Shall we ever see a foiling cruising yacht?

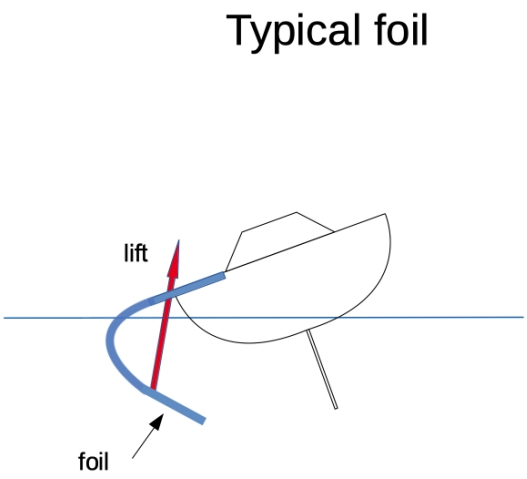
Kim Klaka June 2019

Have you ever wondered how new ideas find their way into yacht design? I recall advice given to me in the late 1960s by an old marine engineer who owned a long-keeled cruiser-racing yacht. It was on the hardstand next to what was then a radical new design – an S&S34. Knowing that I was a budding yacht designer, he pointed to the S&S34's separate fin keel and said: "see that? It's unsound engineering to hang a lump of lead off the bottom of a plastic hull. It'll never catch on". How wrong he was in hindsight, but why? I believe it is because engineering on its own can often constrain ideas, but when the idea is turned into a design, the engineer has little option but to "sort it out so that it works". And there lies the happy marriage between engineering and design.
Now consider the typical trickle-down effect of a new design development:

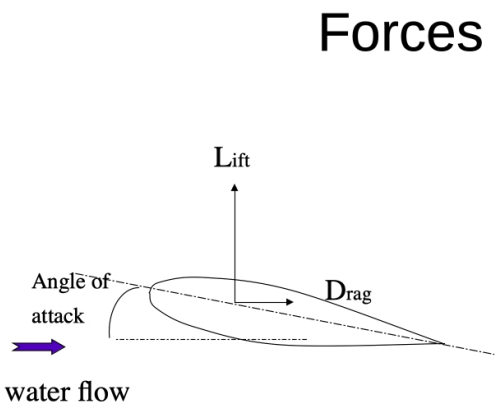
- ➔ specialised craft (America's Cup etc.)
- ➔ high performance racers
- ➔ standard racer/cruiser
- ➔ cruising yacht.

This is more or less the path followed by developments such as fin keels, asymmetric spinnakers, and bowsprit prodders. Roller furling headsails went straight from specialised short-handed racers to cruisers, skipping the high performance fully crewed racers, as did the winged keel. But the general path is common. There is a further step, where developments that trickle down through fashion rather than function can bounce back e.g. the popularity of winged keels on cruising yachts diminished once people realised its advantage over bulb keels was only for a very narrow set of circumstances.
So where are we up to with foils? Specialised foil-supported yachts have been around since the late 1960s but they did not trickle down to high performance racers until the last 5 years or so (they have been around in dinghies for longer). The introduction last year of the 10m Figaro Beneteau 3 foil-assisted short-handed offshore racer has been a paradigm shift. This is a full ocean going EU Category A yacht that has to be sailed on overnight passages in all weathers, manoeuvre in and out of marina berths and is generally capable of doing the things that many cruising yachts have to do. The foils stick out of the sides and are C-shaped, retractable when coming into harbour so they fit snugly against the hull at around the maximum beam position. Not very convenient for cruising, but workable.
Then there is the Dynamic Stability System (DSS) invented 10 years ago. This is a horizontal foil that sticks out from the leeward side of the hull just below the waterline. It can be slid across to the other side when tacking, inside a cassette that lies under the cabin sole. Again, not very cruisey but workable. People probably had similar reservations about centreboards when they were first used in cruising yachts.
In order to work out whether we are likely to see foils on cruising yachts it is helpful to examine the way a foil works, why they have not been seen on racing yachts until recently, and whether their advantages for racing yachts are applicable to cruising yachts.

