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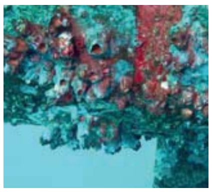


Break the ice

It's not just the harsh weather that makes it difficult to protect and maintain climate specialist vessels

Neil Jones, *Marine Maintenance Technology International*

Maintaining icebreaking and ice strengthened vessels does, as you might expect, have its challenges. For a start, the nature of the way they operate subjects them to a huge amount of vibration, not to mention the impact of constantly operating in harsh weather. But conversely, as Albert Hagander, technical manager of the Swedish Maritime Administration's Shipping Management Department, points out, there is actually a weather-related advantage in that the vessels are not usually in service during the summer.

"You really can't do much when they're in service simply because of the weather conditions, often with ice on deck," he points out. "In the summer, it's often a better situation than with a conventional vessel, as you have the time to work on them while they're alongside the dock or even in dry dock."

The Administration operates four big icebreakers plus a slightly smaller one for Lake Vänern that supplements the capability during the early or late season. That the icebreakers are vital can be seen from the fact that 95% of Swedish export/import trade is seaborne.

MAIN: **Swedish icebreaker Oden, on a mission in the Baltic sea. Picture courtesy of Swedish Maritime Administration**

"On all the vessels – indeed on any icebreaker – the loadings on the engines are extreme," says Hagander. "Most ship engines run for long periods at a constant speed, whereas icebreaker engines have service loads from very low to very high, alternating between the two extremes, as well as coping with the terrific vibrations from the ice. But of course they're not standard engines."

The engines on the Swedish Maritime Administration vessels built in the mid-1970s – Atle, Frej, and Ymer – were constructed at the Wärtsilä shipyard at the same time as the vessels themselves and each engine has an extra bearing to cope with the axial forces. These vessels have five engines with two forward-facing propellers and two rear-facing propellers. "That extra bearing in each engine helps the engines take the extra forces imposed by the constant ramming of the ice," continues Hagander. "All four props can push and pull and can help flush the ice away, but the two forward-facing props are more vulnerable as they can crash into the ice and sometimes sustain small damages that need spot welding."

Paintwork a big issue

One big difference in the way the Swedish vessels are maintained compared with conventional vessels is their paintwork. Below the waterline the Administration uses an epoxy two pack hot feed product from International Paints called Inerta or a cold feed vinylester-based paint called Ecospeed. "These are very thick and very hard, and are only suitable for the hulls," explains Hagander. Paint is also an issue for the two research vessels operated in both the Antarctic and the Arctic by the British Antarctic Survey (BAS). Its Royal Research Ship (RRS) James Clark Ross and RRS Ernest Shackleton are not strictly speaking icebreakers, but operate for much of the year in harsh conditions. RRS James Clark Ross has some of Britain's most advanced facilities for oceanographic research and is the platform for most of the marine science undertaken by the BAS. RRS Ernest Shackleton is primarily a logistics ship, used for the resupply of the BAS's stations and for occasional science and specialist tasking.

With strengthened hulls, they are both capable of handling year one ice conditions – that is, new ice up to 2-3m (6.6-9.8ft) thick, a thickness that they can make progress through without having the back and forth, stop and start movement of a true icebreaker.

"Hull coatings are important," confirms Stephen Lee, the BAS's marine superintendent. "On the James Clark Ross we've been using an Inerta [coating]. That's been on the vessel since it was built. It's been completely recoated once in its lifetime, but we make repairs every season where the paint has been damaged. On the other ship, the Ernest Shackleton, we're not exactly pioneering because it's been around a little while, but in terms of ice strengthened ships it hasn't been used before and that's a Hydrex product called Ecospeed. It's a vinylester product but it's cold feed rather than hot feed. We've used it in both the Arctic and the Antarctic, and found it to be a fantastic product for what we do. And it's a reasonable price!"

Lee continues by saying that the biggest advantage is the conditions in which it can be applied – colder and with more humidity. "We've found Ecospeed to be extremely resilient to ice and the usual erosion that you get at sea. It's made a big difference to our operation. It gives more efficiency through clear water and the lower coefficient of friction means it's better through ice as well."

