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THERAPEUTIC MAGAZINE

NAQI® Aero Speed Gel

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Cycling issue 3 2018

HYPOTHESIS: The hypothesis of the NAQI® Therapeutic Magazine is that the quality and the outcome of therapeutic care and sports performance will substantially increase if treatment is supported by skin therapy/care. The condition of the skin (ao scars, dry skin) can negatively influence therapeutic care and sports performance, even to a degree that skin care becomes a necessity before any other treatment.

EDITOR'S LETTER

Belgian innovation: NAQI® Aero Speed Gel

EDGARD M.GEYSKENS
Editor NAQI Foundation

During the last 15 years the cycling industry has invested enormously to optimize the aerodynamic aspect.

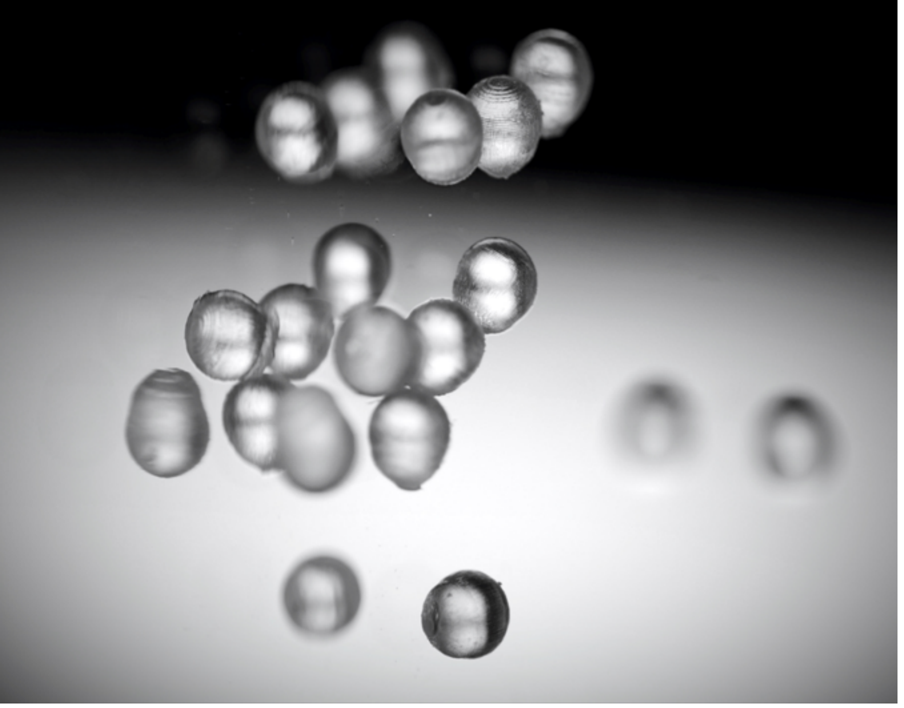
This resulted in the aerodynamic optimization of helmets, clothes (TT suits), shoes, wheels, frames and more. They all use similar technology to manipulate the air flow to reduce aerodynamic drag.

So while the both body and bicycle are aerodynamically fine-tuned to optimize the cycling experience and all of this driven technological innovation, one crucial aspect was overlooked, and that is the skin.

Mrs.Greet Claes, Head of R&D NAQI, has developed in collaboration with the inventor of the idea of the Aero Speed Gel, Mr. Bert Celis, coordinator Flanders' Bike Valley and Mr. Nikolaas Van Riet, PhD in aerodynamics, a carrier to reduce the aerodynamic drag of the cyclist. This innovation is completely in the line with the existent aerodynamic technology used in clothes, wheels, helmets and frames.

The NAQI® Aero Speed Gel is a topical application, specifically a special gel with small particles, which contribute to the total aerodynamics of the cyclist.

Herewith you will find the scientific evidence of the NAQI® Aero Speed Gel written by Mr. N. Van Riet & Mrs. G.Claes and the particle image velocimetry test performed by Mr.Harm Ubbens.



