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Automatic Process Control Valves in Floating Dry Docks

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Abstract

Ballasting and De-ballasting of water are the key operations in working of a floating dry dock in order to dock and undock a water vessel in the yard. These operations involve pumping of sea water from sea chests to their respective ballast tanks through pumps. Since these ballast tanks are present throughout the dock the filling time for each tank is different. Due to this reason filling of tanks with same water flow rate is not practical and hence all the tanks are filled with different pipes and all the pipes are fitted with individual water valves. These water valves are set as per the required water flow rate for different water ballast tank as per the time taken for the water to reach and fill the respective water ballast tank. This valve setting operation can be enhanced better if Automatic Process Control valves are implemented for the same. Process controlled valves are valves which partially open and close as per the flow of water required according to the amount of water filled in respective ballast tank. A process-controlled valve is used with the help of a PLC system which is used to command the valve to control the flow of the water in ballast tank as per the required flow rate.

Keywords
Floating Dry Dock (FDD), PCV, Valves, Water Flow Rate

1. Introduction

The upkeep and operation of floating dry docks are increasingly dependent on Automatic Process Control Valves (PCVs). A massive structure called a floating dry dock is used to perform the required underground maintenance of ships and other vessels. On a floating dry dock, the capacity to control valves can significantly enhance productivity, safety, and efficiency. Within the dry dock system, PCVs are utilized to regulate the flow of fluids like water or hydraulic fluids. This includes controlling how the dock's pumps, valves, and ballast tanks move. Because PCVs can be controlled from a control room or other remote location, personnel don't have to physically go into potentially dangerous areas.

These Process Control Valves use actuators in order to control the water flow as the actuator opens and closes the valve according to the command given by the control room in the form of an electric signal. Basic actuators turn valves either into fully open or fully closed but the modern actuators which we get today allows the valves to hold in intermediate position as well. There are firms which manufacture such modern actuators which are used in marine industries. Rotork has developed the new ROMpak range of electric actuators for the marine industry. Talking about the positional adjustments, There is also Rotork Folomatic positional control, current position transmitter, integral data logger, non-intrusive configuration with a Bluetooth wireless interface and digital bus network connectivity (Actuators for marine valves, 2009)

Safety Hazards are one of the major concerns in marine industries, some of the safety hazards happened till now are mentioned below:

1. Dockside capsizing and sinking of towing vessel Invader and dry dock on March 18,2012 at Vigor Industrial Shipyard, Port of Everett, Washington (Dry Docks, 2018)
2. Overturn and partial sinking of the floating dock No. 1 together with the Hordafor V chemical tanker on April 27, 2017 at Nauta Repair Shipyard in Gdynia (Dry Docks, 2018)
3. Damaging the ship hull M/V Green Egersund and fuel spill on August 27, 2015 at Naval Shipyard in Gdynia.
4. Damaging the plating and fire in the engine room during the operation of undocking of the passenger-car ferry Princess Benedikte on March 11, 2015 at Gdansk Ship Repair Yard.

Safety enhancement is one of PCV's primary advantages in floating dry docks. The use of Process Control Valves (PCVs) can make it less necessary for personnel to enter confined spaces or areas that could pose safety risks, like those close to moving machinery or high-pressure systems. This can make it safer for workers to maintain and operate floating dry docks by lowering the likelihood of injuries and accidents. PCVs have the potential to boost productivity and efficiency in floating dry dock operations in addition to improving safety. In the case of port maneuvers, the impact of the human factor on safety is particularly important due to the limited maneuvering space. This issue has been discussed in the publication (Hejmlich, 2014).

Process Control Valves and other equipment enables movements that are more precise and accurate, reducing the amount of time and effort required for manual operation. The dry dock's overall efficiency may rise as a result, as repairs and maintenance can be completed more quickly. The use of PCVs in floating dry docks is constrained in some ways, despite the numerous benefits they offer. The innovation can be costly to introduce and keep up with, and may require particular preparation for administrators. Additionally, the current PCV technology may not be able to meet the high precision or accuracy requirements of some applications. Overall, the use of PCVs in floating dry docks has grown in importance over the past few years because they can make operations safer and more efficient. The various PCVs used in floating dry docks, their applications, and the benefits and drawbacks of their application in this unique industrial setting will be examined in this paper.

