DYNAMIC POSITIONING CONFERENCE
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Design and Control

Station Keeping Criteria for Dynamically Positioned Vessels

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1. Introduction

The capability plot is often presented as a polar diagram with a number of envelops, depicting the ship's capability to keep position in a certain environment with a certain combination of thrusters.

The capability plot is often set against a scale of increasing wind speed with a fixed current speed and a fixed relation wind speed and wave height. Wind speed is often used as this is the most easily measured parameter. Wave height and current speed is more difficult as it will in most cases require equipment outside of the own ship.

The capability plot depicts for a certain heading, the vessels capability to withstand a certain wind speed coupled to a wave height and a current speed. Normally all three environmental forces are acting from the same direction.

In order to obtain the capability plot, various calculations are to be carried out like:

- Wind forces acting from various directions
- Wave drift forces acting from various directions
- Current drag forces acting from various directions
- Propeller, rudder and thruster efficiency in various directions based on hull interaction, propeller interaction, thruster interaction etc.

2. Det Norske Veritas Environmental Regularity Number (ERN)

This is a theoretical calculation method developed in the 1970's by Det Norske Veritas. At this time Dynamic Positioning was virtually unknown except to a few people working in the North Sea. The calculations are quite simple and are based on lateral forces only. Wind, waves and current are coming in on the beam.

Thruster and hull efficiencies are not considered. Restoring forces are also not considered. Nominal thrust, as given by the thruster manufacturers are to be considered. Det Norske Veritas assumes a current speed of 1.5 knots in the ERN calculation.

The ERN consist of three groups of digits, the first group indicating the chance of the ship keeping position at a certain location in the North Sea providing all systems are working. The second group of digits indicates the chance to keep position if the most ineffective thruster fails. The third group of digits indicate the chance to maintain position if the most effective thruster fails.

Mr. Holger Røkeberg was the person responsible for introducing the ERN. He explained to me, in the late seventies that the ERN was not an absolute method for calculating the station capability but a simple tool for comparing the station keeping capability between different ships. At the time, when the ERN was introduced, most ships claiming to have a DP system, would be carried away by the current only, if a thruster forward stopped.

This ERN method is simple and it caught on. For a time it was a sales argument to have at least (99, 99, 99). Oil companies in their tender specifications often required (99, 99, 99) if a DP vessel was to be considered for charter.

3. Lloyd's Register Performance Capability Rating (PCR)

Lloyd's Register (LR) has taken a completely different approach than their colleagues at Det Norske Veritas with respect to presenting the station keeping capability. In the mid eighties LR introduced the Position Capability Rating or PCR. The PCR consists of two digit groups, the first indicating the time the vessel can keep position providing all systems are working and the second group indicates the time the vessel can keep position if the most effective thruster fails. Wind and wave data are obtained from a fully developed North Sea spectrum.

LR in their PCR calculation consider also the thruster efficiency and a current speed of 1 meter/second (2 knots). Restoring forces of 20 % of the total forces are also to be considered. This means that the actual thruster force used in the calculation is less than 80 % of the nominal thrust.

4. Dynamic Positioning System Vendors and Capability Plots

The DP system suppliers and other organizations have their own calculation methods for calculating the DP capability. The result can vary considerable for the same ship calculated by different organizations. The reason for this may be different way of calculating the wave drift forces and different ways of estimating thruster efficiencies.

5. Current Forces

Current forces can be easily calculated by using simple formulas and the relevant drag coefficients. Tank testing is also a way to obtain more reliable values.

6. Wind Forces

Wind forces can be calculated the same way as current forces. In certain cases, for more complicated structures, wind tunnel tests may be required in order to obtain an accurate result. Wind speed is normally referred to the speed of the wind at 10 meters above the sea level. When calculating the drag forces for semi submersibles etc, the increase in wind speed with the height above the water level must be taken into account.

7. Wave Drift Forces

Wave drift forces can best be obtained from model tests. When calculating the wave drift forces, the wave height is seen as a linear function of the wind speed. This may be true for certain areas

in the world like the North Sea and Mexican Gulf. In other areas there may be a swell component completely independent of the wind speed.

Wave drift forces are very much dependent upon the wave period as short steep waves give higher forces than long waves with the same wave height. Therefore the wave spectrum and the selected wave period in relation to the wave height is very important in calculating the total wave drift force.

8. Thruster efficiency

Thruster efficiency is one of the most difficult variables to get under control. There are many factors influencing the efficiency. The best method to get hold of these efficiencies is to do full scale tests and the second best is model tests.

In the past, full scale tests with the Diving Support Vessels Deepwater 2 and the Energy Supporter was made at a deep water quay in a fjord in Norway. Bollard pull tests were done with the forward tunnel thrusters and the azimuthing thrusters aft. The thrusters were tested one by one and all together. These tests more or less confirmed the thrust values the thruster manufacturer at that time gave as nominal thrust. One phenomena noted during these tests was that when measuring the individual thrust forces of the tunnel thrusters forward, adding these up and comparing the measurements with all three tunnels in action simultaneously the sums were different. In other words the three tunnels influence each other and the total sum is less in practice than in theory.

9. Discussion

The ERN from Det Norske Veritas is not so easy to compare with the PCR from Lloyd's Register.

This means in practice that it is difficult to compare the real position capability between different ships. Commercial considerations often dominate the picture given and the ship is often presented as a better performer with respect to station keeping, than what it really is.