Picture 1 : 3 D-printed vortex generators

Picture 2 : Windtunnel test

Picture 3 : Measurement results

NAQI® AERO SPEED GEL INCREASES CYCLING SPEED BY LOWERING AERODYNAMIC DRAG IN CYCLISTS

Nikolaas Van Riet, Greet Claes***

** Cycling aerodynamics research & development consultant*

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Abstract - *An Aero Speed Gel, consisting of vortex generators in an oil gel, applied to arms and/or legs of a cyclist, is able to significantly lower the drag coefficient of a cyclist. At time trial speeds (50 km/h) this lowering of the drag coefficient leads to gains of up to 15 watt for a typical cyclist in time trial position. This translates to a potential gain of almost 1 second per km. For a triathlete tested at 39 km/h the potential gain was 307 seconds or a reduction in drag of 6%.*

Index Terms *- cycling aerodynamics, time trial, vortex generators*

I. INTRODUCTION

The importance of aerodynamics in cycling cannot be underestimated. In professional cycling speeds above 40 km/h are the norm. In time trial (TT) average speeds above 50 km/h are common. At 40 km/h 85% of the power of the cyclist used to combat the aerodynamic resistance, also known as drag. Rolling and mechanical resistance only accounts for 15%. At 50 km/h aerodynamic drag accounts for 90% of total power.

It must be clear that most potential in increasing a cyclists speed must be found in optimizing aerodynamic drag. The suits, shoes, bikes and helmets of a cyclist are already optimized for aerodynamic drag. The exposed skin is there for a potentially interesting area for aerodynamic optimization.

II. THE SCIENCE BEHIND AERODYNAMICS IN CYCLING

Aerodynamic drag [1]: As you cycle through the air, your bike and body need to push the air around you, This creates higher pressure in front of you and lower pressure behind you. Because of this, the air exerts a net force against you as you ride. There are a few things that dictate how much force the air exerts against you. The faster you ride, velocity V (m/s), the more force the air pushes and pulls you back. You and your bike present a certain frontal area A (m^2) to the air. The larger this frontal area, the more air you have to displace, and the larger the force the air pushes against you. This is why cyclists and bike manufacturers try hard to minimize frontal area in an aerodynamic position. The air density Rho (kg/m^3) is also important; the more dense the air, the more force it exerts on you.
Finally, there are other effects, like the smoothness of your clothing and the degree to which air flows laminarly rather than turbulently around you and your bike. Optimizing your aerodynamic positions also help with this. These other effects are captured in a dimensionless parameter called the drag coefficient, or Cd.

The formula for the aerodynamic drag acting on a cyclist, in metric units, is:

$$F_{drag}(N) = 0.5 \cdot Cd \cdot A \cdot Rho \cdot V^2$$

With A the frontal surface area of the cyclist in m^2, Rho the density of the air in kg/m^3, V the speed of the cyclist in m/s and Cd the drag coefficient. The power $P_{cyclist}$ (Watt) that must be provided to your bicycles wheels to overcome the total resistive force F_{resist} (N) while moving forward at velocity V is:

$$P_{cyclist} = F_{resist} \cdot V$$

with

$$F_{resist}(N) = F_{gravity} + F_{rolling} + F_{drag}.$$

F_{drag} is by far the dominant force in this equation. To give an example: For a typical rider of 70kg, with a bike weighing 7kg, a frontal area A of 0,0509m^2, a drag coefficient Cd of 0,63, on a 0% slope, with normal air density, and a cycling speed op 50km/h, we get: F_{drag}= 38N (527 Watt), $F_{rolling}$= 3,8N (53 W). Or stated differently at 50km/h, for a cyclist in normal position and conditions, almost 90% of the power he/she is producing goes to overcoming the air resistance.

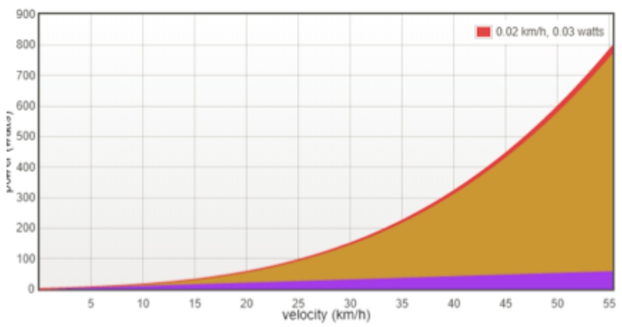

Figure 1 Power in function of velocity. Rolling resistance in purple, aerodynamic drag in orange and drivetrain losses in red. Picture by https://www.gribble.org/cycling/power_v_speed.html

III. AERO SPEED GEL CONCEPT

The NAQI Aero Speed Gel concept works similarly as the dimples in a golf ball. By roughening the surface of a round object, turbulence can be increased in the boundary layer. This increased turbulence causes the flow to become more resistant against separation. This resistance to separation makes the flow stick to the surface longer and thereby creating a smaller wake behind the object. This smaller wake translates into a smaller area of lower pressure behind the object and thus lower aerodynamic drag.

