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DESIGN STUDY IN THE DESIGNING A KART -REAR AND FRONT WINGS

Abstract: *Because Superkarts can reach very high speeds, they need an extra help when it comes to grip, because they are very light. This article aims to create a design of the rear and front wings, to ensure a flow of air so as to obtain a very good grip of the Superkarts. The pressure force acting on the front wing of the Superkart comes from the airfoiled shape of the wings attached to the front wing, which creates a pressure difference between the top and bottom of the wing, according to the Coanda effect. The designed rear and front wings will be subjected to airflow tests to study both performance and airflow behaviour before and after interacting with them.*

Key words: *Superkart, rear wing, front wing, aerodynamics, down force, the Coanda effect.*

1. INTRODUCTION

Unlike normal karts, Superkarts can reach very high speeds, and even if they are very close to the ground, an additional force ensures better grip and stability, this force is especially necessary for these light-weight vehicles (the weight of the complete kart with tires is 136 kg) [1].

The rear spoiler is used to achieve this additional force. However, not all Superkarts are equipped with this technology, as some experts believe that installing a spoiler only increases their weight, thus reducing performance.

It should be noted that this type of kart easily exceeds 200 km/h and that at these speeds the force exerted by the air on the vehicle and the spoiler, if fitted, is very high, thus making large and beneficial contributions to its performance [2]. As you can see, these superkarts have features that bring them as close as possible to the performance of a Formula 1 car.

So, next we will show you the design of the rear and front wings designed by us and study the effects of air on them at the speed of 180 km/h.

2. REAR WING CHARACTERISTICS

The spoiler creates downforce making the air move faster on a side and slower on the other one. This type of air movement causes, according to the Bernoulli's principle, a difference in pressure, namely, on the side where the air will move faster the pressure will be lower, and on the side where the air will move more slowly, there will be greater pressure.

This type of air flow is made by the airfoiled structure (Figure 1) of the spoiler, which causes this difference in air flow rates on the basis of the Coanda principle. Coanda's principle applies, in our case, like this: when air enters a curved surface, it tries to follow that surface, so the air that has to flow through a larger surface will accelerate. To achieve this effect the wing is placed with the largest surface facing down, creating a low pressure under the wing and high pressure above it, thus, achieving downforce.

Figure 1 Airfoiled profile.

The problem with this wing is that performance increases exponentially as air flow rate increases on the spoiler. Therefore, performance will be very poor at low vehicle speeds and will increase as the vehicle speed increases.

3. REAR WING DESIGN

In order to build the rear wing of a kart we need to know that it must not exceed the full width of the kart (140 cm), so we will take advantage of all the available space and make a 140 cm long wing (including winglets), with a total height of 50 cm, including stands. During the design, the highest possible positioning of the spoiler was attempted, so that it would be above the driver's head.

The entire spoiler was made of plastic, except for the clamping parts that are made of aluminium alloy.

The spoiler is made of 1 airfoiled type wing, 2 winglets, 2 wing adjustment plates, 2 wing uprights supports and 2 mounts (Figure 2).

Starting from the bottom, the mounts are for fixing the entire spoiler by the kart, they are made of aluminium alloy and are directly attached to the back of the kart.

The 2 wing uprights supports are made of plastic, and they are having triangle shaped holes in it, to reduce the amount of material used, making them as light and durable as possible. It also has the necessary holes to attach the wing adjustment plates on it.

Figure 2 Kart rear wing.

The 2 wing adjustment plates are fixed to the wing and has holes that allow the wing to be attached to its supports in different positions and angles.

The 2 winglets, located at each side of the wing are used to reduce the wingtip vortices, the twin tornados formed by the difference between the pressure on the upper surface of the wing and the lower surface of it [3].

The wing, made of 140 cm long airfoiled type, plastic material, it is the main piece of the spoiler, and is attached to the supports bay the wing adjustment plates.

4. REAR WING PERFORMANCE

After the final design of the spoiler has been chosen, air flow tests have been made on the airfoiled wing made by us, to see the behaviour of the air around it.

The test consists in performing a simulation, which mimics the wind flow at the speed we chose on the inserted object.

In our case the chosen object is represented by the wing, and it has been chosen an average speed that super karts have on the circuit, 180 km/h.

After performing more than 200 iterations, the following results have appeared.

As shown in Figure 3 at 180 km/h you can clearly see the Coanda effect, and how the air flow follows the profile encountered, accelerating over the larger surface and slowing down over the lowest.