Consider a ship with the environmental forces coming in on the beam. When the current increases from 1.5 – 2.0 knots to 3 – 4 knots, the current force will soon be dominating.

A simple method to evaluate the station keeping capability between different ships could be to measure the speed athwart ships in calm weather. This would give a good indication of the station keeping capability for a mono-hull. By doing this you will also have an indication of the stability of the DP system by checking the heading. The installed power of the thrusters aft are determined by the propulsion requirement and the power of the thrusters forward are determined by the station keeping criteria. There is a certain unbalance in power on most DP ships between forward and aft.

Most supply boats and offshore support vessels have more or less the same type of lateral profile so it may be assumed that the wind-force has about the same amount of influence for the same type of ship.

10. Transverse Speed Criteria

The "transverse speed criteria" is simple to measure and can be done in the following conditions:

- 100 % power and thrusters available
- 50 % power and / or thrust available

Wind driven current is often around 1.0 – 1.5 knots. The ship should do more than 2 knots transverse, if less, then the station keeping capability must be regarded as very poor.

The heading variation during this exercise should be below ± 3º. A heading variation of ± 3º means that the bow of a 80 m long vessel will vary ± 2.1 meters, which can be a lot, close to a fixed platform for example.

In certain areas of the world like in the Gulf of Mexico surface current may run up to 4 knots for shorter periods. Off the Congo River in West Africa, current speed of up to 3 knots have been observed. In the Campos field, off Brazil, strong currents have also been noted.

The transverse speed method is a very simple indication of the DP Position Capability and it does also eliminate all discussions about thruster efficiency when comparing the DP capability between different ships.

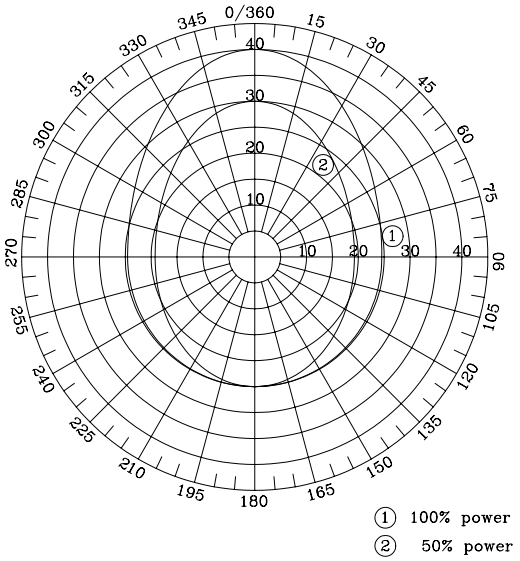

Fig 1. DP Capability Plot.

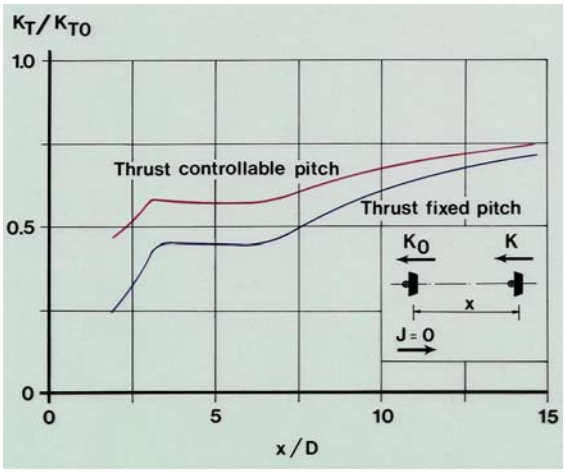

Fig 2. Example of Thruster efficiency

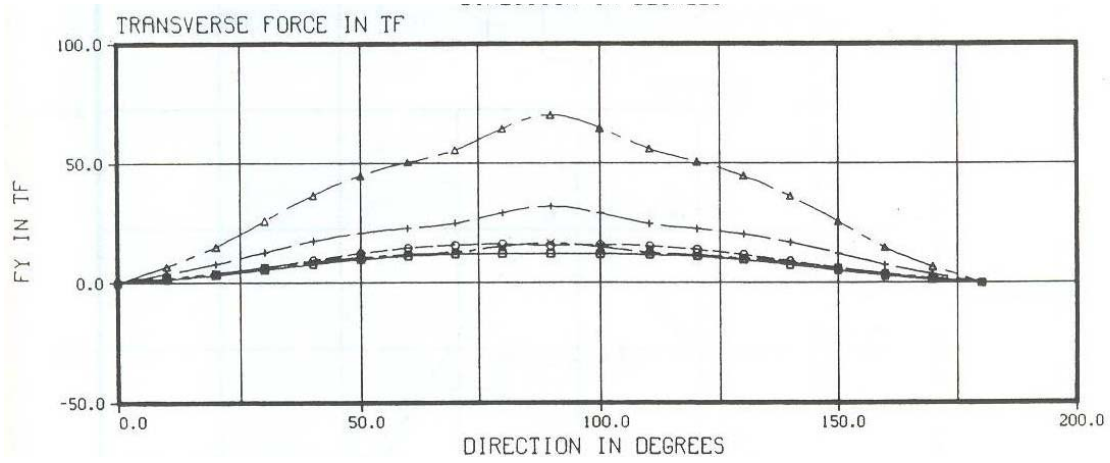

Fig 3. Example of wave drift forces as a function of wave period. Wave periods are from top to bottom 4 sec, 8 sec, 10 sec, wind force and current force 1.5 knots.