Dynamic Positioning Systems

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GME 2010-11

Abstract

This Paper describes the Dynamic Positioning Systems used onboard ships. Dynamic positioning is a computer controlled system which automatically maintain a vessel's position and heading by using its own propellers and thrusters. These systems help the ship to maintain their status quo in terms of positioning, depending on the analysis and reaction to real time forces acting on the ship. This is achieved with the help of Position reference sensors, combined with wind sensors, motion sensors and compasses that provide information to the computer pertaining to the vessel's position and the magnitude and direction of environmental forces affecting its position.

Key Words:

Dynamic Positioning Systems, Jack-up Barge, Anchoring, DP Modes, Classification Societies.

Dynamic positioning Systems

Dynamic positioning is a computer controlled system to automatically maintain a vessel's position and heading by using its own propellers and thrusters. Position reference sensors, combined with wind sensors, motion sensors and gyro compasses, provide information to the computer pertaining to the vessel's position and the magnitude and direction of environmental forces affecting its position. Examples of vessel types that employ DP include, but are not limited to, ships and semi-submersible Mobile Offshore Drilling Units (MODU) and Oceanographic Research Vessels. [1]

Various types of ships used for commercial trade such as tankers and reefers carry cargo from one port to another. When these ships are at port they are tied (moored) so that they do not change their position and remain stationery during the entire process of loading or unloading of the cargo. When they sail out for their destination, the cargo is safe and secure and the weather conditions which make the ship rock and roll within reasonable limits do not have much effect except for inconvenience to the crew members. But there are another category of vessels whose operations depend on their staying at one particular position and direction despite changing weather conditions and sea currents. These jobs could be several types such as underwater cable laying, drilling, mine sweeping, surveying the ocean floor to name a few. These operations require the ship to remain relatively stable even when weather and ocean are trying to move it around from a fixed position and direction.

These ships require specialized systems which help them to maintain their status quo in terms of positioning, depending on the analysis and reaction to real time forces acting on the ship and such systems are known and dynamic positioning systems. [2]

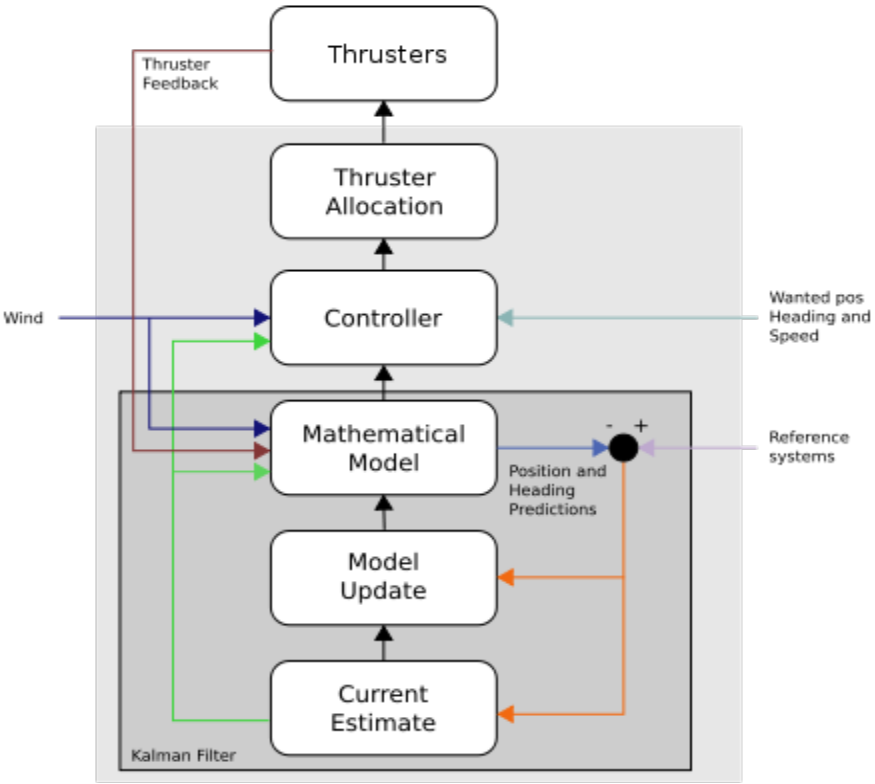

FIGURE NO: 01. BLOCK DIAGRAM OF CONTROL SYSTEM

Dynamic positioning systems provide a highly versatile "anchoring" system for vessels that must remain on a given location out in the deep ocean. While no single system design can be universally used, general guidelines can be established to assist in the selection and the design of the various subsystems.[3]