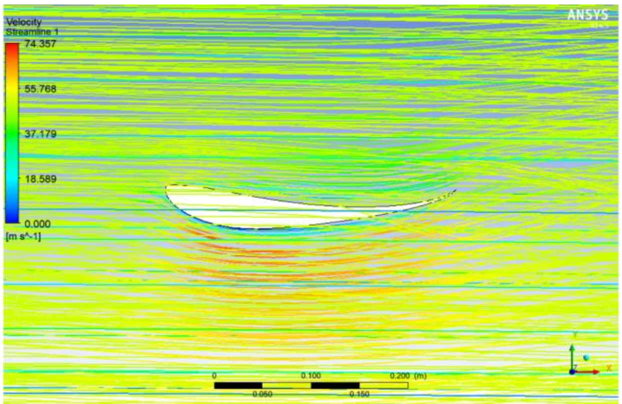

Figure 3 Rear wing, wind direction.

This tells us that the airfoiled structure we chose for the construction of the wing is a good one, and that even if the kart is traveling at an average speed, the spoiler contributes to the performance of the vehicle.

If we look at the simulation from another angle, specifically from behind the wing, it can be clearly seen that, as shown in Figure 4, in the absence of the winglets, whirls are formed at the wing's edges, increasing drag. So, the choice to mount on our spoiler one winglet at each side of the wing, is a good choice, because they reduce the drag, removing the wing-created vortices.

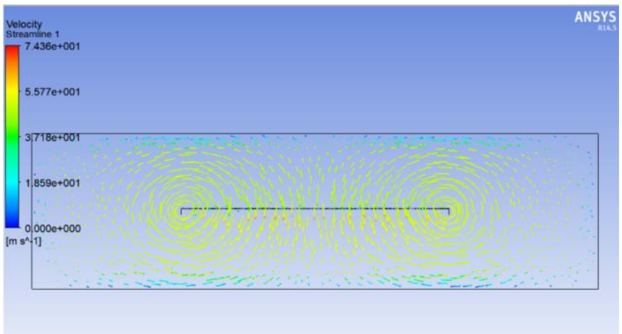

Figure 4 Rear wing vortices.

Another wing feature, which can be seen after the simulation, is the speed of the wind around the wing.

As shown in Figure 5 the wind speed is different at different points around it. Below the wing, the wind speed is up to 260 km/h, while, above the wing, the wind speed, in some areas, is only 70 km/h. This difference in air flow speeds around the wing creates a pressure difference. This difference can be clearly seen in figure 6, where on the top of the wing we have a pressure of approximately 17 Pa but at the bottom of the wing the pressure value is only 4 Pa.

This large pressure difference between the top and bottom of the wing creates the downforce we are looking for. We must remark that this force is applied at an average speed of 180 km/h and that this force increases exponentially as speed increases.

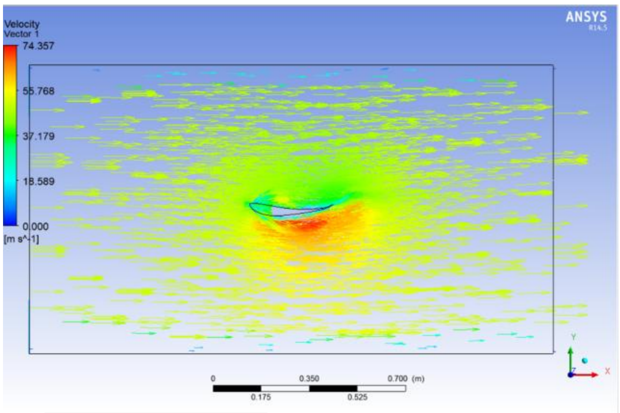

Figure 5 Rear wing, wind speed.

5. FRONT WING CHARACTERISTICS

The front wing of a Superkart is one of the most important elements that make up its aerodynamics. It is the first aerodynamic part that meets the undisturbed air flow, and for this reason it is responsible for how the air flow will interact with the rest of the kart.

The front wing's sole focus is to create downforce but is also preparing the airflows that will hit the rest of the superkart body and its components in the correct way [4].

Another important characteristic of the front wing is that must get the air to flow around the tires. Until now the front wing was attached to both the nose cone and the body of the Superkart covering the wheels. The new design will take out the part that covers the wheels and create an airflow around the tires preparing it to hit the rear wing (Eleron) just like the front wing of a Formula 1 car.