By adding vortex generators to a gel, that is applied to arms and/or legs of a cyclist, these special particles aid in the generation of turbulence in the boundary layers and therefor the postponement of flow separation behind the arms and/or legs of the cyclist. Figure 2 show the flow separation around a spherical object with two different separation points, marked by the red arrows.

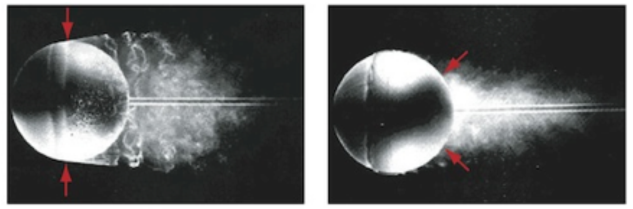

Figure 2 show the flow separation around a spherical object with early separation on the left and late separation on the right side. Source: https://plus.maths.org/content/fly-walks-round-football

IV. AREO SPEED GEL MEASUREMENT PHASE 1

All aerodynamic drag testing was done in the state-of-the-art low speed wind tunnel testing facility at Flanders' Bike Valley. Initial testing of the first prototypes was done on a cylinder wrapped with pig-skin. Second phase of testing was done on real cyclists.

A. Setup 1, Aero Speed Gel on pig-skin

To test a reference object that simulates a leg or arm of a cyclist, a cylinder was chosen with a diameter of 100mm. This cylinder was wrapped with the skin of a pig, because this closely resembles human skin. The goal of this test protocol was to optimize the carrier liquid and vortex generator inside the liquid.

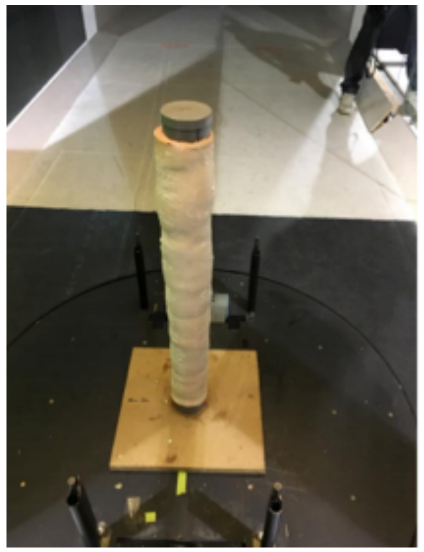

Figure 3 wrapped cylinder setup in wind tunnel

To see the effect of the air speed on the turbulence, it was chosen to test a four different air velocities, all correlated to relevant cycling speeds. Chosen wind tunnel air velocities: 10.4, 11.8, 13.3 and 14.8 m/s. This corresponds with cycling speeds of 37.5, 42.5, 47.9 and 53.3 km/h. Measured drag force on the cylinder were converted to watt for easier comparison.

Each measurement was repeated four times. Two times with a measurement time of 30 seconds, and two times with a measurement of 60 seconds. This was done to check the repeatability of the test setup. The difference between the four measurements was always below 0.1 N, which proves that the repeatability was excellent.

