DYNAMIC POSITIONING CONFERENCE
October 14-15, 2014

THRUSTER SESSION

DYNAMIC EFFICIENCY -

Propulsors with Contra-Rotating Propellers for Dynamic Positioning

---

By Kari Kyyrö and Markus Niemi

(Steerprop Ltd.)

Return to Session Directory

Abstract

Azimuthing propulsors with Dual-End Contra Rotating Propellers offer many benefits for DP vessels. Properties of this concept are highlighted and compared to those of ducted units. Considerable fuel savings are possible thanks to an excellent overall efficiency in a typical operating profile of the ship. Ice navigation and ice management bring out even more strengths of the configuration. Some differences between fixed and controllable pitch units are discussed.

Introduction

The main advantage of utilizing azimuth propulsors in Dynamic Positioning (DP) is obvious; full thrust from any main propulsion unit is available to any direction. In a propulsion configuration with two or more azimuth propulsors, a combination of vectored thrust and turning torque can be produced that enables the ship to even traverse laterally, easing up the load on bow thrusters.

Figure 1 - Propulsor configurations

Earlier, the main choice concerning the type of azimuth propulsion for DP vessels was between open and ducted single propeller units. Ducted units produce a high bollard pull which is advantageous in DP. However, with traditional nozzle types, this high bollard pull came at the price of compromised efficiency in transit conditions.

In the 1980's it became technically and economically feasible to use Contra-Rotating Propeller (CRP) technology on a larger scale in azimuth propulsion. These CRP propulsors have made it possible to produce a high bollard pull with superior propulsive efficiency in comparison to a single propeller unit in transit conditions.

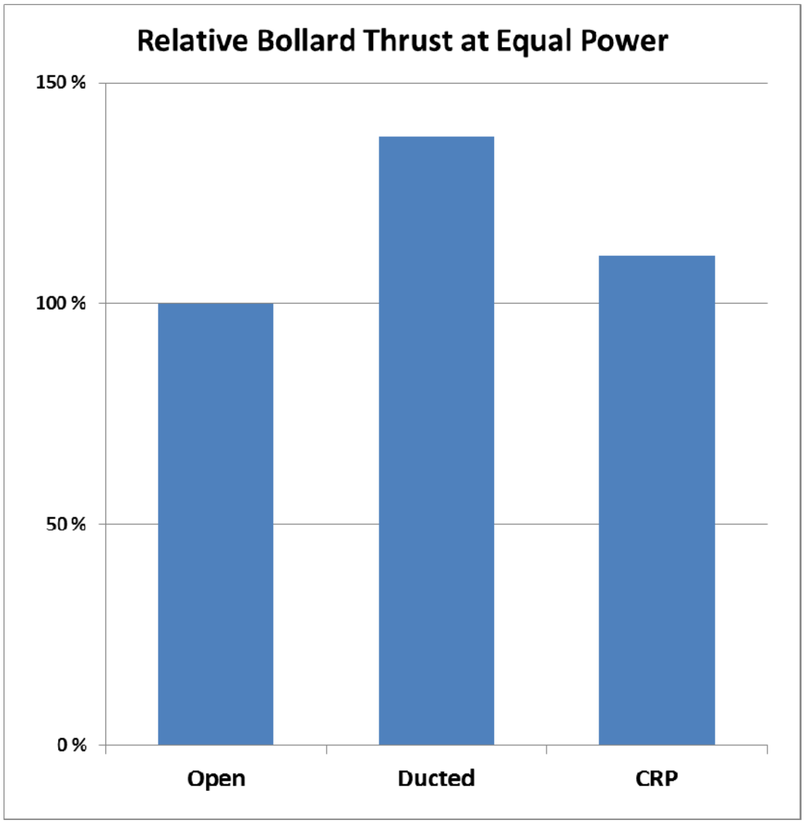

Figure 2 – Approximate relative bollard thrust of propulsive units.