Comparison between position-keeping options

Other methods of position-keeping are the use of an anchor spread and the use of a jack-up barge. All have their own advantages and disadvantages.

TABLE NO: 01. COMPARISON BETWEEN POSITION-KEEPING SYSTEMS

Jack-up Barge	Anchoring	Dynamic Positioning
Advantages: • No complex systems with thrusters, extra generators and controllers. • No chance of running off position by system failures or blackouts. • No underwater hazards from thrusters. **Disadvantages:** • No maneuverability once positioned. • Limited to water depths of ~150 meters.	**Advantages:** • No complex systems with thrusters, extra generators and controllers. • No chance of running off position by system failures or blackouts. • No underwater hazards from thrusters. **Disadvantages:** • Limited maneuverability once anchored. • Anchor handling tugs are required. • Less suitable in deep water. • Time to anchor out varies between several hours to several days. • Limited by obstructed seabed (pipelines, seabed).	**Advantages:** • Maneuvering is excellent; it is easy to change position. • No anchor handling tugs are required. • Not dependent on water depth. • Quick set-up. • Not limited by obstructed seabed. **Disadvantages:** • Complex systems with thrusters, extra generators and controllers. • High initial costs of installation. • High fuel costs. • Chance of running off position by system failures or blackouts. • Underwater hazards from thrusters for divers and ROVs. • Higher maintenance of the mechanical systems.

Although all methods have their own advantages, dynamic positioning has made many operations possible that were not feasible before. [1]

Dynamic positioning - basic principles

Forces and motions

A seagoing vessel is subjected to forces from wind, waves and current as well as from forces generated by the propulsion system.

The vessel's response to these forces, i.e. its changes in position, heading and speed, is measured by the position-reference systems, the gyrocompass and the vertical reference sensors. Reference systems readings are corrected for roll and pitch using readings from the vertical reference sensors. Wind speed and direction are measured by the wind sensors.
The dynamic positioning control system calculates the forces that the thrusters must produce in order to control the vessel's motion in three degrees of freedom - surge, sway and yaw - in the horizontal plane.

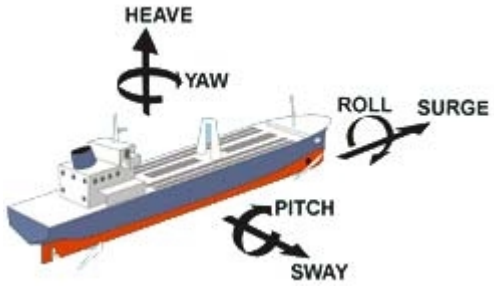

FIGURE NO: 02. MOTION MODEL - FORCES WORKING ON THE SHIP

Control principles

The dynamic positioning system is designed to keep the vessel within specified position and heading limits, and to minimize fuel consumption and wear and tear on the propulsion equipment. In addition, the system tolerates transient errors in the measurement systems and acts appropriately if a fault occurs in the thruster units.[4]