B. Measurement results

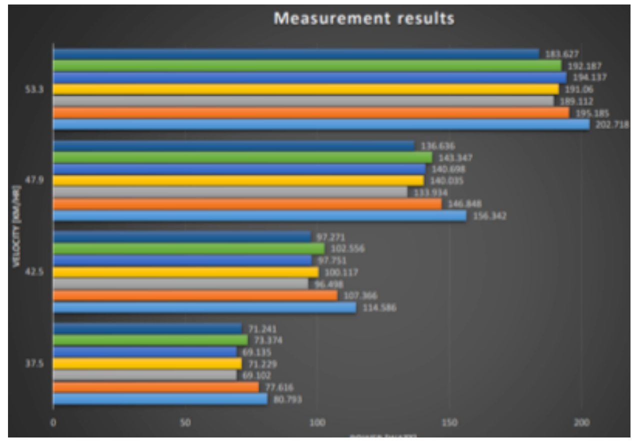

Figure 4 measured drag (in watt). Light blue gives baseline drag without NAQI aero speed gel. Other colors are the results different protypes with changing vortex generators inside the gel.

In figure 4 we can clearly see that all NAQI Aero Speed Gel prototypes show an improvement in comparison to the untreated baseline (light blue). The best performing vortex generators were chosen for the next testing phase.

V. IMPROVEMENT AERO SPEED GEL MEASUREMENT PHASE 2

A. Setup Aero Speed Gel testing on real athletes

The second testing phase was with real cyclists. It was chosen to test with a cyclist in TT position and clothing, with standard clothing a position for normal road cycling and with a triathlon suite on a triathlon bike. 5 athletes were used as test subjects. It was also chosen to test the gel on both the arms and the legs, depending on the specific clothing and discipline (TT, road, triathlon). For this testing phase it was chosen to only test at one air speed. The choses air speed chosen to be relevant for the specific discipline. The chosen air speed was 13.9 m/s or 50.0 km/h for TT position, 12.4m/s or 44.64 km/h for standard cycling position and 10.9m/s or 39.2 km/h for triathlon.

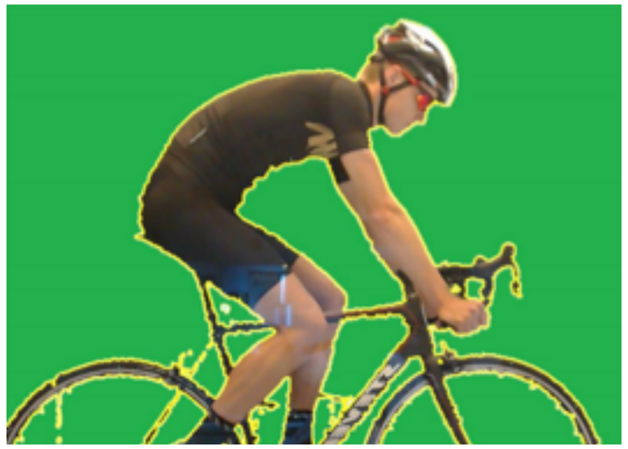

Figure 5 contour tracking to ensure exactly the same position is taken for every measurement

Because the position of the cyclist with different gels and without the gel has to been exactly the same, the repeatability was also checked by doing every measurement twice. Within a range of about 1.5 watt, the results correlated well. The position of the cyclist was checked and adjusted for every measurement to be exactly the same, by plotting the contours of the position of the reference measurements in front of the cyclist. This way he/she could check and adjust his/her position to exactly match that of the reference. See also Figure 5.

B. Measurement results

In TT position the average drag was 374.5 Watt, without NAQI Aero Speed gel and with gel the drag was 360.5 Watt. This gives a difference of 14 Watt at the chosen speed. Which corresponds with an reduction in drag close to 4%. The gain in time on a 9 km TT using this NAQI Aero Speed gel is 8.4 seconds or 46.6 seconds on a 50 km TT. Thus close to 1 second per km. This result was obtained by only applying NAQI Aero Speed Gel to the legs of the cyclist.