High bollard pull versus overall efficiency

Figure 2 shows typical differences in maximum bollard pull for open, ducted and CRP propulsors when operating at same input power. Clearly, the ducted option excels, but it might be worth extending the focus on the overall operating efficiency. Figure 3 illustrates a case study on the performance of the propulsors in a DP vessel. The high bollard pull of the ducted unit may be beneficial when operating near the limit of the DP capability. However, these extreme circumstances account for only a minute part of the vessel's operating time. Besides, for a typical offshore supply vessel with lateral wind area concentrated near bow, stern forces do not typically limit DP performance. As the majority of the time at DP is spent operating with low power (maybe about 15% of maximum), the strong benefits of CRP propulsion come to the fore as Figure 3 illustrates.

The basic theory behind a Dual-End CRP concept is that a propulsor's efficiency can be improved by dividing the propulsive load between two propellers and torque between two independent sets of gear wheels, propeller shafts and propellers. As the propulsive load is divided this way, slower, larger propellers can be used. The principle is shown in Figure 4.

This greatly enhances the propulsor's efficiency and also improves its reliability as the components are subjected to less mechanical strain. By utilizing a relatively simple mechanical construction with few moving components, this reliability is enhanced even more. In addition of course, the contra-rotating effect regains energy from the slipstream of the front propeller, leaving less loss in the propeller race.