On-deck equipment

One of the obvious issues is the amount of corrosion on the upper deck machinery and fittings. "Such is the nature of the seas they are working in that they ship a lot of green water in very cold temperatures and ice

RIGHT: **The RRS James Clark Ross has some of UK's most advanced facilities for Antarctic and Arctic oceanographic research and is the platform for most of the marine science undertaken by BAS**

A LITTLE BIT OF HISTORY

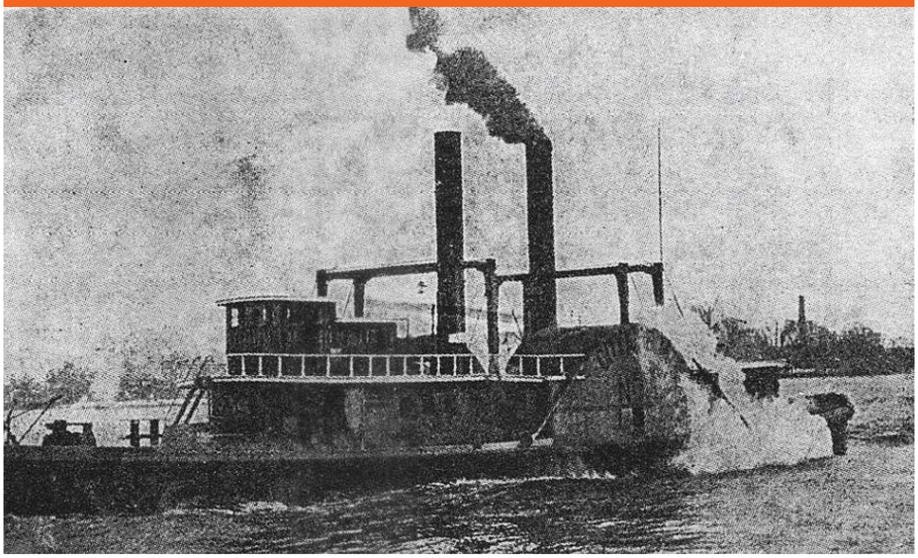
The history of boats with specific design features that enable them to operate in icy waters goes back, remarkably, almost 1,000 years.

It is thought that the earliest designers of such vessels were the Pomors, or 'seaside settlers', who lived on the Russian coast of the Arctic Ocean. They developed small one- or two-masted wooden sailing ships that they used for voyages in the icy conditions of the Arctic seas and, later, on Siberian rivers.

These earliest ice-capable vessels were called kochs and their hulls were protected by a band of ice-floe resistant oak or larch skin-planking along the waterline.

The crafty bit of the design was the rounded hull shape, crafty because if – usually more like when – a koch became squeezed by the ice-fields, it would simply be pushed upwards out of the water and onto the ice with no damage. And with a false keel it could then be dragged across the ice.

By the end of the 19th century, some notable sailing ships featured the rather egg-shaped form of the koch, not least the Fram, used by Fridtjof Nansen and other great Norwegian polar explorers. Fram is said to be the wooden ship to have sailed the farthest north (85°57'N) and the farthest south (78°41'S), and was perhaps the strongest wooden ship ever built. Although the Pomor boat builders might disagree!



On the James Clark Ross we've been using an Inerta [coating]. It's only been completely recoated once in its lifetime, but we make repairs every season where the paint has been damaged

Stephen Lee, BAS's marine superintendent

accretion can be on there for days or even weeks," explains Lee. "Yes, there are products available to prevent ice accretion. But you still need to put the guys out on deck and with temperatures of -50°C [-58°F] when you factor in the wind chill, they can do only 10 minutes at a time at the most. The human factor is a major challenge. Sorting out one little bit of rust in a temperate climate might take 30 minutes. In extreme conditions you'd be lucky to tackle it in a day. And when the ship moves back into temperate climates you get the onset of sometimes aggressive corrosion."

All the equipment, especially that on the upper decks such as cranes and winches, must be able to handle extremes of temperature, from -40°C (-40°F) to +40°C (104°F). Luffing cylinders, for example, are more expensive than those required in temperate climates, which increases the cost of running the ships. Hydraulic hoses need replacing far more frequently than normal, partly because they perish faster in the low temperatures and partly because under the Antarctic Treaty the penalties for discharging any sort of oil into the environment are extremely severe. Both the BAS vessels were originally built for the job they are doing, so they are both double-hulled; the RRS James Clark Ross, for example, has an outer hull of 32mm-thick [1.26in] polar-grade steel with a 1m [3.2ft] void space. According to Lee, "You could puncture the outer hull with impunity. We did indeed do that once when it went aground. The crew was relying on incomplete charts and caught an outcrop. The result was we needed to replace 30m [98.4ft] of steel." The issue of hull integrity is taken up by Steve Bremner, the BAS's head of engineering. "Within the vessel there are areas where the loads and stresses are distributed, and that's where there's the potential for cracking. Energy gets transferred through the ship so brackets may break or crack in places you wouldn't necessarily expect it. And you won't find those until you do a major structural inspection. It's a naval architecture problem – at the design stage you can model those stresses, but until the ship is in the water and you take it into the ice, you're never really sure."

