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# Super fluent pipes
## Shark skin for drag reduction

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## Motivation

Drinking water network is very extensive and consists of around 130.000 km of water mains in the Netherlands. The resistance in the water network can be the result of a (relatively) high wall roughness and obstacles in the network; e.g. valves, hydrant, bends, crossings. In addition, the higher the resistance in a pipe, or in the water network in general, the more likely microbial growth will occur. The microbial growth or biofouling decreases the water quality.

Water companies in the Netherlands use pumps to overcome this resistance and to supply drinking water with enough pressure to all customers. By reducing the resistance, pipes with smaller diameters but higher flow velocities could deliver the same volume flow rate demanded by all customers. This is beneficial not only for energy efficiency and impeding the microbial growth, but also manufacturing and maintenance costs of the pipes as well.

Therefore, the motivation of this research project is to develop a very low resistance water transport system. The main benefits gained from this would be saving energy by lowering the required pumping power.

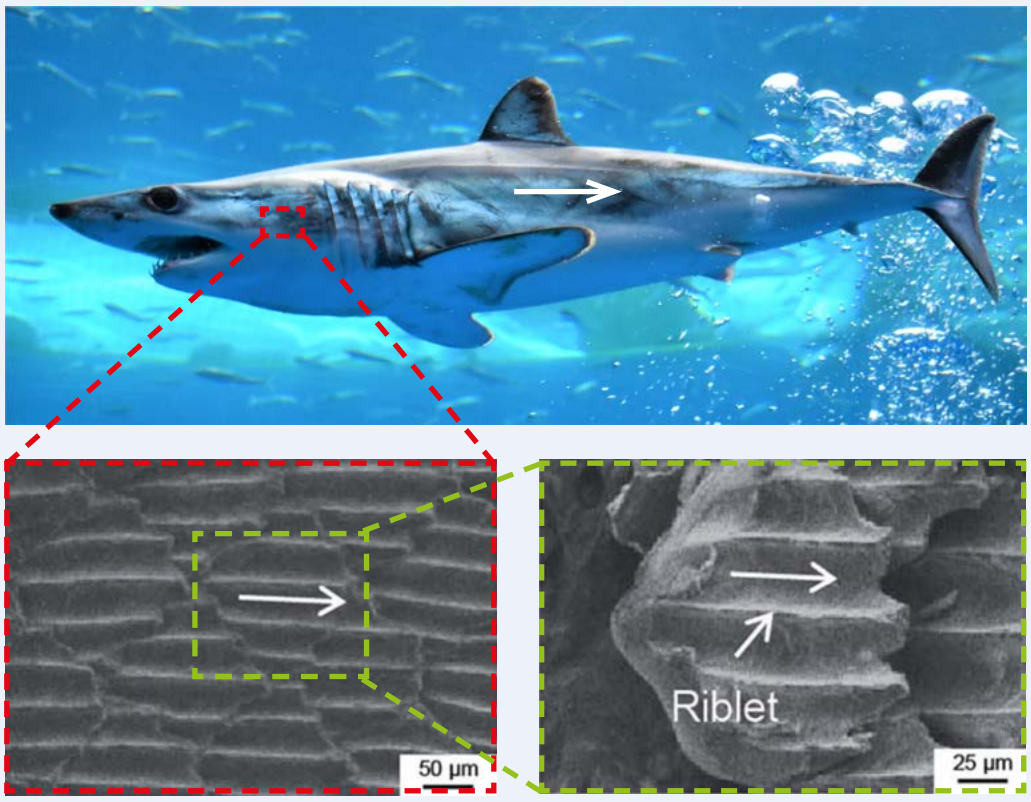


*Figure 2. (Top) Digital photo of a Shortfin Mako Shark. Adapted from www.wikipedia.org/Shortfin_mako_shark. (Bottom) scanning electron microscope (SEM) images of shark skin at two magnifications. Adapted and modified with permission [3]. The riblet structures on the skin of fast swimming sharks reduce skin friction drag in the turbulent flow regime allowing them to swim faster.*

## Technological challenge

Introducing a solution for lowering flow resistance which is cost effective, nontoxic, and durable is the main technological challenge. One way to overcome this challenge is to fabricate shark skin inspired riblets on the inner wall of the pipes.

Riblets lead to drag reduction by both impeding the translation and lifting the streamwise vortices (Figure 1) [1]. The riblet structures on the skin of fast swimming sharks reduce skin friction drag in the turbulent flow regime allowing them to swim faster (Figure 2).

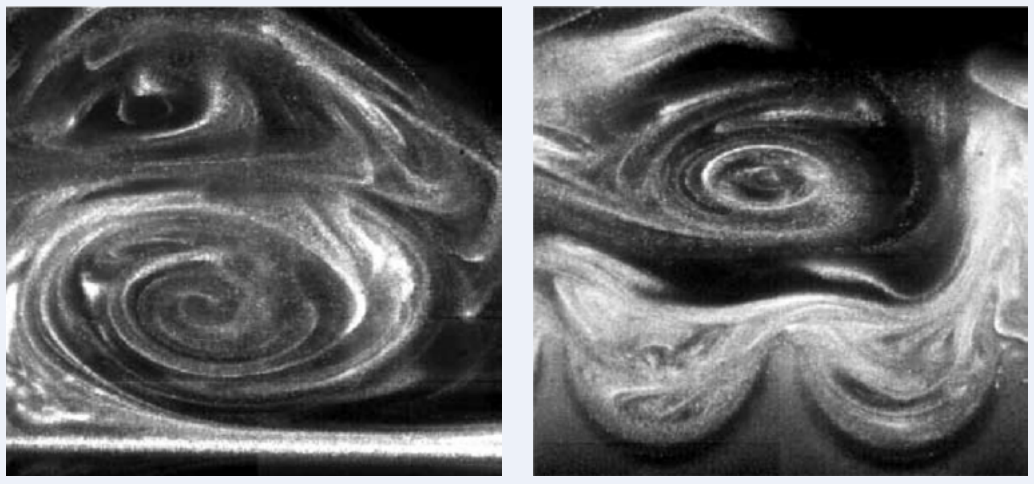

*Figure 1. Flow visualization images of streamwise vortices in the vertical cross-section on: (left) flat plate, (right) riblet surface [2].*

## Research goals

To develop a fundamental understanding of, and engineering design strategy for, the interior surface of a pipeline to enable the reduction of energy losses in water transport systems is the objective of this research.

1. The research goals of the project are to:
2. Understand the relation between flow, pipe resistance, and surface design.
3. Develop an analytical or numerical model, or extend an existing model, to analyze the role of surface topography on drag reduction in pipelines.
4. Fabricate the patterns on surfaces and pipes with suitable texturing procedure or production method.
5. Establish a test setup to quantitively measure and demonstrate the effect of modified surfaces.
6. Perform a parametric experimental study to uncover the optimum surface topography that drag reduction is maximum.

## References

[1] B. Dean , B. Bhushan , Philos. Trans. R. Soc. 2010, 368, 4775.
[2] S. J. Lee , S. H. Lee , Exp. Fluids 2001 , 30 , 153 .
[3] G. D. Bixler , B. Bhushan , Soft Matter 2012 , 8 , 1 1271

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