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Breaking the Ice

Ice-going azimuth propulsion

Steerprop Ltd. is a Finnish company specialized in the design, production and service of azimuth propulsors. Due in part to the company's northern location, developing and building azimuth propulsion for arctic and ice-going vessels has always been Steerprop Ltd.'s particular speciality – as a matter of fact, many of the over 550 azimuth propulsors contracted or delivered by Steerprop Ltd. have had some form of ice-classification, some even in the stringent ARC 7 and Icebreaker 7 ice-classes of the RMRS classification society. In 2008, Steerprop Ltd. delivered two record-breaking 8400 kW mechanical azimuth propulsors to serve as the main propulsion for the arctic multi-purpose icebreaker Varandey. In Icebreaker 7 ice-class of the Russian RMRS classification society, the Varandey is the most powerful icebreaker with azimuth propulsion in the world.

i The Varandey

The basic theory of azimuth propulsion was conceived as early as the 1940's and the first widespread usage of azimuth propulsion was in military landing crafts. But due to technological limitations, it was not until the 1960's and the advent of the Z-drive technology that it became technologically and economically feasible to produce azimuth propulsors of any significant size. These larger, more powerful propulsors were first used in harbor tugs – giving birth to the Z-drive tug vessel type. As these tugs became more common, the main advantage of azimuth propulsion – outstanding maneuverability based on the ability to direct thrust in full 360 degrees became more widely recognized.

But it was only after 20 years of operating experience that azimuth propulsion was introduced to ice-going applications. In the early 1980's, Z-drive harbor tugs intended for year round operation in the Finnish oil harbors in the Baltic Sea were designed and built. Despite their relatively light ice-class, the tugs were able to operate year-round in most ice conditions, helping larger ships into port in all but the most severe ice conditions. In their first winters in operation, it was discovered that the tugs were capable of limited ice management operations with their propeller flow – an indication of new methods of icebreaking that would become available with larger, more powerful azimuthing vessels.

Based on the promising experiences from tugs, multi-purpose vessels were commissioned during the early 1990's partly as buoy tenders for the Baltic Sea and partly to serve as prototypes for a more powerful class of ice-going azimuth propulsion powered vessels. In effect, the vessels were built to experiment with both mechanical and the newly designed electrical azimuth propulsion in ice. For the purpose of the experiment, one ship was equipped with a single ducted mechanical azimuth propulsor, while the other was equipped with a single open propeller electrical azimuth propulsor.

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The practical experiments done by the vessels confirmed several indications from the tugs; that the vectored thrust, ie, the slipstream from the propeller could be used in several ways in ice management operations. By directing the slipstream, ice ridges could be blown away or broken up and offshore installations could be relieved from ice pressure. The outstanding maneuverability of an azimuthing ship also made it easier to break free from ice and avoid too severe ice. It was also theorized that with if a vessel was equipped more than one azimuth propulsor, it could widen a fairway as it moved through it.

"These experiences showed that while a nozzle improves thrust and bollard pull and enhances ice managing capabilities, at the same time, in icy conditions, a nozzle also brings certain disadvantages," states Steerprop Ltd.'s Hannu Jukola, M.Sc. Naval Architect specializing in hydrodynamics, "such as the nozzle with clogged with ice. With a vessel that is equipped with a single propulsor, this could be difficult to unclog."

Another disadvantage discovered had to do with the physical size of the underwater body of the propulsor that extended from the ship's hull. Though the propulsors in the early 1990's were relatively small in comparison to more current propulsors, it was noticed that in more severe ice conditions that the propulsor body became effected by the physical load of the underwater ice load when the propulsor turned, requiring more torque to be turned. This issue is still present in larger unit sizes that require powerful steering motors for azimuthing. Impacts from the ice below the ship also attempted to turn the propulsors by themselves, causing strain on the steering motors themselves, necessitating some form of overload protection for the steering motors to avoid damage from extremely forceful ice-loads.

Based on the results from these multi-purpose vessels, the first true class of azimuthing icebreakers, the Finnish Fennica-class, was commissioned in the mid-1990's. In almost 20 years of continued operations in winters of varying ice severity, these ships have proven the capabilities of azimuth propulsion in ice and inspired new kinds of possibilities for ice-going azimuth propulsion. Among these possibilities is the idea of a vessel with a bow optimized for open water conditions and the stern optimized for breaking ice, an operational profile made more feasible by the azimuth propulsor's ability to turn a ship around in relatively little space and ability to propel the ship astern just well as forward. The idea of this kind of vessels later materialized into several arctic tankers and cargo vessels. A decade of actual service in the Baltic and the Arctic Ocean has proven the effectiveness of this type of vessel – the ships sometimes have even acted as ad hoc icebreakers for other ships operating along their routes.