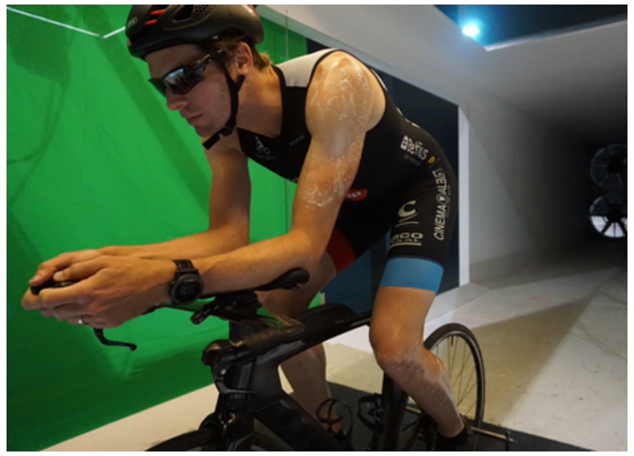

Figure 6 Cyclist in TT position in the wind tunnel

Similar tests were done on a triathlete and road cyclist in normal position and clothing. For the triathlete the average baseline drag was 235.5 watt. The drag with NAQI Aero Speed Gel on the arm/shoulder and legs was 222 watt. It might seem contradictory that applying the gel to both arms and legs instead of just legs, does not give rise to an extra reduction of drag. But remember that for the triathlete the testing was done at 39km/h instead of 50km/h.

Figure 7 triathlete in wind tunnel testing NAQI Aero Speed Gel on arms and legs

The average reduction in drag was 13.5 watt. This leads to a time saving of 307 seconds on the iron man distance. Or a reduction in drag of almost 6%.

For the standard road racing position and clothing baseline drag was 420.7 watt at 44.6 km/h. With the NAQI Aero Speed Gel on the legs the drag was reduced to 405.2 watt. Which again leads to a drag reduction of almost 4%.

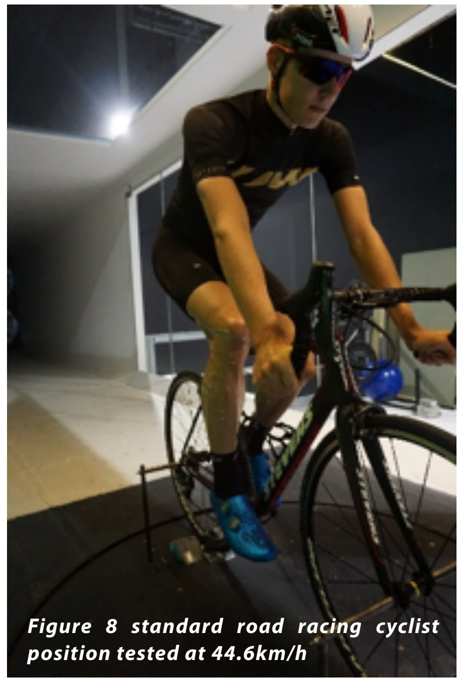

Figure 8 standard road racing cyclist position tested at 44.6km/h

VI. CONCLUSION

- *The NAQI® Aero Speed Gel* **uses vortex generators to enhance the turbulence** *in the boundary layer of the air flow across certain parts of a cyclist.*

- *This enhanced* **turbulences leads to later flow separation and** *a corresponding* **smaller wake and lower drag.**

- *Extensive* **wind tunnel testing showed a drag reduction** *of almost* **4%** *when* **used** *on* **only the legs** *of a cyclist.*

- *When* **also applied to the shoulder and arms** *of a triathlete a* **reduction in drag of almost 6%** *was obtainable.*

