correction term can be introduced -

BA = C(RA) + SC + SC*RA^2*QC

Where,
BA = Bending Angle
RA = Required Angle
SC = Springback Constant (5-15)
C = Proportionality Constant (1.025-1.075)
QC = Quadratic Constant (0.0001-0.001)

This formula can achieve less than 1% error, and requires a minimum of 3 test values to begin with.



A	B	C
Experimental Data	Actual Angle	Bending Angle
	30	40
	39	50
	47	60
FORMULA	y = 0.5474x + 16.225 + 0.0082x2	
Calculator		
Required Angle	35	
Bending Angle	55.474	

This can be implemented in an excel spreadsheet to calculate the compensation angle for a specific type of pipe.

INFORMATION ON DIFFERENT VESSELS AT GSL

TALWAR CLASS FRIGATES

INTRODUCTION:

The Talwar-class frigates are a series of guided missile frigates that were built for the Indian Navy. These frigates were constructed under a technology transfer agreement between Russia and India. The name "Talwar" is derived from the Hindi word for "sword."

The Talwar-class frigates are multi-role warships designed for a variety of missions, including anti-submarine warfare (ASW), anti-air warfare (AAW), and anti-surface warfare (ASuW). They are equipped with a range of advanced weapons and sensors that enhance their operational capabilities.

The frigates feature a stealthy design with reduced radar cross-section, making them less visible to enemy radar. They are armed with an array of weapons, including BrahMos supersonic cruise missiles, surface-to-air missiles, anti-ship missiles, torpedoes, and guns.

These frigates have played a significant role in enhancing the Indian Navy's capabilities. They have been actively involved in various operations, including counter-piracy missions and humanitarian assistance and disaster relief efforts.

Overall, the Talwar-class frigates are a versatile and capable platform that has strengthened India's naval forces and contributed to its maritime security.

SPECIFICATIONS:

Disp	3,850 t (4,240 short tons) standard load [3] 4,035 t (4,448 short tons) full load [4]
Length	124.8 m (409 ft 5 in)
Beam	15.2 m (49 ft 10 in)
Draught	4.2 m (13 ft 9 in)
Speed	32 knots (59 km/h; 37 mph)
Time	30 days
Crew	180 (18 officers)[2]

ROLE OF GSL:

Goa Shipyard Limited has been awarded the contract to construct two talwar class frigates namely the INS Triput and the INS Tavasya by the Indian Navy. GSL will be working alongside Yantar Shipyard of Russia for the completion of this project. The two frigates are expected to be delivered by late 2026 and 2027 respectively.

INS SHARDUL

INTRODUCTION:

INS Shardul is an amphibious warfare ship of the Indian Navy. It belongs to the Shardul-class of ships and is primarily designed for transporting troops, vehicles, and equipment for amphibious operations. The name "Shardul" is derived from the Hindi word for "tiger."

The ship was constructed by Garden Reach Shipbuilders & Engineers (GRSE) in Kolkata, India. It was commissioned into the Indian Navy in March 2003. INS Shardul has since been actively involved in various military and humanitarian missions, demonstrating its versatility and importance in supporting India's naval operations.

The ship is also equipped with a variety of facilities to support the embarked troops, including accommodation, medical facilities, and workshops. It can carry up to 500 troops, along with their vehicles and supplies.

INS Shardul is armed with close-in weapon systems for self-defense against air and surface threats. It is also equipped with modern navigation and communication systems to ensure operational effectiveness.

In addition to its military role, INS Shardul has been extensively involved in humanitarian assistance and disaster relief operations. The ship has participated in numerous relief missions, both within India and in neighboring countries, providing aid and support during natural disasters and humanitarian crises.

INS Shardul has proven to be a vital asset for the Indian Navy, enabling it to effectively carry out amphibious operations, support troops, and respond to humanitarian emergencies. The ship's capabilities and versatility make it a valuable asset in India's maritime security and disaster response efforts.

SPECIFICATIONS:

Displacement	5650 tons
Length	125 m (410 ft)
Beam	17.5 m (57 ft)
Draught	4 m (13 ft)
Propulsion	Kirloskar PA6 STC engines
Speed	16 kn (30 km/h; 18 mph)
Troops	500
Crew	11 officers, 145 sailors

ROLE OF GSL:

Goa Shipyard Limited has been contracted to undertake a major refitting operation of the INS Shardul under the Ship Repair (SR) department. The entire hull underwent a remake using the newly introduced material used in navy ships (DMR 500). Some of the other tasks being carried out at GSL include making all the entry points to the tank space watertight in case of rough sea conditions.