2. Objective

Floating Dry Dock consists of more than fifty valves for movement of water throughout the water ballast tanks. The type of valves used in the operations is also of major importance for better efficiency and productivity of the system. This research is hence conducted to analyze the usage of Remove Operated Valves over the conventionally used gate valves on the basis of its maintenance efficiency and safety. This research paper would give a detailed analysis of the usage of control valves in floating dry dock in order to give a clear idea about valves while choosing the type of valve for docking operations.

3. Literature Review

A mobile marine structure called a floating dry dock is used to lift ships out of the water for construction, maintenance, and repair. Floating dry docks can be moved and towed to various locations as needed, in contrast to conventional dry docks, which are stationary structures. A large, rectangular platform that is buoyant and supported by watertight chambers or pontoons makes up floating dry docks. Using a system of ballast tanks and pumps, the platform can be submerged or raised, allowing ships to flotilla into and out of the dock.

Cost of the maintenance and repairing is cheaper comparing with the others drydocks especially graving drydocks, easy mobility make it able to sail and this is the main advantage of this type drydocking method, contrary to the other drydocking methods which are fixed and are unable to provide services offshore (Control Valve Basics, 2018).

A series of blocks and keel blocks can be used to secure a ship once it is in the floating dry dock. These blocks support the ship's weight while it is out of the water. This lets workers do a lot of different things, like fix the hull, paint it, and put in new engines or equipment. The size of floating dry docks can vary, with some having the capacity to lift ships weighing several thousand tons. They are in many cases utilized in shipyards, maritime bases, and other marine offices all over the planet to help the upkeep and fix of vessels of different kinds and sizes. You can refer Figure 1 to have a clearer idea about Floating Dry Dock.

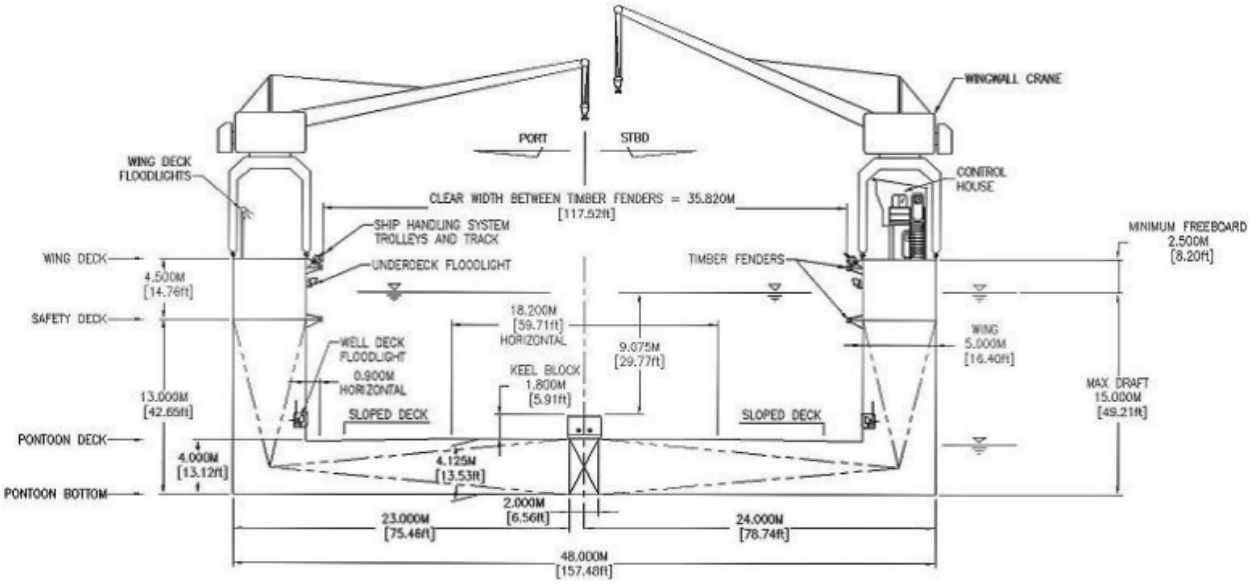


Figure 1. Floating Dry Dock (Design and Development of Dewatering Pumping System for Dry-Dock, 2022)

