Geek **Hub**

An ancient invention suddenly undergoes a renaissance.

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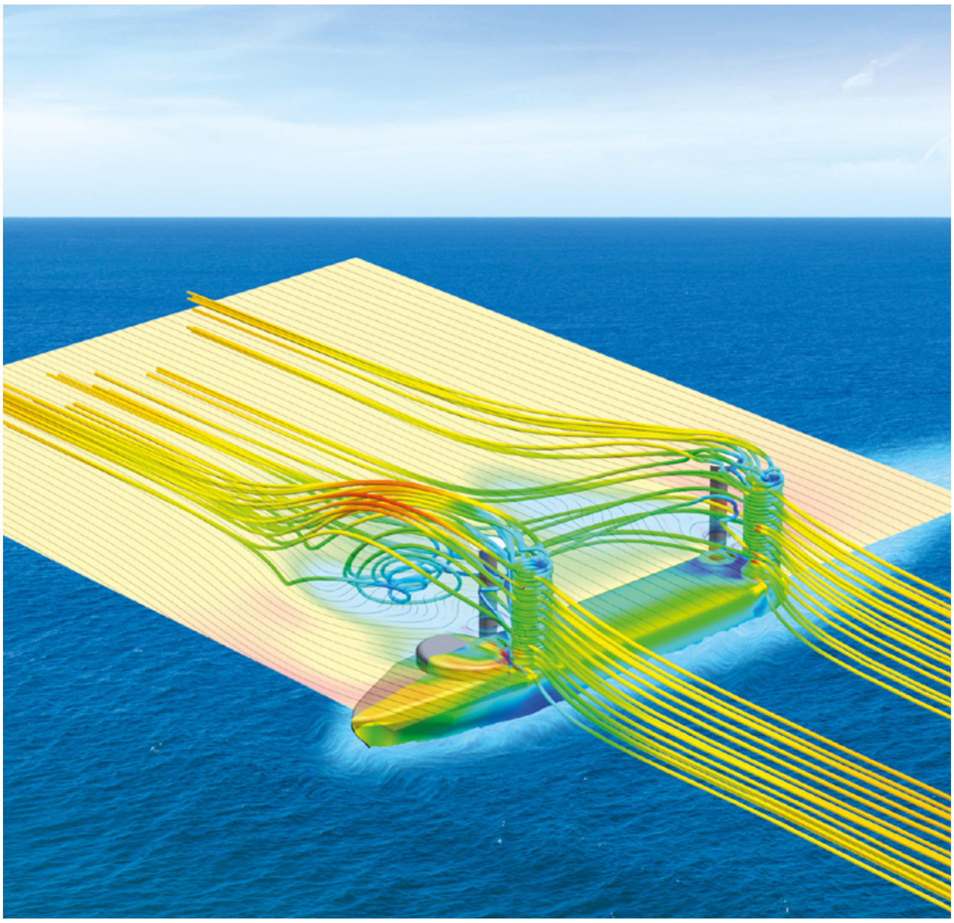
About 15 years ago, I became aware of the Flettner rotor in a book about "forgotten inventions". Anton Flettner invented a rotor ship, equipped with the rotors named after him. The rotors use the Magnus effect, named after Heinrich Gustav Magnus. Two ships were built in the 1920s, the Buckau, renamed Baden-Baden, even sailed from Germany to America and back.

The second ship, the Barbara, was equipped with two diesel engines and three rotors and has been used as a commercial freighter in the Mediterranean. With wind force 5, it ran at 13.5 kn operating with diesel engines (which powered the ship propeller) and rotors simultaneously. Without operating the rotors, running with the diesel engines only, it ran at 10 kn. Using the rotors only, without diesel engines, it was almost as fast at 9.5 kn. This means the rotors were able to achieve almost the same ship velocity as the diesel engines. In the single rotor operating condition, the Barbara gained almost the same speed as the single diesel engine operating condition [1]. The economic crisis, cheap oil and the increasing performance of the diesel engines, with which these kind of sails could no longer compete, unfortunately sealed the end of this technology in the 1930s [1].