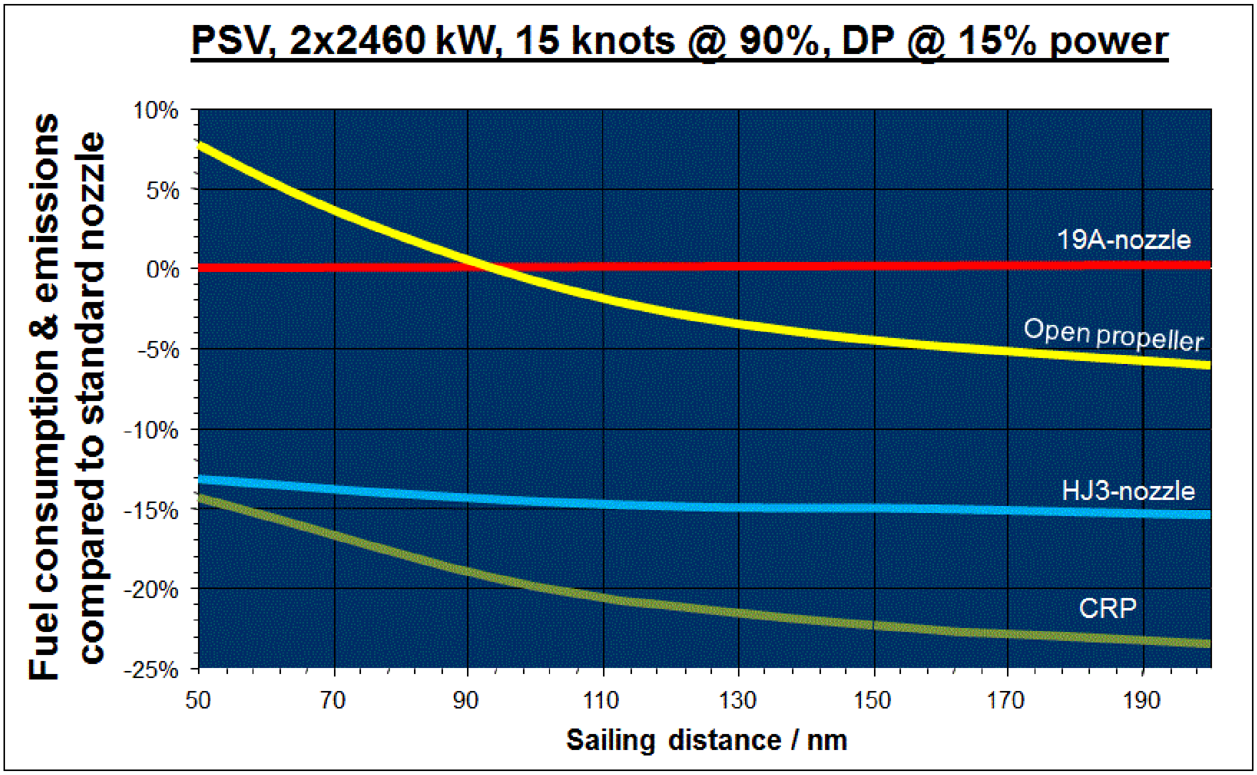

Figure 3 – A case study: Difference in fuel consumption of a DP vessel with different propulsive unit types, relative to a vessel with conventional nozzles.

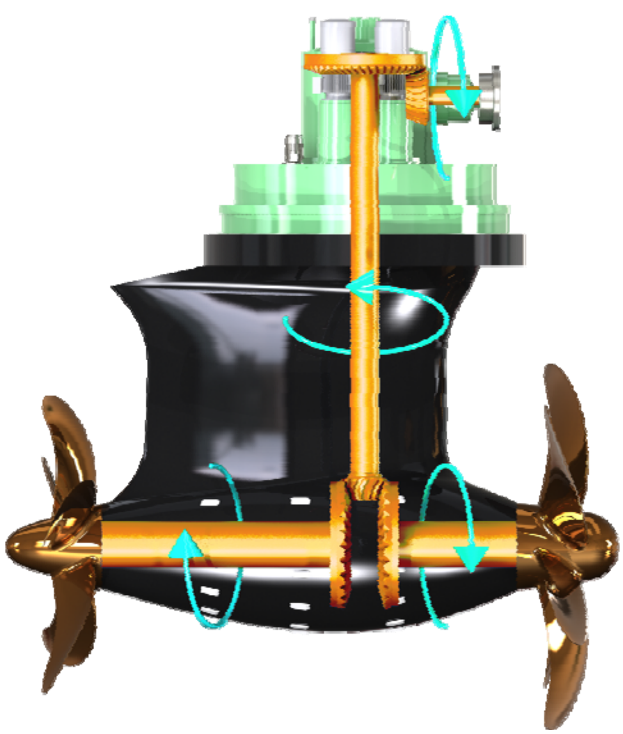

Figure 4 – Mechanical principle of the Dual-End CRP.

Ice operation

Slower propellers also enable Dual-End CRP propulsors to be reinforced against ice or other debris in Arctic or shallow-water applications. Because of this, Steerprop has conducted a series of ice model tests at the Aker Arctic ice laboratory, focusing in particular on the effects of CRP propeller flow in ice management.

In these tests, the Steerprop Dual-End CRP was compared with a variety of different propulsion solutions in different vessel configurations such as Arctic supply vessels, icebreakers and dedicated ice-management vessels. Figure 5 illustrates a supply vessel test in progress in the ice basin.

Test results show that the CRP brings considerable benefits in icebreaking and ice management. Similarly to a ducted propeller, the CRP unit concentrates the propeller slipstream, enabling a strong and far-reaching flow for ice flushing. The dual end concept ensures that no ice floe interacts with both propellers simultaneously as the propellers are located meters away from each other. Hence, ice blockage cannot cause damage to the propulsors.

With these proven advantages in both bollard pull and icy conditions, the Dual-End CRP is obviously an excellent choice highly beneficial for DP in ice. Dual-End CRP propulsors are particularly beneficial in ice-going DP applications where utilizing ducted propulsors could be risky as the nozzle could be blocked by ice.