Valves play a major role in controlling the flow of water in floating dry docks. These structures use a complex system of pumps, pipes, and valves to control the flow of water in and out of the dock as per the requirements. There are two majorly essential types of valves namely Ballast Valves and Bilge Valves. Ballast Valves are responsible for controlling the flow of water inside the ballast tank which eventually sink the structure to let the vessel such as ship inside the dock on its respective keel structure, whereas Bilge Valves are responsible for removal of water from ballast tanks in order to get the dock back on the water surface.

The flow rate of water plays a major role in the operation of a floating dry dock. This rate of water during ballasting and de-ballasting decides the speed at which the tanks can be filled and emptied. A higher stream rate will consider faster ballasting or de-ballasting, lessening the time the vessel spends in the dry dock and limiting the potential for postpones in the maintenance or support process. A higher flow rate can also assist in preventing imbalances that could result in damage or instability and ensuring that the ballast tanks are filled or emptied uniformly. In contrast, when precise control of the ballasting or de-ballasting process is required, a lower flow rate may be advantageous. A slower flow rate, for instance, can help reduce the risk of damage during the ballasting or de-ballasting procedure when working with delicate or delicate vessels.

This water flow rate is controlled by valves that regulate the amount of water entering or leaving the ballast tanks. These valves are usually located on the pipelines leaving from the pumps to their respective ballast tanks in the pump rooms where the valves are easy to adjust manually.

The valves can be controlled manually or automatically. Manual valves are worked the hard way and are utilized to change the stream rate in view of the operator's judgment and experience. On the other hand, automatic valves are controlled by control systems which consists of actuators and positioners that keeps a control on the valve openings. Actuator (See Figure 2) is a device which takes up the signal from the control system and produces force to open or close the valve. Whereas, positioner is a device which tracks the valve opening with respect to the signal received and provides the actuator with force to correct the position if not (Figure 3).

Figure. 2. Actuator (Dymarski et al. 2005

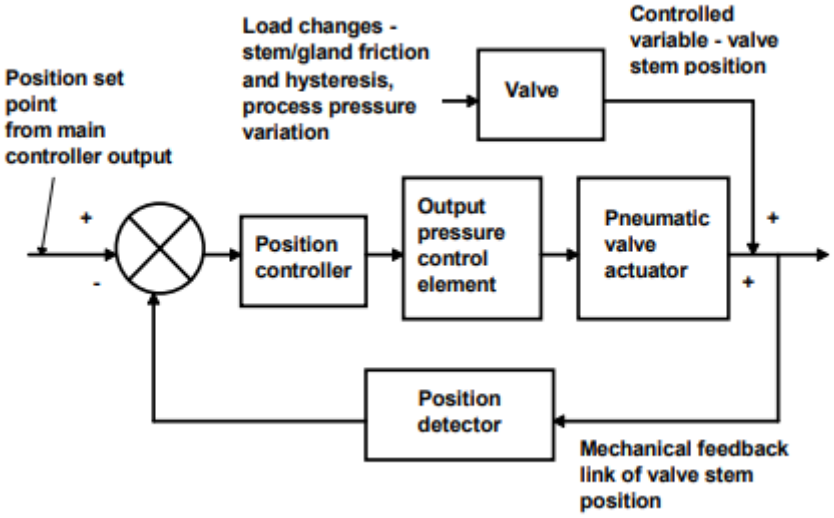


Figure 3. Block Diagram For Control System Assembly (Dymarski et al. 2005)

The size and type of valves used in floating dry docks are determined by several factors, such as the dry dock's capacity and size, the kind of vessels being serviced, and the flow rate necessary for effective operation. Depending on the type of water being used and the operating conditions, valves can be made of brass, stainless steel, or PVC.