A few years ago, as a young application engineer, I tried to reproduce this effect, but I did not succeed in successfully simulating this effect. A couple of months ago, my colleague, Jim Petroski, drew my attention to this technology again, because it has again been fulfilled and applied in today's shipping industry [2, 3]. In the meantime, rotating capabilities were developed for FloEFD. Therefore, it is also time for me to pick up this example again.

The Magnus force, which is the main influencing factor, can be simulated in FloEFD. Figure 1a shows a rotating cylinder.

A rotating, round object in an airstream experiences a force transverse to the flow direction. This is illustrated in Figure 1a by the blue low pressure area above the cylinder.

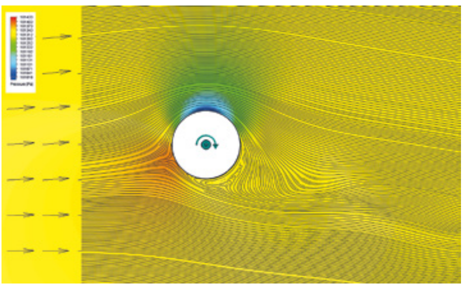


Figure 1a. Rotating cylinder

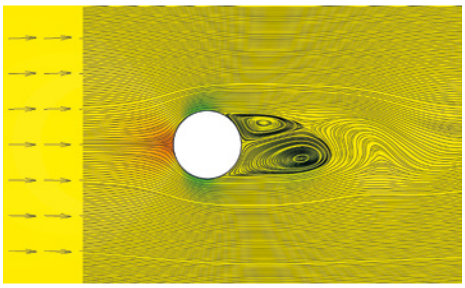


Figure 1b. Stationary cylinder

The modern application of the Flettner rotor offers one main advantage. A rotating cylinder produces a force transversely to the air flow direction through the Magnus effect of suction and compression forces. The forces of the rotors are generated by the rotation and act transversely to the wind direction. Hence, they do not generate any savings in situations where the resulting wind direction is directly from the front or from behind, comparable to sailing “in irons” or “running with the wind”. The greatest advantages can thus be achieved when the wind comes from the side. The speed of the rotor must be adapted to the wind speed. At higher wind speeds, the rotor speed is also increased so that high drive energy is also to be provided for the rotors at high wind energy. Modern measuring and control systems allow an efficient adjustment of the rotational speed and direction of rotation and therefore make this technology interesting again in terms of fuel savings.

A simplified example of a vessel equipped with the four shown rotors was used and the forces of the air flow only, are considered. The water forces were neglected for this comparison. The ambient velocity for the simulation is the resultant of the wind speed and the forward movement of the ship.

The goal was to reproduce the influence of the Magnus effect and to visualize it. Even if only qualitative results can be shown, the effect can be illustrated visually. This example is based on a generic, simplified model of a vessel, so there are no real drag coefficients here.

Figure 4 shows the vessel example and the resulting air velocity directions for the study. The air speed is 20 kn, from several directions between 20° and 160°. The height of the rotors is 20m with a diameter of 4m. The rotating speed of the rotors is 100 RPM for the four rotors. A parametric study was applied in FloEFD.

Figure 5 shows a qualitative comparison of the vessel example. As can be seen in the diagram, the resulting drag force on the ships body is less on rotating rotors. Less drag force means a lower fuel consumption, which saves money and protects the environment.

As expected, the highest reduction in the drag force is achieved at approximately 90°. It is not exactly at 90° due to the influence of the vessels shape, which also corresponds to the available public information [4].

Of course, it is also necessary to consider the weight of the vehicle, the maintenance, the control technology, the possibly lost freight capacity etc. in order to be able to evaluate the savings. According to public operators‘ information, the fuel savings are estimated to be about 25% due to the use of Flettner rotors. Considering the high utilization rates in shipping industry, it is certainly an attractive and environmentally friendly measure. Maybe we will see similar approaches in future for ferries and cruise liners.