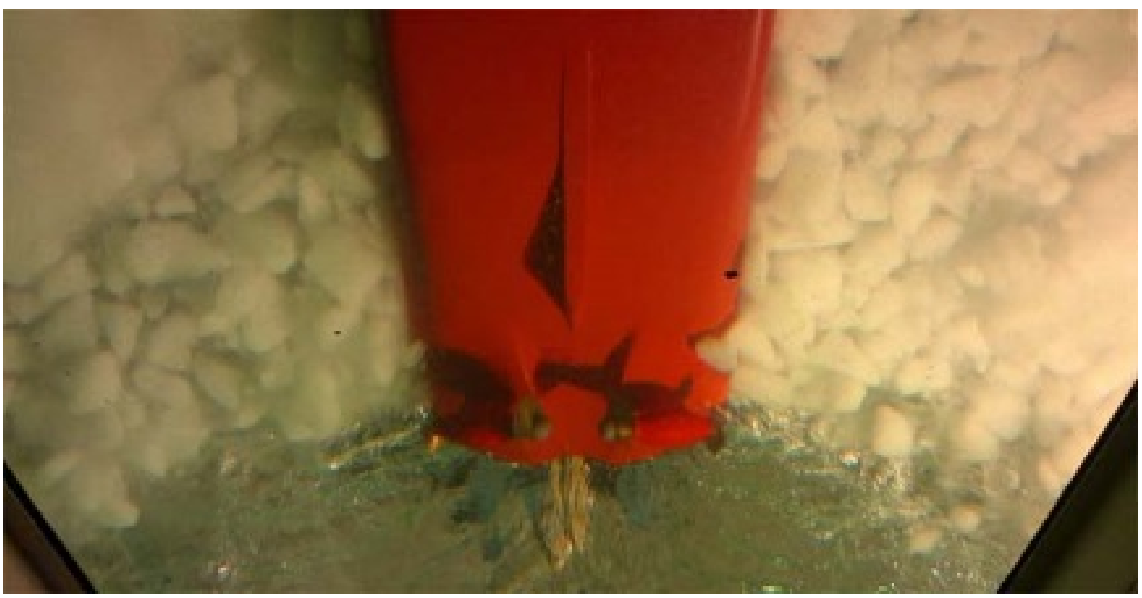

Figure 5 – Ice basin tests at Aker Arctic.

Fixed versus controllable pitch

In modern variable speed drive technology utilized with diesel-electric systems, fixed pitch propellers are the usual choice for DP vessels. Most of the time, only low thrust is required in DP operations. Slow-turning fixed pitch propellers (FPP's) produce this thrust economically, running at design pitch with the prime mover motor's rpm adjusted as necessary. Controllable pitch propellers, often connected to prime movers with limited rpm capability, operate on high revolutions and low, off-design pitches and waste a lot of energy by just producing turbulence in water.

For the same reason, noise, vibration and cavitation erosion risks are less of a concern with FPP's. In a CRP unit, these risks are further reduced thanks to low propeller loading and slower rpm. Mechanically, the Dual-End CRP units with FPP's are robust and simple, without the complexities and possible fatigue issues of a pitch adjusting system.

In some occasions, controllable pitch is selected in view of power availability in both bollard and free running conditions. Utilizing field weakening of electric motor prime movers, the design point of the fixed pitch unit can be selected to achieve a suitable balance between the two conditions. Then only little power capacity may be lost in bollard pull and/or free running, depending on the case and on the width of the field weakened rpm range.

Conclusion

A ducted propeller unit offers an excellent DP-capability in conditions close to the design limits of the vessel. These kind of conditions are, however, encountered rather rarely in a typical operating profile. Taking into account the overall efficiency, with the majority of fuel expenses caused by low-power DP operation and transfer voyages, the Dual-End CRP concept shows its strength. At a price of some reduction in DP extreme capacity, fuel savings are significant.

In ice operations, where a ducted unit usually isn't feasible due to nozzle clogging, the Dual-End CRP is even more beneficial. The unit offers a good bollard thrust with a simple, robust construction and an excellent propeller race for ice management.