The very recent breakthrough in the valve industry being the Control Valves have found their uses in many fields and is deploying in the marine field as well. The valve journey in Floating Dry Docks initiated with the use of the conventional manual gate valves followed using automatic valves with pressure sensors linked with control systems. Now, Automatic Process Control Valves is the futuristic technology which is more efficient from the maintenance point of view and a safer alternative for the conventional valve assemblies used in the floating dry docks.

The conventionally used manual valve being slow and inefficient have a potential risk of having uneven water flow rate while ballasting and de-ballasting due to human error which may cause imbalances in the tanks which will eventually lead to toppling of the dock. These valves also had many maintenance issues as it was handled manually by humans there is a chance of rough handling which may require regular maintenance which will eventually increase the maintenance costing. Apart from these, it also has a safety concern as workers may have to go in the confined spaces while ballasting and de ballasting operations in order to adjust the valve openings.

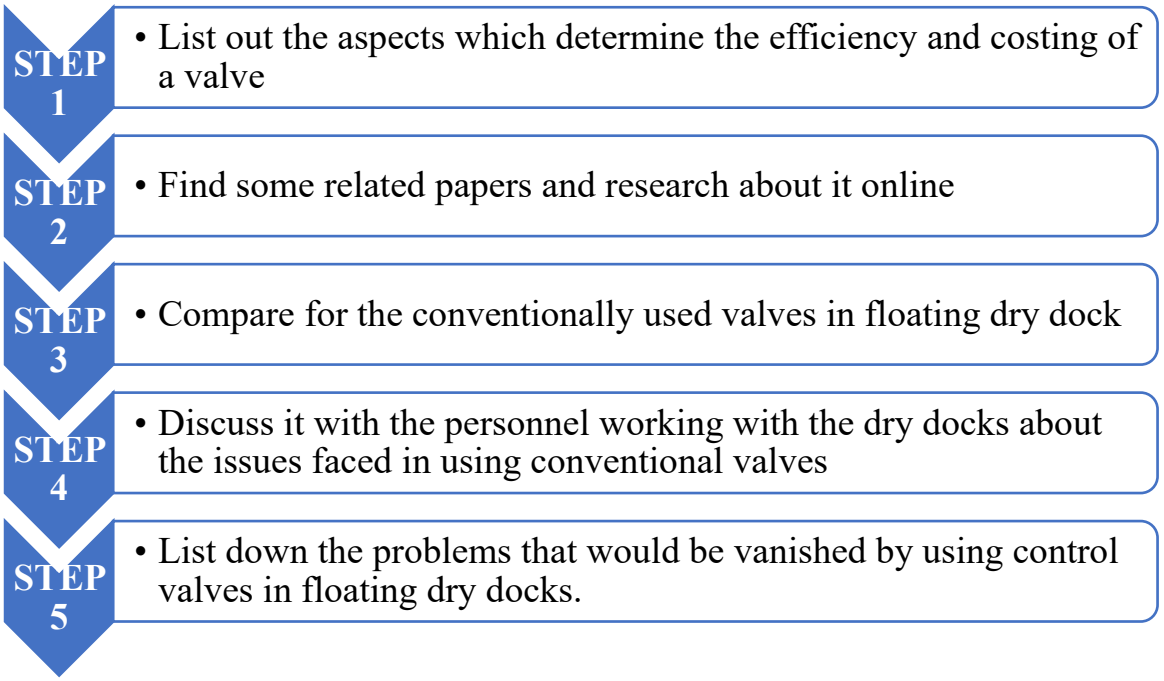
These issues were then overcome by automatically handled Control Valves which had all the necessary sensors which adjust the openings of the valves according to the water pressure and the water level present in the tank. Automatic valves process the ballasting and de ballasting in a floating dry dock in lesser time leading to reduced

turnaround time which apparently increases its efficiency with high precision of water flow rate in tanks which reduces the risk of imbalance in tanks. These valves are less prone to failures as it can be monitored all the time from a remote location which saves the issues of downtime and associated costs which makes it more reliable. Since these valves can be operated remotely it reduces the safety hazards due to working in the confined spaces. Since these valves are used automatically, the scope of rough usage and human errors decreases which cause less maintenance issues eventually reducing maintenance downtime and all the related costs.