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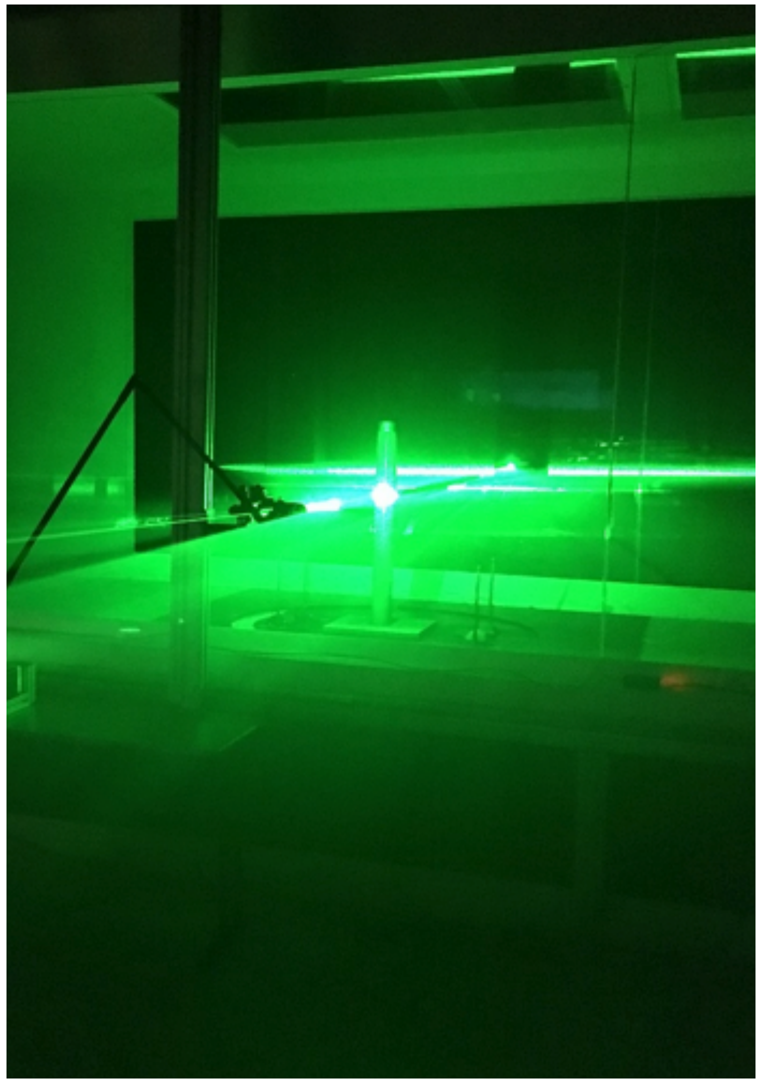

SPEEDGEL PIV TESTING NAQI

Harm Ubbens, Project manager aerodynamics Flanders' Bike Valley

With the use of particle image velocimetry (PIV) the effect of the NAQI Aero Speedgel is visualised on a pvc cylinder in a wind tunnel. With the use of small oil particles the flow around an object can be traced and visualised using this measurement method. By performing two measurements – one measurements of the bare cylinder and one measurement of the cylinder with Speedgel applied to it – the aerodynamic effect of the Speedgel can be shown.

The setup is installed such that the laser illuminates the oil particles from the side and the camera captures the images from the top to see the flow around the cylinder installed vertically in the wind tunnel as can be seen in Figure 1.

As the measurement setup made use of planar PIV the particles on the rear side of the cylinder (as seen from the laser) are not enlightened as they are in the shadow of the cylinder itself as can be seen in Figure 2. This will result in a unstable region in the figures at this location as a result of camera noise.

The NAQI Aero Speedgel that was used to conduct the testing was the OM20 speedoil (Figure 3). This speedoil was previously used in investigations in the wind tunnel on real riders where it showed a decrease in aerodynamic resistance on each rider tested.

Figure 1 – Measurement setup

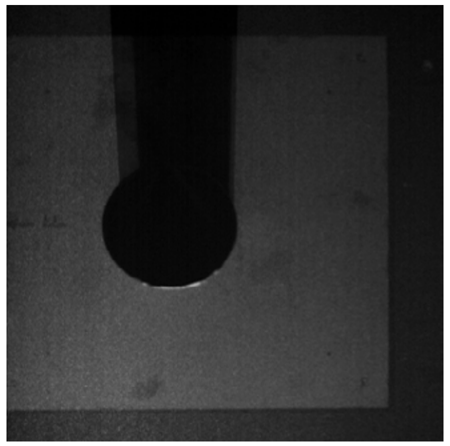

Figure 2 – Camera output with shadow region behind the cylinder

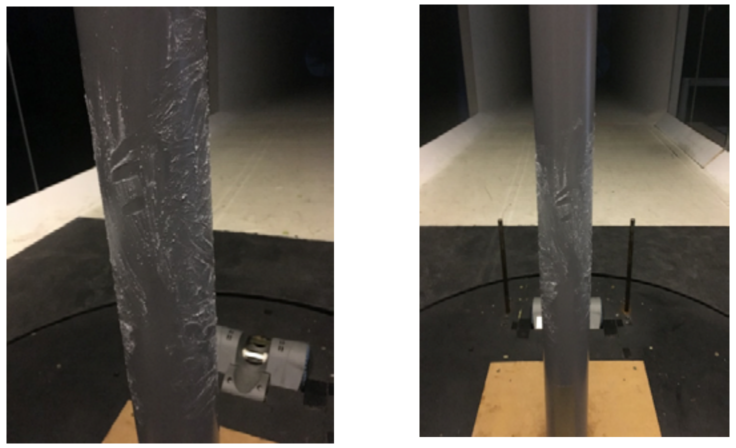

Figure 3 – OM20 speedoil applied to the cylinder

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The result of the PIV measurements can be found in Figures 4 and 5.