ARMY FAST PATROL BOATS

INTRODUCTION:

Fast patrol boats used by the army serve several purposes and play a crucial role in military operations. Some of them include:

- Surveillance and Reconnaissance: Fast patrol boats are employed for surveillance and reconnaissance missions, particularly in riverine and coastal areas. They can quickly patrol vast stretches of water, gathering intelligence, and monitoring activities along the shoreline. These boats are equipped with sensors, radars, and communication systems to detect and report any suspicious or hostile activities.
- Border Security and Counter-Terrorism: Fast patrol boats play a vital role in securing maritime borders and preventing unauthorized border crossings. They help in intercepting and deterring smuggling activities, illegal immigration, and terrorist infiltration through waterways. These boats often operate in coordination with other security forces, such as coast guard and naval units, to enhance border security measures.
- Amphibious Operations: Fast patrol boats are utilized in amphibious operations, where they provide support for troop transport, surveillance, and fire support. They can swiftly transport troops, supplies, and equipment between ships and shore, enabling rapid deployment and enhancing operational flexibility. These boats may also have the capability to land troops directly on beaches or riverbanks during amphibious assaults.

Overall, fast patrol boats used by the army are versatile assets that contribute to maritime security, border protection, counter-terrorism efforts, and disaster response operations. Their speed, agility, and versatility make them valuable assets for a wide range of military tasks and ensure effective force projection in coastal and riverine environments.

SPECIFICATIONS:

Length : 35 m

Maximum speed : 35 to 40 knots

Armaments: 2 heavy machine guns

ROLE OF GSL:

Goa Shipyard Limited has been awarded with the contract to build a total of 12 fast patrol boats for the Indian Army. These boats are to be used in high altitude operations specially in the Leh and Ladakh regions. The fast patrol boats are built using futuristic manufacturing techniques such as fibre moulding also some of these boats are being made such that they could be controlled remotely or could operate autonomously.

ICGS SAGAR

INTRODUCTION:

ICGS Sagar is an offshore patrol vessel (OPV) of the Indian Coast Guard. It is part of the Sagar-class OPVs and serves as a versatile platform for maritime security and surveillance operations. The name "Sagar" is derived from the Hindi word for "ocean."

ICGS Sagar was constructed at Goa Shipyard Limited (GSL) in India and was commissioned into the Indian Coast Guard in February 2019. It is designed to safeguard India's maritime interests, enforce maritime law, conduct coastal patrols, and support search and rescue operations.

The vessel has a displacement of around 2,140 tons and a length of approximately 105 meters. It is equipped with modern navigation systems, communication equipment, and advanced sensors, including radars and surveillance systems. These systems enable the ship to effectively detect, track, and monitor vessels in its operational area.

ICGS Sagar is armed with medium and light machine guns for self-defense and maritime law enforcement purposes. It has the capability to launch and recover rigid inflatable boats (RIBs) for boarding operations, search and rescue missions, and interdiction of suspicious or illegal vessels. The vessel is also equipped with modern facilities to support the embarked crew and personnel during extended missions. It has accommodations, medical facilities, and a flight deck to accommodate a helicopter for aerial surveillance and search and rescue operations.

ICGS Sagar plays a significant role in safeguarding India's coastal and maritime security. It conducts patrols in the Exclusive Economic Zone (EEZ), monitors and protects fishing zones, and carries out anti-smuggling operations. The vessel has also been involved in humanitarian missions, providing assistance during natural disasters and maritime incidents

SPECIFICATIONS:

Displacement	1,800 t (1,800 long tons)
Length	102 m (334 ft 8 in)
Beam	11.5 m (37 ft 9 in)
Draught	3.4 m (11 ft 2 in)
Propulsion	2 x SEMT Pielstick 16 PA6V280 (4,707 kW or 6,312 hp each) diesel engines
Speed	22 knots (41 km/h; 25 mph)
Complement	15 officers and 113 sailors

ROLE OF GSL:

The Indian Coast Guard Ship (ICGS) Sagar was brought to Goa Shipyard Limited from its home port of Chennai to Install the support/ seating for two new heavy machine guns being installed onboard along with other regular maintenance operations.

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