Further approaches to fuel economy can be found on the Internet, e.g. Container ships with sails or the Vidskip [5], Many opportunities for further geek hub studies…

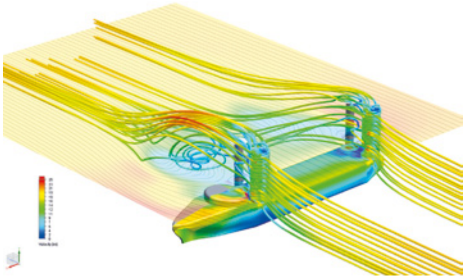


Figure 2. Vessel simulation with FloEFD

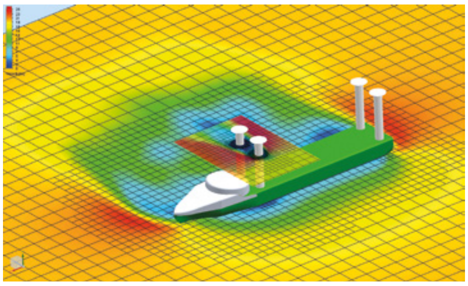


Figure 3. Vessel simulation with FloEFD

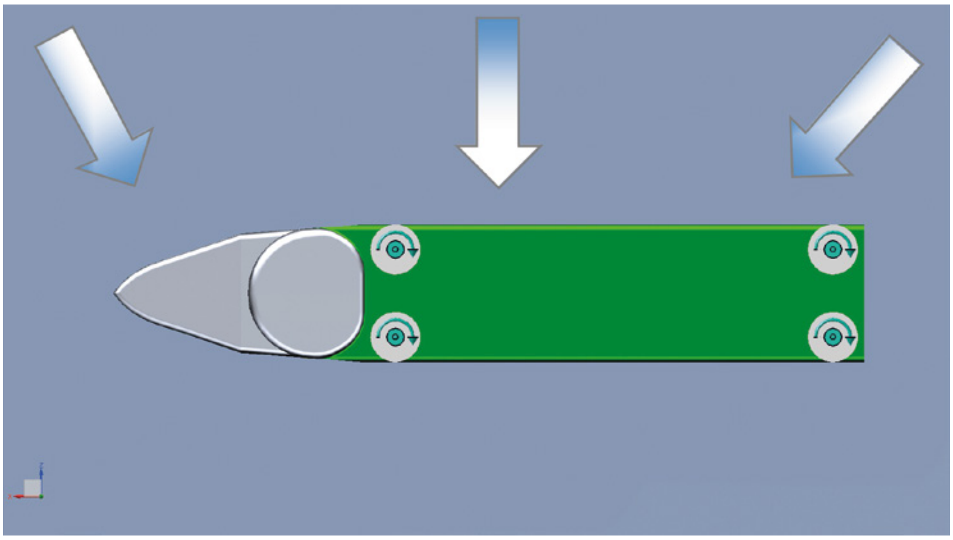


Figure 4. Vessel example with resulting air directions

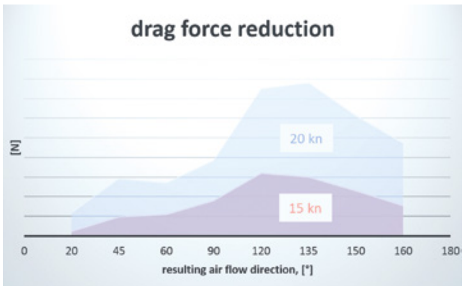


Figure 5. Drag force reduction

References

[1] Christian Maehr, „Vergessene Erfindungen: Warum fährt die Natronlok nicht mehr?“, DuMont 2002, ISBN 3-8321-7816-3

[2] https://www.youtube.com/watch?v=kDyBrSW1_Og

[3] https://www.youtube.com/watch?v=2pQga7jxAyc

[4] https://www.youtube.com/watch?v=aQXp75Qt99M

[5] http://www.ladeas.no/
http://www.auerbach-schifffahrt.de/
http://go.mentor.com/4NmtM