6. FRONT WING DESIGN

To build the front wing of a superkart we need to know that it must not exceed the full width of the kart (140 cm), but this time it will be even less, because the front part of the kart is slimmer than the back, so the total width of the front wing, including winglets it will be of 1230 mm.

The whole ensemble it will be made by plastic, and it will be attached to the rest of the superkart only by the nose cone.

The front wing will have 2 sets of wings, one set on each side of the nose cone and each set will have 2 wings. The lower wing, called the main plane will run the airflow in two ways. First it will run the air under the kart in a non-turbulent way, and secondly to the upper wing (spoiler). The upper wing (spoiler) will have an inversed NACA profile, (the longest curved plane will face downwards), that will create de pressure difference.

The front wing will have 2 winglets that will get the air to flow around the tires, and all this will be attached by the nose cone, that it also has and aerodynamic shape, making the airflow go faster on the upper side of the nose cone (Figure 6).

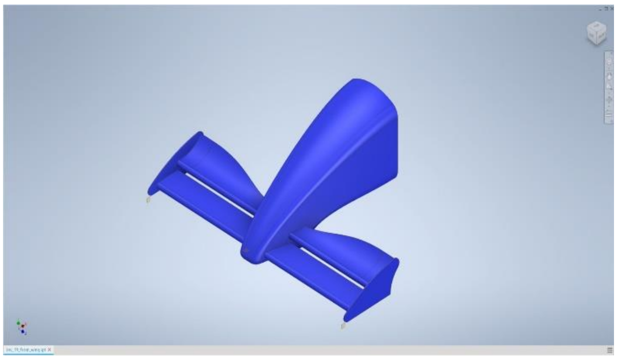

Figure 6 Kart front wing.

7. FRONT WING PERFORMANCE

When the design of the front wing is finished, it will undergo an airflow test to see the airflow behaviour around the hole assembly.

The test consists in performing a simulation, which mimics the wind flow at the speed we chose on the inserted object.

In our case the chosen object will be the entire front wing, simulating its performance at a speed of 180 km/h. After performing various iterations, the results were as following:

First, we manage to see the speed of the airflow around the entire front wing body.

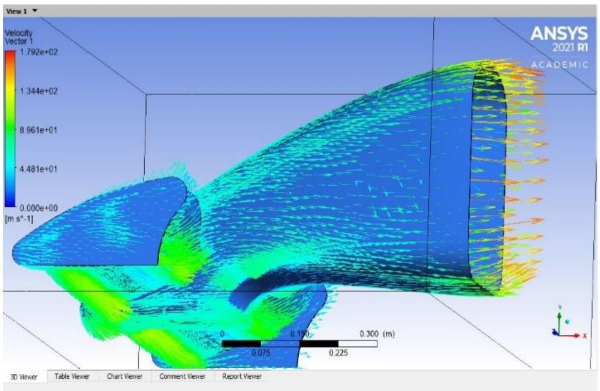

Figure 7 Front wing, air speed.

As you can see in the Figure 7, the airflow accelerates at speeds above 360 km/h at the exist of the wing. Because the surface area of the nose cone is larger, we can see that the air accelerates even more at the end of the nose cone profile.

As you can see in the Figure 8 is represented, in a various colour pallet, the airflow speed around the wings and how the Coanda principle works. First, the airflow loses its speed at the impact with the nose of the wing, then, the air that flows on the upper side of the wing is speeding down and the airflow under the wing accelerates.

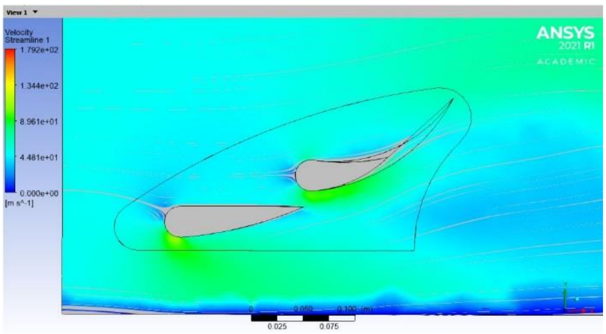

Figure 8 Wings air speed.

All this velocity modification has an impact on the pressure around the front wing, shown in the Figure 9.