This research was conducted for a company I was interning at where the floating dry dock consisted of manually handled valves which caused imbalances in the ballasting and de ballasting operations leading to tilting and toppling issues in the dock. This research made me gain enough ideas about valves to discuss about the benefits of Control Valves in Floating Dry Dock on this paper. The dock was modified and all the valve assemblies were changed to automatic valves. This paper will hence discuss about the methodology used and the results obtained in accordance with the process and approach used.

4. Methodology

This paper focuses on the analysis of Automatic Process Controlled Valves based on its efficiency and costing over the conventionally used manual valves. This will eventually give a clear idea about which valve to choose while selecting the assemblies for using in a Floating Dry Dock. The research followed the following steps:



4.1 Aspects Determining the efficiency and costing of a valve

Following below is the list of aspects determining the efficiency of a valve:

1) Valve Coefficient
2) Pressure Drop
3) Leakage
4) Durability
5) Ease of Operation

Following below is the list of aspects determining the costing of a valve:

1) Installation Costs, i.e., Cost of procurement and installation
2) Maintenance Cost i.e., how much regular maintenance is required to keep it well enough for use

5. Results & Discussions

Aspects Determining the Efficiency of Valves in Floating Dry Dock

There are a lot of aspects which determine the efficiency of a valve which mainly depend on the flow of water through it in accordance with the pressure drop. Following below are the listed aspects for determining the efficiency of a valve:

1) **Valve Coefficient** also known as flow coefficient or C_v Value. This value is the amount of water flowing through the valve per minute and is calculated in gallons per minute.

2) **Pressure Drop** which is the pressure difference in the water flowing between both the ends of a valve.

Once the Valve Coefficient is known, the pressure drop can be calculated using s pressure gauge and the numeric efficiency of the valve can be calculated according to the below given formula.

Efficiency = (Valve **Coefficient (C_v) GPM** / **Pressure Drop (P) Pa**) ^2

In this way, numeric efficiency of a valve is calculated. Apart from this, there are many other factors which affect the efficiency of a valve while using in a floating dry dock.

1) Leakage: The amount of leakage from the valve affects the flow rate and hence the C_v Value which affects its efficiency.

2) Durability: Durability of a valve also plays a major role in finding efficiency. The valve which is durable enough to withstand the harsh marine conditions without getting corroded is usually and considered to have higher efficiency.

3) Ease of Operation: The valve which is easy to open or close is more efficient.

Keeping all the above factors in mind and comparing the conventional manual valves and automatic valves we can make the following observations (Table 1):

Table 1. Observation table for manual & automatic valve efficiency

Aspect	Manually operated valves	Automatic process controlled valves
NUMERICAL EFFICIENCY	Since there is less precision in the valve coefficient to pressure drop measurements, theoretically there is not much difference in both the types. Also, due to the manual operations, there are chances where the pressure drop increases and the efficiency value decreases in practical usage.	The chances of pressure drop due to human error decreases as the precision increases. Hence, increasing the numeric efficiency of Automatically Driven Valves in practical usage.
LEAKAGE	Due to human errors, the chances of Leakage in Manually Driven Valves increase which affects the C_v value and hence decreasing the efficiency of the valve.	There is very less scope for leakage in the valve due to human error. The leakage can only occur due to some technical error which lessens the room for leakage in practical usage and hence increasing the efficiency for the valve.
Durability	Since these are manually driven the chance of wear and tear increases over time. Which reduces the	Since these valves are automatically driven the chance of wear and tear decreases over time as these have

	durability Chances of corrosion and rusting exist in marine conditions	pneumatic or electrical actuators and positioners which opens or closes the valve with precision in single attempt. Chances of corrosion and rusting exist in marine conditions
Ease Of Operation	Since these are manually operated it is difficult to operate them as presence in confined space is required to open or close the valves.	There is an ease of operations in these type of valves as these have actuators and positioners which opens and closes the valves and presence of human in confined spaces is not required while operation.

