Making eco-friendly waves

Building high-performance boats requires strong materials. Typically, stainless steel is not even under consideration for ship construction, but that may be changing. In fact, governments and businesses the world over are starting to take an interest in a new, low-maintenance and environmentally friendly ship hull, built entirely from high-strength, molybdenum-containing super- and hyper-duplex stainless steel.

Depending on their size and purpose, ships are most commonly made of steel, aluminum or fiber reinforced plastic (FRP). No matter what, ships are generally expensive to keep because they are constantly exposed to water and humidity, which will break down nearly any construction material over time. Steel ships are strong and tough, but steel is heavy and requires corrosion protection and a lot of maintenance. Aluminum is light, but it is very soft, dents easily, has serious fatigue cracking problems, and corrosion is a concern. Carbon fiber reinforced plastic is very light, but it is expensive, can crack when it hits a rock, and can even go up in flames when there is a fire on board. It is also not recyclable at its end of life. Hence, the time is ripe for a better, more sustainable solution.

Keeping sea life at bay

Among the most important design aspects for the performance of a boat are its weight and its hull surface quality. Reducing its weight improves its agility, top speed and fuel consumption. However, if the surface is rough, there is more drag in the water, which slows a ship down and increases fuel consumption. Furthermore, barnacles, seaweed and other marine organisms readily attach to most surfaces submerged in seawater. This process is called “fouling” and it makes the surface bumpy and rough, creating more resistance.

To minimize marine growth, the ship hull under the water line is treated with biocide paint. These paints can be extremely toxic, not only to the target-organisms, but also to aquatic life in general. Even with such treatment, marine growth is only slowed, not eliminated, so it has to be removed by divers to keep it in check. For commercial ships that may be a monthly chore. Anti-fouling paint itself must also be reapplied at least every few years, as it is consumed over time loosing its effectiveness. This takes a ship out of the water, and with that, out of commission. But now, ships built with specialty stainless steel offer an alternative solution.

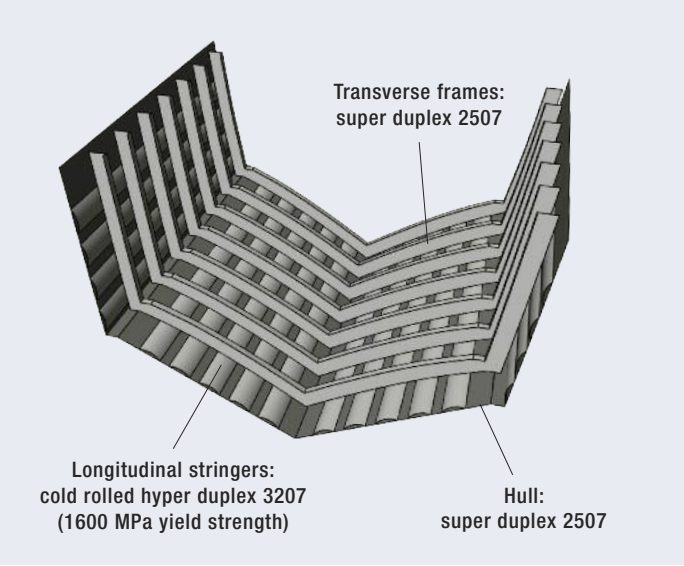
Lighter, faster, stronger

Realizing the dream of building a lighter, faster and stronger vessel, entirely from stainless steel wasn’t plain sailing for the entrepreneurs Håkan, Petra, and Alistair Rosén of SSY. Traditional stainless steels, such as austenitic Types 304 or 316, are not sufficiently corrosion-resistant in seawater. And while they are quite tough, they are not that strong. However, when the entrepreneurs discovered the far superior properties of super and hyper-duplex stainless steels, in particular their great combination of high-strength and outstanding corrosion resistance, a seed was planted. With a stainless steel that is up to three times stronger than the carbon steel traditionally used for shipbuilding, it

would be possible to significantly reduce the thickness of the hull, and with that, the weight of the whole ship. But the problem is that thin sheet, no matter how strong it is, buckles easily under wave load when used in normal ship design.

To solve this problem, inspiration finally came from studying the shipbuilding techniques of the seafaring Vikings – over a thousand years ago – and their efficient, strong and flexible wooden hulls. Using a similar design approach in stainless steel resulted in a construction that is both strong and light. The boat glides effortlessly through the water, is very fuel-efficient, and will survive a major impact without springing a leak or losing its structural integrity.