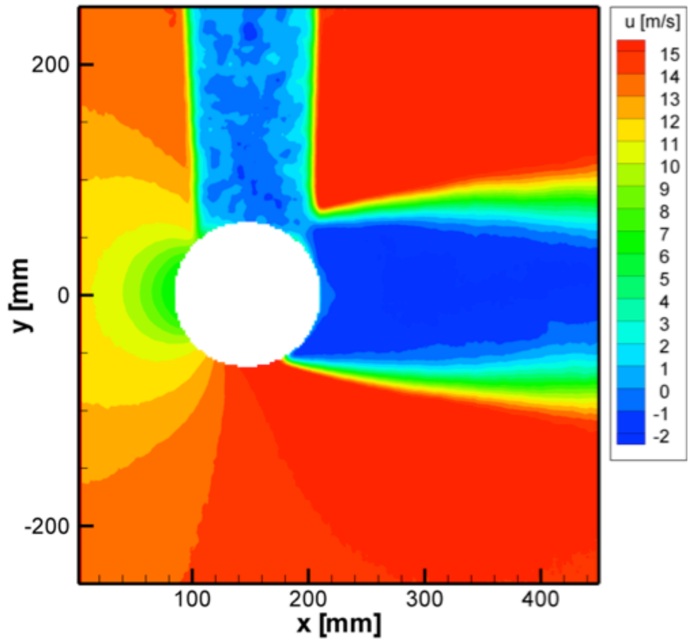

Figure 4 – PIV figure of the cylinder without product.

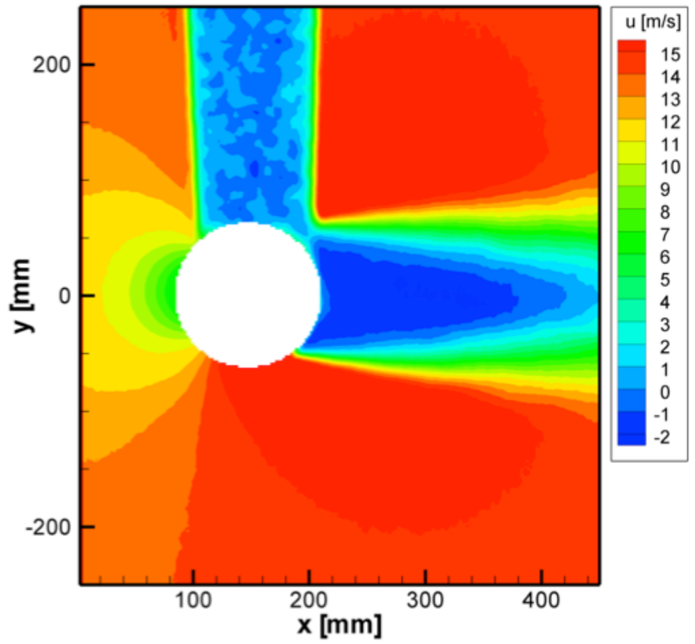

Figure 5 – PIV figure of the cylinder with OM20 speedoil.

As can be seen in the figures the region blocked by the cylinder (above the cylinder in this orientation) shows a region with noise and airspeeds around 0m/s. This region should therefore be neglected during the analysis of the PIV figures.

In the PIV figures the wind flows from left-to-right with an airspeed of 14m/s. This results in a stagnation point on the LHS of the cylinder and a low-velocity unsteady wake on the RHS of the cylinder. It is clearly seen that the speedoil influences the airflow around the cylinder. Due to the increased roughness the separation point is pushed backwards on the cylinder and the severity and size of the wake are reduced. This will cause the pressure difference between the front and rear part of the cylinder to be lower in the case with the speedoil. A lower pressure difference means a lower pressure drag. As the pressure drag is the main contributor of the total drag for a bluff body the total drag is reduced as well.

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