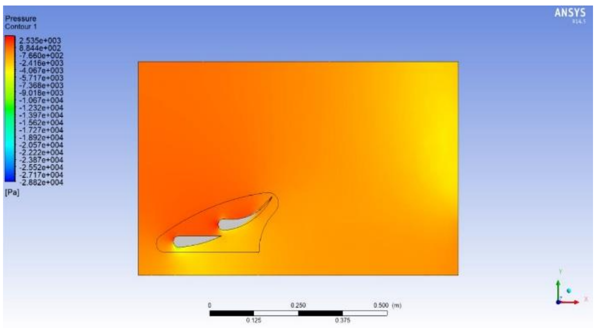

Figure 9 Wings pressure.

If we compare the two images, we can see that where the speed of the air is lower the pressure is higher, and vice versa.

The same principle is available for the nose cone too. In the Figure 10 is directly represented the pressure values around the nose cone. At the impact with the nose cone, the air goes slower, and the pressure is bigger. As the air gains speed the pressure drops, as a result the low pressure at the tail of the nose cone.

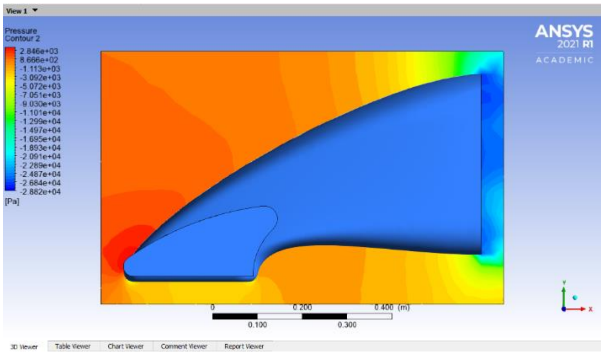

Figure 10 Nose cone pressure.

Finally, we wanted to see the direction of the airflow after and before impact with the wings. We wanted to see if the air is prepared for the impact with the rear wing and how the fins make the air flow around the tires (Figure 11).

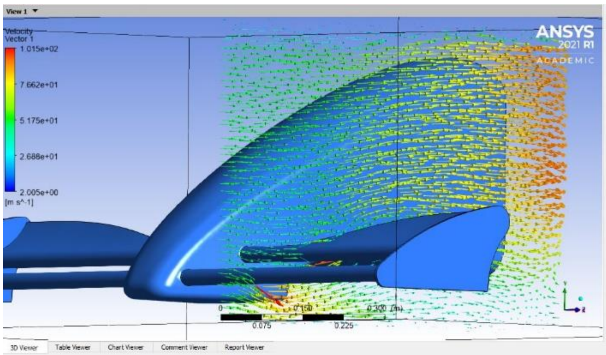

Figure 11 Front wing, air flow.

As you can see this design of the front wing is excellent for the preparation of the airflow to hit the rest of the kart body, but it has a problem. This design slows down the air that goes under the kart to make it non-turbulent.

At last, in the Figure 12 we can see how the winglets work.

The winglets, situated at the extremities of the front wing have such a shape, inspired form the formula 1 front wings, that make the air flow go around the tires. This is necessary because the tires have not an aerodynamic shape, and at the impact with the air they slow down the kart.

As we can see in the Figure 12 the air bends around the place where the tires will be and is then redirected to the body of the kart.

Thanks to the new changes of the kart front wing the kart will have less weight and will gain more grip.

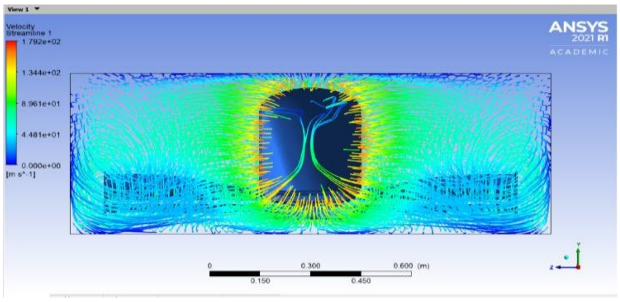

Figure 12 Air flow, rear view.

8. CONCLUSIONS

In conclusion, as you can see on the superkart racing tracks nowadays, more and more superkart are equipped with rear wings, because as it has been demonstrated, the action of a rear wing helps to increase the performance of the kart. Superkarts are strong enough to overcome the spoiler's forward resistance, and to bear its weight, to benefit from the downforce performed by it at high speeds.

We can also say that the front fender is a very important component of the superkart, or any type of racing vehicle, because they all have front fenders. Currently, all karts and superkarts have front fenders, but that doesn't mean they can't be upgraded.

This new design comes with less weight and creates more grip, and if tested on real racetracks, we're confident that these new rear and front wings will give the superkart the few seconds it needs to win.

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