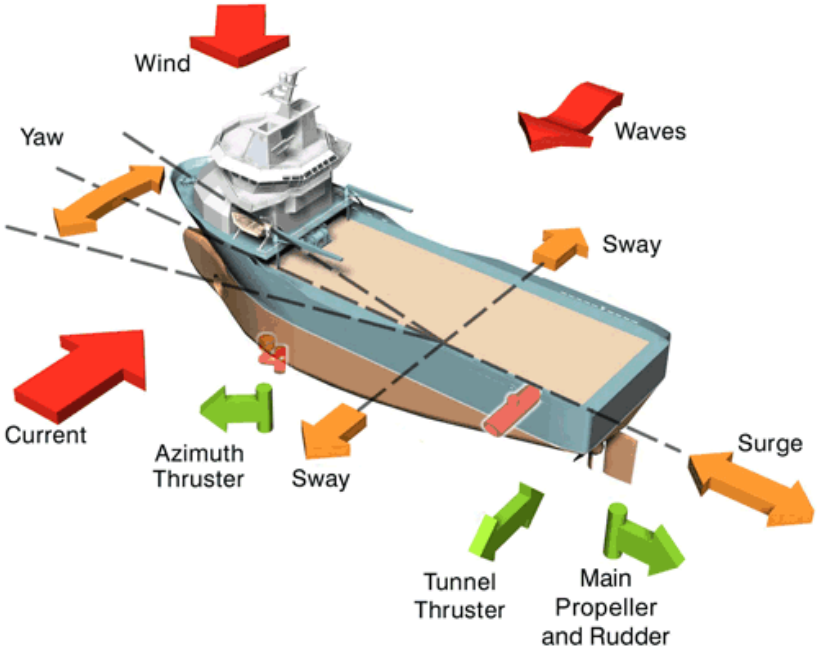

FIGURE NO: 03. DPS - BASIC FORCES AND MOTIONS

Dynamic Positioning System; Modes

Depending on the application, dynamic positioning systems can include the following operational modes:

- ☐ **Joystick**: The joystick mode allows the operator to control the vessel manually using a joystick for position and heading control.
- ☐ **Auto heading**: The auto heading mode automatically maintains the required heading
- ☐ **Auto position**: The auto position mode automatically maintains the required position and heading
- ☐ **Mixed joystick/auto**: The mixed joystick/auto mode allows the operator to select automatic control of either one or two of the surge, sway and yaw axes
- ☐ **Follow target**: The Follow target mode enables the vessel to automatically follow a moving target
- ☐ **Anchor assist**: The anchor assist mode provides thruster assistance when operating within a mooring pattern
- ☐ **Autopilot**: The Autopilot mode enables the vessel to steer automatically on a predefined course
- ☐ **Auto track**: The auto track modes (low-speed, move-up and high-speed) make the vessel follow a specified track described by a set of waypoints. All Auto Track modes are for marine operations only and are not to be used for navigation purposes
- ☐ **Track line**: The track line mode enables the vessel to follow a constant Course Over Ground (COG). The Track Line mode is for marine operations only and are not to be used for navigation purposes

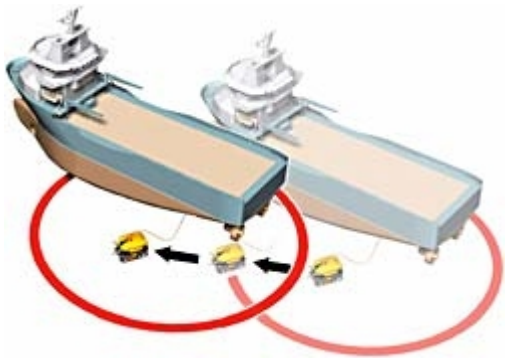

FIGURE NO: 04. FOLLOW TARGET MODE

Follow target mode – enables the vessel to automatically follow a moving target and keeps the vessel within a "position window" relative to the target

Three configurations

Our dynamic positioning systems may be installed in single, dual or triple configurations, depending upon the level of redundancy required. A single DP control system provides no redundancy. A dual or two-computer system provides redundancy and auto-changeover if the online system fails. A triple system provides an extra element of security and an opportunity for 2-out-of-3 voting.

- ☐ Single system - non redundant
- ☐ Dual system providing - master/slave redundancy
- ☐ Triple system providing triple - modular redundancy (TMR) and majority voting [4]

Class Requirements

Based on International Maritime Organization publication 645 the Classification Societies have issued rules for Dynamic Positioned Ships described as Class 1, Class 2 and Class 3.