Crew experience

"Two things are vital in maintaining hull integrity," Bremner continues. "One is a vigilant program of surveys. The second is the knowledge of the crew. Vibration is a big issue and an experienced crew will understand how this affects the vessel's structure."

That knowledge and experience comes to the fore because often there are tasks that need to be done that would not be usual at sea. "If something fails they have to remedy it and make effective repairs to get home," says Bremner. "They have to be sufficiently trained to be able to take on tasks that would normally be done in the dockyard."

That issue of crew expertise is echoed by Gary Ivany, director of marine engineering for the Canadian Coast Guard. "Our maintenance philosophy for first and second level tasks is our own people," Ivany explains. "We have a total fleet of 117 vessels, of which 15 are what we call our 'ice capable fleet' – two heavy icebreakers, four medium-size icebreakers, and the balance ice strengthened ships that are used for things such as community resupply, search and rescue work, research, and so on.

"All the fleet is aging, with the oldest (and largest) of our icebreakers built in 1968. That means one of the major challenges is maintaining electronic systems that are analog rather than digital. But even things such as engine overhauls are undertaken on board. It's part of the Coast Guard culture and inherently demands that our engineering crews are highly skilled and extremely versatile."

Part of the reason for this culture of self-sufficiency is that, as far as the ice fleet is concerned, its big bases with major facilities are all in the south, while its main operational areas are north, from the St Lawrence Seaway and Newfoundland up into the Arctic.

RIGHT: RRS Ernest Shackleton is primarily a logistic ship, used for the resupply of BAS's stations

> **The fleet is aging, with the oldest of our icebreakers built in 1968. That means one of the major challenges is maintaining electronic systems**
>
> **Gary Ivany,** Canadian Coast Guard

Hull coatings

As with the Swedish and BAS ships, hull coatings are a major issue and the Canadians are also using Inerta but moving into cold application coatings to cope with the cold and damp weather in which the vessels operate.

"Structurally, though, we have minimal problems as the vessels were very well built in the first place, despite their age," claims Ivany. "But with the propulsion systems, getting technical support for analog propulsion control systems is a challenge. It may have been cutting-edge technology when the vessels were built but, for example, the cycloconverters on our AC electric-driven vessels are about the size of an average living room – the latest digital technology fits it into something not much bigger than a suitcase!"

Another feature of the Canadian vessels is the active bubbling systems for hull lubrication in ice, where constant streams of air bubbles are blown out through holes in the side of the hull to help keep the hull clear of ice. "This needs a lot of maintenance because of age and erosion," says Ivany. "You can get between 10% and 20% erosion every year. And if that erosion is inside the void spaces or tanks, then it's really a dry-docking job. With the age of the vessels these issues are becoming a higher priority. But if in the short term Ivany and his Coast Guard colleagues have their hands full with some tough problems, they can at least look forward to the different challenges of commissioning a new polar icebreaker that is expected to enter service in 2017 or 2018. "It will be bigger than any of our existing fleet and is currently being designed. The plan is to station it permanently in the Arctic and only bring it south for maintenance every two years."

First real icebreaker

Essentially though, until the 19th-century, boat design focused more on resisting and avoiding damage from 'nipping' (where the boat is trapped by the ice) rather than smashing its way through. The first vessel built specifically for icebreaking duties was a 51m (167ft) wooden paddle steamer, City Ice Boat No 1, built for the city of Philadelphia by Vandusen & Birelyn in 1837. The ship's wooden paddles, powered by two 250hp steam engines, were reinforced with iron coverings. The first European steam-powered (and first ever metal-hulled) icebreaker was the Russian Pilot. With a rounded hull shape that enabled the Pilot to ride up on top of the ice, a bow altered to clear the ice and more power than was usual for its size, the vessel had all the three main design elements to qualify as an icebreaker. Built in 1864 on the orders of merchant and shipbuilder Mikhail Britnev, it was used between then and 1890 for navigation in the Gulf of Finland between Kronstadt and Oranienbaum, thereby extending the summer navigation season by several weeks.

Even now, almost 150 years after the Pilot was built, the ability to ride up and use its own weight to break the ice, and then clear that ice along the sides of the hull are still what is looked for in an icebreaker. But supplement that with vastly more power (whether that be nuclear, gas turbine or diesel-electric), technology such as shielded propellers, both fore and aft – in thick ice the vessel will proceed by charging the ice again and again – and ballast tanks and water pumps so that it can be rocked from side to side if it gets nipped, and you have the essence of the modern icebreaker. \\