In 2006, Steerprop Ltd. was involved in expanding the power range of azimuthing icebreakers when two SP O 4,5 ARC 8200 kW mechanical azimuth propulsors per ship were delivered to the Russian newbuilt Moscow-class of icebreakers of the RMRS Icebreaker 6 ice-class, the Moskva (Moscow) and the Sankt Petersburg (Saint Petersburg). These two vessels proved the capabilities and the endurance of azimuthing icebreakers in Baltic waters during the severe ice winter of 2010 when they were able to operate through the winter without interruptions when older, less powerful conventional icebreakers of the Russian Baltic icebreaker fleet had to temporarily cease operations.

Two years later, in 2008, the record-breaking 8400 kW SP O 4,5 ARC azimuth propulsors were delivered to the RMRS Icebreaker 7 ice-classed multi-purpose icebreaker

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Varandey. Though of a similar type than the propulsors delivered to the Moscow-class, these propulsors were significantly more reinforced due to their more demanding ice-class.

ii 3D model of the Steerprop SP O 4,5 ARC propulsor installed on the Varandey

With almost 30 years of experience with azimuth propulsion in ice, new methods and technologies are being developed based on the lessons learned during those decades. New capabilities and ice-going vessels are now available as manufacturing technology enables even larger and more powerful azimuth propulsors to be produced. One particular new application of ice-going azimuth propulsion is the theory of an icebreaker that could break open a wide fairway by proceeding side first – propelled by three azimuth propulsors to do so. With especially designed hull, this type of vessel could prove revolutionary in efficient and economical icebreaking.

As the natural resources of the Arctic are becoming more important and more accessible, improving and further developing mechanical azimuth propulsion for ice-going applications may play a vital role in the utilization of those resources. With a compact underwater body that collects very little ice-load and can thus be turned with relatively little steering torque, a mechanical azimuth propulsor doesn't require extremely powerful – and expensive – steering motors for turning. And the compact auxiliary systems – such as hydraulics and control – free up precious space aboard arctic vessels. Space that can be better used for other vital systems or cargo space. As the propulsor's underwater components are accessible even while the ship is out at sea and the auxiliary systems are located inside the ship itself, almost all components are accessible for ease of service and can be easily optimized to the ship's unique operational profile.

"With the electrical prime motor inside the ship, it can be easily optimized to the operational profile of the ship," continues Mr Jukola, "also the compact size of the underwater body, even at higher power ratings, ensures that the propulsor body itself does not gather ice-load that necessitate a high steering torque."

Steerprop Ltd. is approaching the future of ice-going azimuth propulsion from two directions. Firstly the ARC- series of arctic azimuth propulsors is being constantly developed and refined for even more efficient and more powerful propulsors based on the experiences of the ARC-propulsors currently in operation. At this time, Steerprop Ltd. is able to deliver ARC propulsors up to 16 MW in demanding ice-classes. The Steerprop ARC is also available in the ultra-demanding PC 1 ice-class.

Secondly, Steerprop Ltd. is developing a new high-power, high-efficiency propulsive system based on the proven Steerprop Dual-End CRP technology. This new propulsion system, named the ECO CRP, is envisioned to bring the outstanding maneuverability of azimuth propulsors, the inherent reliability of mechanical propulsion and the unsurpassed efficiency of Dual-End CRP technology to high power ranges

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and even the strictest ice-classes.

iii 3D-model of the SP ECO CRP

"This new propulsion system has undergone both open water and ice model tests and thus far the results have been quite promising." states Mr Jukola. "With the propulsive load distributed between two gears in the underwater body, new possibilities for propeller optimization are available – smaller ice-reinforced propellers can be used without compromising the CRP technology's inherent efficiency."

As the propulsive load is evenly divided between two independent gear wheels, shafts and propellers, the propellers and the propulsors themselves can be more easily optimized to a variety of different vessel types and operational profiles without compromising the Dual-End CRP's unsurpassed efficiency. Currently the ECO CRP is available up to 20 MW in demanding ice class. The ECO CRP is also available in the PC 1 ice-class.

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