The ductility and energy-absorbing properties of duplex stainless steel even give the hull good anti-ballistic properties, ensuring it deforms to absorb a potential impact without rupturing. Military and law enforcement organizations have shown interest in the vessel due to its enhanced protection against bullets and explosives.

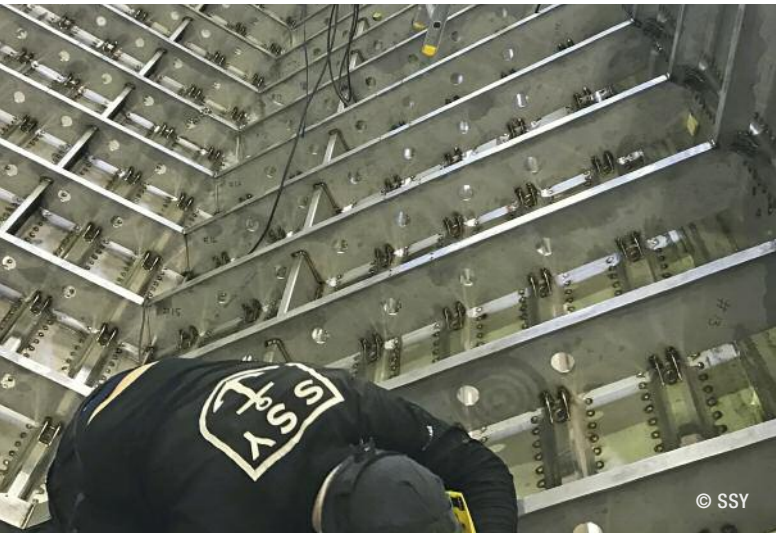


The stringers are spot welded to the hull plates. The frames, welded to the stringers, are not in direct contact with the hull. The flexibility of the stringers allows them to absorb the wave force preventing the hull from bucking.

Corrosion resistant in high seas

While light-weighting was a primary driver for using advanced duplex stainless steels, a further advantage was their ability to resist the severely corrosive nature of seawater without any protective coating. Both duplex stainless steel alloys used in the design contain more than the 2% molybdenum found in Type 316 stainless steel. SAF 2507 super-duplex includes around 4% molybdenum, while SAF 3207 hyper-duplex contains around 3.5%.

These levels of molybdenum significantly increase the corrosion resistance of stainless steel, making it ideal for handling the high-chloride salt levels found in seawater over a prolonged period. Such steels already have a proven track record in offshore oil and gas exploration as well as hydraulic and instrumentation applications in tropical marine environments.

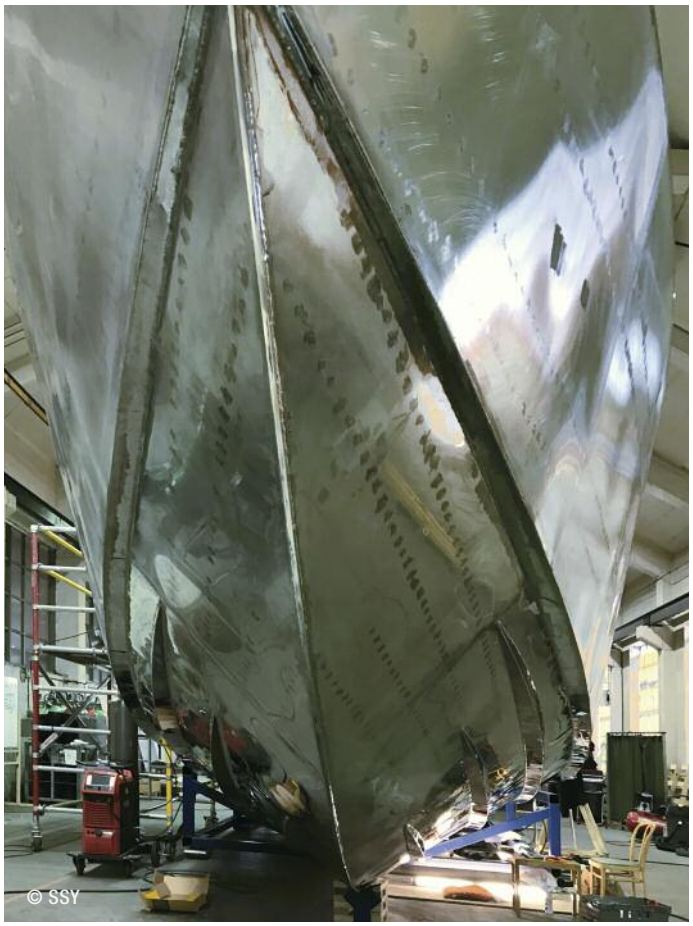


Welding of the interior structure of a ship.