- Equipment Class 1 has no redundancy.
  Loss of position may occur in the event of a single fault.

- Equipment Class 2 has redundancy so that no single fault in an active system will cause the system to fail.
  Loss of position should not occur from a single fault of an active component or system such as generators, thruster, switchboards, remote controlled valves etc., but may occur after failure of a static component such as cables, pipes, manual valves etc.

- Equipment Class 3 which also has to withstand fire or flood in any one compartment without the system failing.
  Loss of position should not occur from any single failure including a completely burnt fire sub division or flooded watertight compartment.

TABLE NO: 02. CLASSIFICATION SOCIETIES CLASS NOTATIONS:

Description	**IMO** Equipment Class	**LR** Equipment Class	**DnV** Equipment Class	**GL** Equipment Class	**ABS** Equipment Class
Manual position control and automatic heading control under specified maximum environmental conditions	-	DP(CM)	DYNPOS-AUTS	-	-
Automatic and manual position and heading control under specified maximum environmental conditions	Class 1	DP(AM)	DYNPOS-AUT	DP 1	DPS-0, DPS-1
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault excluding loss of a compartment. (Two independent computer systems).	Class 2	DP(AA)	DYNPOS-AUTR	DP 2	DPS-2
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault including loss of a compartment due to fire or flood. (At least two independent computer systems with a separate backup system separated by A60 class division).	Class 3	DP(AAA)	DYNPOS-AUTRO	DP 3	DPS-3

Redundancy

Redundancy is the ability to cope with a single failure without loss of position. A single failure can be, amongst others:

- Thruster failure
- Generator failure
- Powerbus failure (when generators are combined on one powerbus)
- Control computer failure
- Position reference system failure
- Reference system failure

For certain operations redundancy is not required. For instance, if a survey ship loses its DP capability, there is normally no risk of damage or injuries. These operations will normally be done in Class 1.

For other operations, such as diving and heavy lifting, there is a risk of damage or injuries. Depending on the risk, the operation is done in Class 2 or 3. This means at least three Position reference systems should be selected. This allows the principle of voting logic, so the failing PRS can be found. For this reason, there are also three DP control computers, three gyrocompasses, three MRU's and three wind sensors on Class 3 ships. If a single fault occurs that jeopardizes the redundancy, i.e., failing of a thruster, generator or a PRS, and this cannot be resolved immediately; the operation should be abandoned as quickly as possible.

To have sufficient redundancy, enough generators and thrusters should be on-line so the failure of one does not result in a loss of position. This is left to the judgment of the DP operator. For Class 2 and Class 3 a Consequence Analyses should be incorporated in the system to assist the DPO in this process.

Disadvantage is that a generator can never operate at full load, resulting in less economy and fouling of the engines.

The redundancy of a DP ship should be judged by a failure mode and effects analysis (FMEA) study and proved by FMEA trials.[8] Besides that, annual trials are done and normally DP function tests are completed prior to each project. [1]

Conclusion

The Dynamic Positioning Systems onboard ship helps in keeping a constant route according to the set route. This is accomplished by the assistance of some sensors and the Global Positioning Satellites. The Application of these System onboard ships indirectly helps in economic development as the accidents rates are reduced due to proper navigation in narrow and port areas. There are new technologies being developed like the Octopus DP System which even forecasts the weather conditions and plan the steps for dynamic positioning appropriately. This system is gaining importance day by day and helping the growth of the nation.

Acknowledgement

Every organization work has imprint of many people and this work is no different. This work gives me an opportunity to express deep gratitude for the same.

While preparing Paper Presentation I received endless help from number of people. This report would be incomplete if I don't convey my sincere thanks to all those who were involved.

I would like to thank our respected Course Incharge R.V.Anvekar, for giving me an opportunity to present this paper and his indispensable support, priceless suggestions and valuable time.

Finally, I wish to thank my friends of being supportive, without whom this paper would not have been complete.

Every work is an outcome of full proof planning, continuous and organized effort. This work is combination of the efforts put together sincerely.

Mr. Benven Pascoal Kinny

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