Shark skin used for minimizing drag forces

Thomas Smitshuysen og Emil Jensen
B.Sc Physics and Nanothechnology
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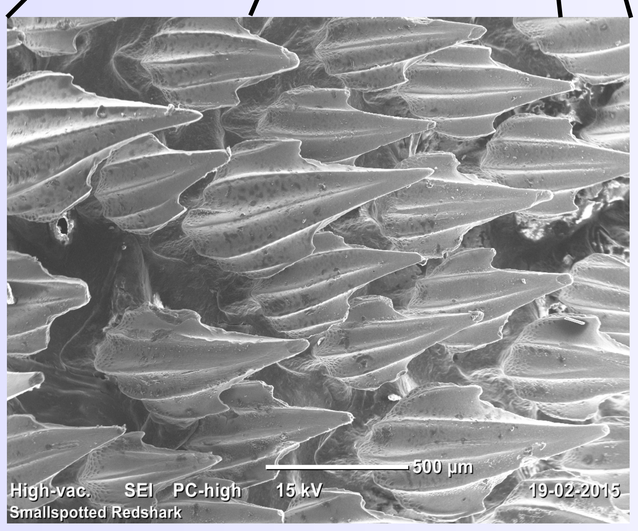
Why is shark skin interesting?

Looking at a shark makes it seem it is all smooth, but fact is that all over its body, it has tiny little skin denticles. Gliding your hands over the skin reveals this, as it actually has a very rough surface. But why is this? As it turns out these tiny denticles, that can hardly be seen by the naked eye, help the shark use less energy when it swims!

The goal is to implement artificially made surfaces with these properties. Scientists of Beihang University in Beijing (China)* have succeeded in creating surfaces that reduce the drag of up to 24.6%! If this type of surface could be on every cargo ship and airplane it would have a tramendous impact on fuel consumption in the world.

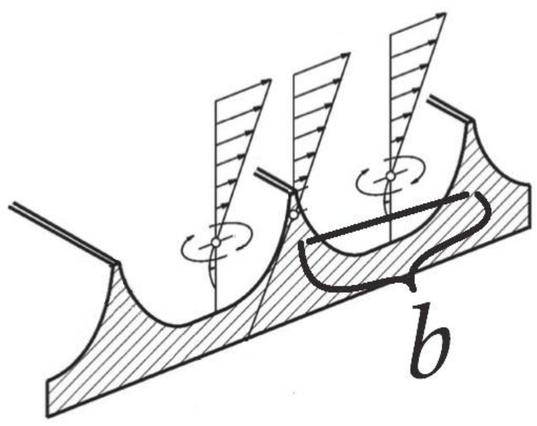


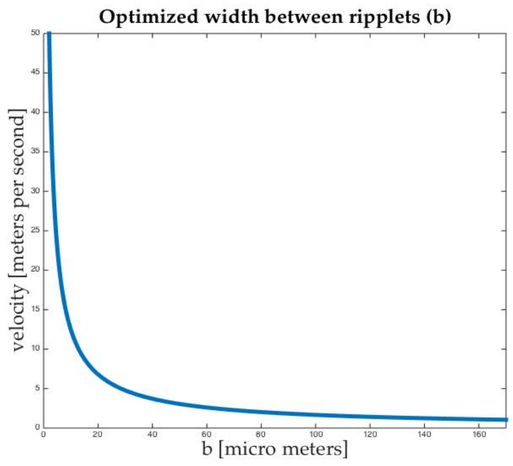
*On world wide scale, the fuel consumption caused by container ships of medium to large size is about 150-250 tons per day. If shark skin like surfaces could be implemented properly on ships, a 24.6 % drag reduction would save up to roughly 16 billion kr per year and 600'000 tons of CO2 per year on container shipping alone***

What have we worked on?

In our physics project, we have worked towards a finer understanding of how these skin denticles work with the flow around them. In doing so we have used a clever type of technology; Micro Particle Image Velocimetry Analysis. Or uPIV for short. The idea is to send a fluid containing small beads over the skin and track it with a camera. The analysis of the pictures can then give us a velocity vector field of the flow over the skin.

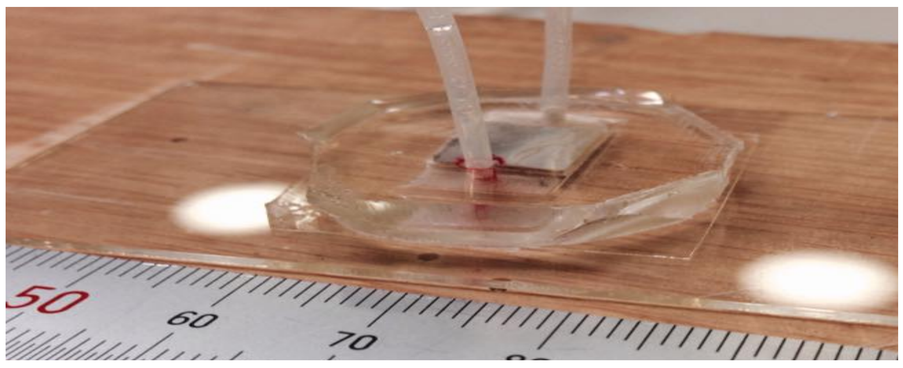
The results have shown that the rotation of fluid over the skin surface, is a huge factor in the flow dynamics. These rotations change with the dimensions of the skin. It has been shown that the width(b) and the height of the riplets correlates with the drag reduction. The drag reduction also changes with the speeds, and different widths and heights gives different optimized speeds. This is why, shark skin look so different between species.





The flowchambers used

The uPIV analysis forced us to produce a unique flow chamber just for the purpose of examining one 1x1 cm shark skin sample at the time. These flow chambers were finally produced in PDMS, by pouring it in its liquid form over a 3D-printed model and waiting forit to harden.



How come this is not on all ships and vehicles yet?

As much as we would like to produce this type of surface ourselves, this technology is still in its preprototype state. One thing is figuring out what kind of a surface works for reducing drag forces. A whole other thing is to be able to fabricate it and make it tough enough to last, while not being costly.

As it is known from the behavior of sharks and from experiments, different kinds of surfaces give totally different kinds of flow. Firstly we would have to conduct thorough research of the different kinds of shark skins and possible surfaces, so that an optimized surface for different kinds of movement could be found. Secondly we need to find a way to fabricate such a surface.

* ZHANG DeYuan, LI YuanYue, HAN Xing, LI Xiang and Chen HuaWei "High-precision bio-replication of synthetic drag reduction shark skin", *Chinese Sceince Bulletin*, 2011
doi: 10.1007/s11434-010-4163-7

** Calculations based on followiing assumptions: Diesel price is 4.5 kr/kg, there is usually 10,000 medium to large cargo ships in the world, all sailing 70% of the time. Furthermore it is assumed that a common diesel engine runs with a 25% efficiency.