Looking at the above points, marine industries consist of equal risk in both the valves when it comes to corrosion and rusting. Apart from that, considering the durability and reliability in the heavy and rough marine industry based uses we can come to a result that Automatic Valves are better than the conventionally used manual valves.

6. Conclusion And Future Research

In this study, we analyzed the usage of manual valves and automatic control valves in floating dry dock. We compared both the above-mentioned valves on the basis of:

1) Numerical Efficiency: Looking at the numerical formula for calculating the efficiency of valve, there is a scope of human error which may lead to higher pressure drop which decreases the efficiency of manual valves. Whereas, automatic valves have no such scope of error.
2) Leakage: C_v value i.e., Valve coefficient depends very much on the amount of water passed through the valve per minute. Any leakage in the valve would hence affect the Cv value which eventually decreases the overall efficiency of the valve. Manual Valves have greater chances of leakage than automatic valves as there are greater chances of error in closing of valve.
3) Durability: There are equal chances of corrosion in both the valves. Though, the chances of deterioration due to wear and tear decreases in the case of automatic valves.
4) Ease of Operation: Automatic valves are easier to use and are more user friendly whereas manuals are not easy to use as there is a requirement of human presence in confined spaces.

Hence, we can conclude the analysis by coming to the point that using automatic control valves would be more effective in floating dry docks.

There is a great scope of future research in the field of process control valve in marine field. Following points may be considered for further research in the mentioned field:

1) Maintenance: Since maintenance is one of the major tasks in marine vessels, research should be conducted further to ease the maintenance part.
Suggestion: Since floating dry docks have more than fifty valves, a system should be made where it indicates the valve number and position in case of any breakdown or issue to save time and energy of locating the valve with issue.

2) Artificial Intelligence: Artificial Intelligence is being adapted widely and to keep the marine technology in line with the advanced technology.
Suggestion: Since there is a requirement of a person in the control room, merging the system with Artificial Intelligence to monitor and control the actuators in positioners in order to open or close the valve could save a lot of money and increase productivity.

References

Actuators for marine valves, World Pumps, Volume 2009, Issue 512, Page 20, 2009
Control Valve Basics: Sizing & Selection by A. Bhatia, 2018.
DRY DOCKS: OVERVIEW OF DESIGN AND CONSTRUCTION, Academic Research International Vol. 9(1) March, 2018
Design And Development of Dewatering Pumping System For Dry-Dock, International Journal of Mechanical Engineering and Technology (IJMET) Volume 13, Issue 1, 2022.
Det Norske Veritas AS., Rules for Classification of Floating Docks. National Transportation Safety Board., Marine Accident Brief. Dockside Capsizing and Sinking of Towing Vessel Invader and Dry Dock,3, 2012
Dymarski, C., Preliminary analysis of proposed ship docking systems for a designed floating dock. Polish Maritime Research. Tom S1, pp. 61-64, 2005.
Hejmlich, A., Czynnik ludzki w ocenie bezpieczeństwa manewrów portowych. Prace Wydziału Nawigacyjnego Akademii Morskiej w Gdyni. Tom Z(29), pp. 81-88, 2014.
Rosochowicz, K. Łącki, T., Ecological floating dock. Polish Maritime Research. Tom S 1, pp. 4-14, 2005.
Selected Problems Of Ship Safety In The Process Of Docking, Assoc. Prof. Magdalena Kaup and Dr Eng. Dorota Łozowicka Vernon-Harcourt, 1911; Volney, 1957 and InchPound, 2009