Efficient and eco-friendly

High-strength stainless steel also contributes much to the fuel efficiency of these vessels. Increased strength means that the amount of material required is considerably less than traditional boat construction. For example, high-speed stainless steel patrol vessels that are 15 to 25 meters in length require stainless steel sheets that are between two and three millimeters thick. This is one third to one fifth the thickness of the steel used in a traditional ship. Overall, these agile vessels weigh about 50 % less than a similar carbon steel vessel. Surprisingly, they are also lighter than boats made from aluminum and even what is usually considered the lightest material – carbon fiber reinforced plastic.

Additionally, the hull's mirror-polished finish minimizes drag and friction, which also affords fuel efficiency and reduced emissions as well as greater speed and agility. Moreover, the performance does not deteriorate over time, because the hull is so smooth, it makes it difficult for any performance-reducing marine growth such as barnacles to hold onto the surface. Avoiding the monthly removal of fouling by divers and reapplication of the toxic anti-fouling paint every five to seven years leads to significant operating cost savings.



Stainless steel hull of a prototype at the ship yard before mirror-polishing under the waterline and painting above it.

Besides the direct cost of such maintenance, the ship is not generating any revenue while sitting in a harbor or on a dry dock to apply the paint.

Because super-duplex stainless steel does not corrode, it also will not have to be repaired to replace deteriorated panels. And at the end of its life, stainless steel is completely recyclable. All these benefits add up to huge cost savings over the life of a ship, but maybe more importantly, they significantly reduce emissions and eliminate the impact of biocides on marine life.

Overcoming the welding challenge

Joining the thin-walled super and hyper-duplex stainless steels with corrosion-resistant, high-integrity welds is part of the core strength of the boat design. SSY worked in partnership with stainless steel producers, a welding supply and an industrial gas company, to develop the specialized welding techniques. The welds have proved to be as strong as the stainless steel sheets and stringers, and the team has been delighted with the consistency and quality of the results. Thanks to the lightweight, optimized design and the efficient welding technique, these stainless steel boats cost around the same as traditional aluminum, steel, or composite boats. In the future, with higher production volumes, stainless steel vessels will cost even less than those made of traditional building materials.

Bigger and Better Applications

The first 10.8-meter prototype, Elvira, successfully set sail on its maiden voyage in 2014. This revolutionary approach to boat design marked the beginning of a new era of faster, lighter and more agile boats. Two more prototypes, xxx and 17.5 meters in length, followed the first vessel, with plans to build another six in the near future. These boats will be displayed at shows and events in the U.S., Europe and elsewhere.

There are numerous other opportunities for marine applications that can benefit from the durable, lightweight design developed by the company. Static floating hulls for solar and wave power generation are among them. The first wave power prototype of a super-duplex stainless steel hull for a Swedish power company is currently being tested. It has been suggested that eventually around 100 of these huge 85-meter floating structures will be used in a single location. By building the hulls out of super-duplex stainless steel, they can remain in the water without any maintenance for the target lifespan of 50 years and beyond.

Other potential applications include the building of much larger ships such as super and mega yachts of more than 100 meters in length. Even bigger ambitions will see the development of giant vessels such as container ships and cruise liners. Reducing the drag and the weight of these vessels using mirror polished, molybdenum-containing super-duplex stainless steel offers a considerable opportunity to reduce fuel consumption and, more importantly, pollution. It has been estimated that one container ship – the length of six football pitches – produces up to 5,000 tons of sulfur each year – the equivalent of 50 million cars. Calculations show that duplex-stainless steel hulls could reduce fuel consumption and emissions by an estimated 20%.

Whether producing a patrolling vessel or luxury liner, the benefits of using molybdenum-containing super-duplex stainless steel are evident. Lightweight ships with an exceptionally smooth hull surface, have considerably lower fuel consumption than traditional ships while maintaining their essential integrity and strength. At the same time, there is no need for regular maintenance cleaning and repainting of the hull with toxic anti-fouling treatment. This adds up to significant operating cost savings as well as much reduced environmental impact. With those benefits, the opportunities for super-duplex stainless steel structures in marine applications are limitless. (XX)