How do foils work?



What is a foil trying to do? It is designed to either increase the sail carrying power (righting moment), or lift the hull partially out of the water, or a bit of both. This requires the foil to generate lift force.



In order to work out whether foils are likely to work on a cruising yacht we need to understand the relationships between the forces created by the foil, the speed of the boat, and the weight of the boat. The foil generates a vertical force called lift, just like an aeroplane wing does in order to keep it in the air. The amount of lift generated depends on the angle of the foil to the flow, the area of the foil, the speed of flow over the foil, and the shape of the foil. The most important of these factors is

the flow speed because the lift increases with the square of the flow speed – if you increase the flow speed by 20 %, the lift increases by 40%. In contrast, if you increase the foil area by 20% then the lift increases by only 20% i.e. that is only a linear relationship, not a square one.
There is an almost inescapable consequence of creating lift: you generate drag. This type of drag is unimaginatively called induced drag, because it is induced by the creation of lift. The induced drag varies with lift squared e.g. if you double the lift you end up with four times the induced drag.
How much lift do we need to generate? In order to lift the hull out of the water, the foil has to generate enough lift to support the entire weight of the boat. And in order to provide useful righting moment it has to do as much stability work as the lead keel.
If you pick out the important points from the above explanation, they are:

- the lighter the boat, the less lift required, and the less drag created.
- the faster the boat, the more lift is created.

And that is more or less all the theory we need to know in order to work out whether we will see foils on cruising boats.

Increase the righting moment

Why do we want to do this? Increasing sail carrying power has an obvious advantage of greater speed and stability. It is achieved by angling the foil to the water such that the generated lift is opposing the heeling force from the sails. This is not a new idea, not even in cruising boats. In 1980 the young Southampton naval architect Malcolm Barnsley (designer of world sailing speed record holder Sail Rocket 2), designed and built a 5.5m foiling trimaran in which he cruised the south coast of England. It was, however, rather small and specialised, and it was not until recently that foil stability has become popular in racing yachts. Good ideas can take time to evolve! The main reason for the slow adoption of foil-assisted stability is that basic law of foil theory – the lighter the boat , the less lift required. Hull designs had to become lighter (carbon fibre etc.) and hence faster, before foils could become effective.

Lift the hull

Lifting the hull out of the water gets rid of almost all the wave-making drag and a lot of friction drag, which together amount to most of the drag of a normal yacht hull.
As racing boats have become lighter, due mainly to the application of new materials like carbon fibre, the foil doesn't have to produce so much lift, therefore it can be smaller and also have less drag. Then the boat will travel faster, so the foil can be even smaller, so less drag again. So it will go faster, so the foil can be smaller etc. i.e. once you have a boat that is light enough, the foils suddenly become an efficient design option.
It follows that, for foils to be a design option for a cruising boat, the boat has to be light and quite fast. It is noteworthy that the foiling Figaro 3 is 10m long but weighs less than 3 tonnes; that is why the foils can work. This is not the design space where most existing cruising yachts sit, but you may have noticed it is quite a good description of a modern high performance cruising catamaran. That is where we are starting to see foils being fitted e.g. the Gunboat designs. We are likely to see a foiling production monohull cruiser within the next three years (the Bavenneau Dreamliner?). After that, there is the strong possibility that foils will trickle further down the design chain, as fashion mimics the fast boats. Then the marketing and sales team get on the bandwagon and away you go – foils everywhere!
After a while, the cruising community will realise this trickle-down effect has been pushed a bit too far, and we will only see foils on the lighter cruising yachts.
What about the other, practical obstacles? How can you bring a foil boat alongside a harbour wall? What about the intrusion into the cabin space? And the extra complexity of moving them in and out or up and down? And their apparent fragility in a seaway? All these factors are challenging, but the ingenuity of yacht designers and the resourcefulness of engineers will doubtless overcome them to a greater or lesser extent.