THE DESIGN OF, AERODYNAMICALLY SOUND, BIKE'S HELMET

(Group 5)
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ABSTRACT

In this paper, we are going to present the aerodynamics of the helmet. Helmet is a "must" equipment to be worn by rider. However, helmet will increase the frontal area of the rider's head and this will affect the aerodynamics of the rider, thus, the rising of drag. Therefore, helmet must have a good aerodynamics shape to minimise the effect of the frontal area. Two track cycling helmets are used to investigate the performances of drag in different position. A mannequin wearing helmet is attach to a support frame, drag force then been measured using a strain gauges.

KEYWORDS

Drag, Helmets

1. INTRODUCTION

Drag force is an important factor in cyclist performance. There are two types of drag, namely **frictional drag** and **pressure drag**.

Frictional drag is the contribution from the surface roughness, can be related to surface area exposed to the flow. **Pressure drag** is associated with the formation of wake by the profile of the body in a fluid, and it is related to the cross-sectional area of the body. Formally, both types of drag are due to viscosity of the flowing fluid. Method like streamlining, that is elongating the rear portion of the body such that the boundary layer keep attach to the surface and prolong the separation. A streamlined body will have a smaller drag coefficient than the blunt body with the same frontal area. On streamlined body, frictional drag is the dominance resistance because the pressure drag is comparatively small. The only aspect that contributes the drag over streamlined body now is how good the surface roughness is. Where else for a bluff body, pressure drag is dominance factor. In most cases, minimum drag on a body provides the proper balance between friction drag and pressure drag.

In order to enhance aerodynamics of the cyclist, we can always change the cycling position, clothing and well-designed cycling gears. The largest part of the rider body that contributes the most drag resistance is the torso. This can be improved by altering the position to reduce the frontal area of the body, mean parallel torso to the direction of flow. However, to obtain this position the rider's knees may hit his chest while riding and this will reduce the rider's performance since it is not a comfortable position. Meanwhile, riders for different body size can only find the best position for their torso, which can provide them with a comfortable position during riding. Aerodynamics helmet does play important role to promote a streamline profile between the head and the torso.

According to (Kyle at el, 1987 “Streamline Your Body and Your Bike”, Bicycling), an aerodynamic helmet does provide a 5.2% aerodynamic advantage and save 47 seconds if travelled 40 km. Aerodynamics helmet is relatively crucial and valuable to an athletes.

There are many ways for drag reduction. For example: **streamlining, moving skin on a body, vortex generator, guide vanes, discharging fluid, suction methods, riblets and others.**

In this paper, we present experiment results on two track cycling helmets previously use by the Australian Institution of Sports (AIS), and analyse body and head, pose influence the drag force at different speeds.

Figure 1: White helmet (left) and Yellow helmet (right). These are the helmets that are being discussed in this paper.

2. METHODOLOGY

In order to test the helmets in the KC wind tunnel in Holden Labs, we have taken steps as the following. Firstly, the mannequin, as designed to simulate a cyclist position on a bicycle as close as the condition as in racing. The flow over the mannequin may relate to the helmets and take into consideration. The mannequin is made of polystyrene foam. This material is rigid enough and has good formability, so we could shape a human body and head easily. The dimension of the mannequin is conforming to a standard human of a size of 180 cm height, 70kg male. Since the upper half body contributes more to the drag resistance. Mirror finish putty was applied to the surface of the polystyrene to strengthen the surface, enhance surface finish and enable it for painting.

Figure 2 Mannequin and the apparatus

The head and the body are designed separately, and then joined together by a metal tube, as shown in figure 2. To allow the body to move to any direction we want, a universal ball joint has been used, which is also can be seen in the figure 2. Then rubber foam is used to fill out the gap between the head and the body as the neck section. A dedicated support with a specified angle is use to support the mannequin and attached to the frame with rosette strain gauge configuration. This special designed frame provides the mannequin's body to turn at a maximum angle of 85^o.

A Pitot-static tube is located at the opening of the wind tunnel, then attach to the Statometer that can be shown in a barometer where water is used as the indicator. Then the displacement of the incline water is converted to calculate the tunnel velocity by

$$V = \sqrt{\frac{2\rho_{water} gh}{\rho_{air}}}$$

Where V is the free stream velocity, ρ_{water} and ρ_{air} are the density of water and air respectively, g is the gravitational force and h is the displacement.

By regulating the voltage of the motor, the stream speed of the wind tunnel could be adjusted, and then the body will produce drag force. Eventually, the drag force will be transmitting to the frame with strain gauges, measurement can be obtain by degree of deflection. The deflection is measured as a voltage signal with can be shown in the voltmeter. The value will be in negative if the mannequin is pushed backward, or vice versa.

3. CALIBRATION

The strain gauges were calibrated to obtain a relationship between strain-induced voltage and applied force. Loads varying from 6g to 1kg were applied. By using the suspended wire through the "frictionless" pulley on the calibration rig, we can generate a calibration curve as follow:

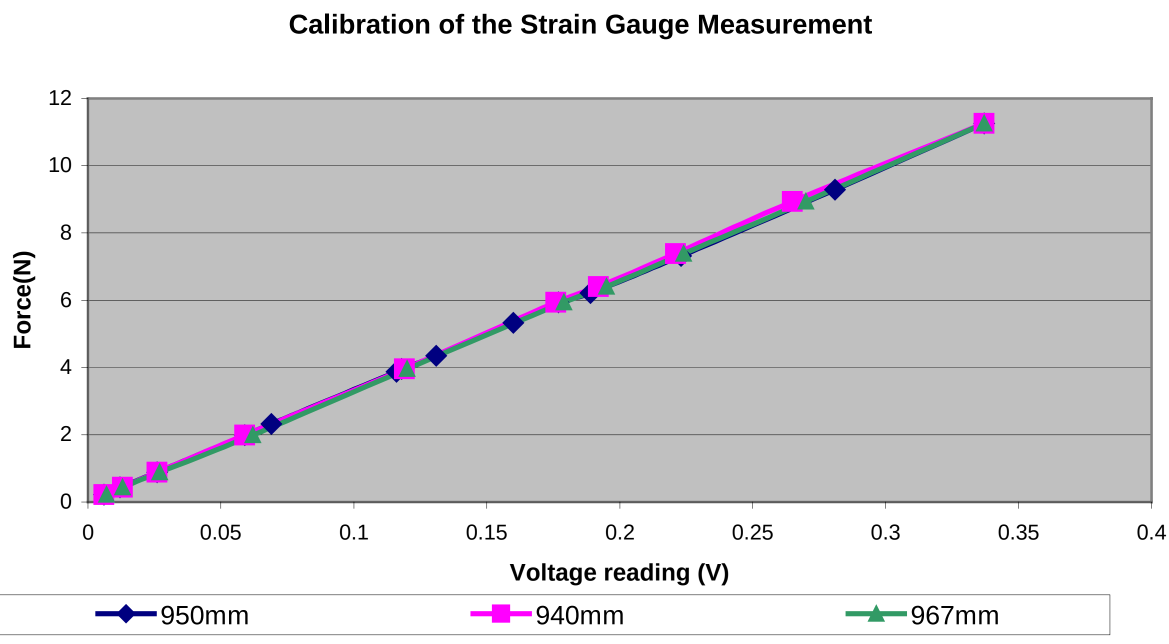

Figure 3

In order to examine the accuracy of the strain gauge to measure drag only we conducted three tests. For each test we change the height of the pulling point on the head. The three testing heights are 950mm, 940mm and 967mm. We can conclude that the Rosette configuration strain gauge does only measure drag force, in figure 2 shows excellent agreement between the three tests which indicates that the effect of lift force and moment is negligible. The linear relation of the line was generated by using Linear regression option available in Microsoft® Excel. We also generated an equation to relate the forces and voltage.

$$\text{Force(N)} = 33.45915(\text{voltage}) + 0.01152$$

4. RESULTS & DISCUSSIONS

By comparing figure 5, 6 and 7, the helmets are providing better aerodynamics when the head tilted at 45° than in 65° and 30°. This shows that the design of the helmets is the optimise position for the helmets when the head tilt 45°. For the tunnel velocity below 47km/h, the drag force is approximately the same. When the tunnel velocity beyond 47km/h, the drag force is diverging and deviate in figure 5, 6 and 7.

In figure 7, the head tilts at low angle, the tail of helmet is heading upward and the drag will increase as frontal area getting bigger. The results have proved that, as the drags obtained in figure 7 are higher than in the other two angles. By wearing the yellow helmet, the highest drag achieved is 8.5 N where the highest drags shown in figure 5 and figure 6 are below 8 N. As shown in figure 1, the tail of yellow helmet is longer than white helmet thus giving the highest drag in 30°.

In figure 8, the highest drag is more than 10 N and is the highest results in all the positions. The helmet is designed to provide a good aerodynamics to the rider for looking forward, when the head is looking sideway, this actually increases the frontal area of the helmets. This could cause more drag. Overall, by changing the direction of the rider looking at, this will alter the frontal area of the rider’s head. Thus, the cyclist needs to find a particular helmet, which is suitable for their head’s size and has the optimise performance for the cyclist position, not depend how well the design is.

The mannequin without helmet will have a lower drag all time is because there is no hair on the head, and the ear is disable as well. In the real world, the hair and ear do contribute more drag on a body and lead to major source of error in the drag measurement of the experiment.

Figure 4: The head made a tilt of 45°

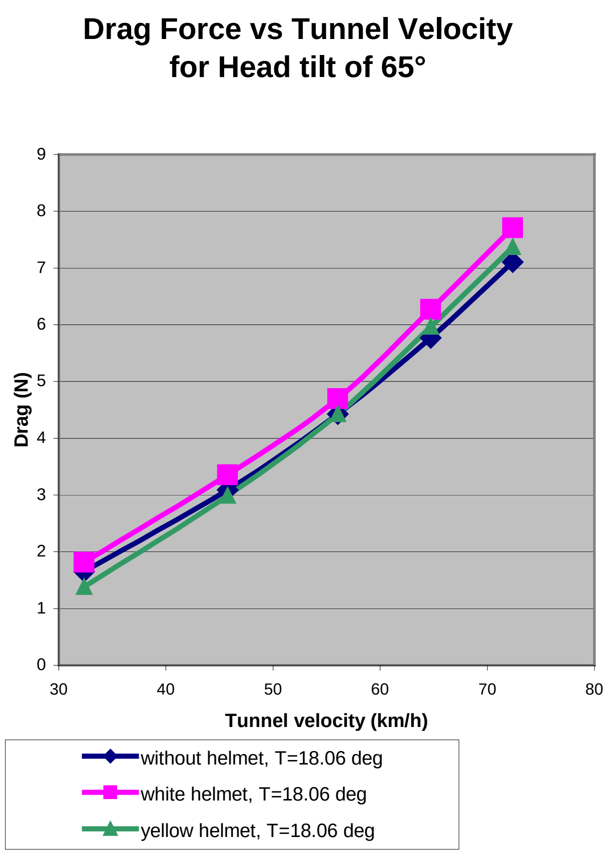

Figure 5

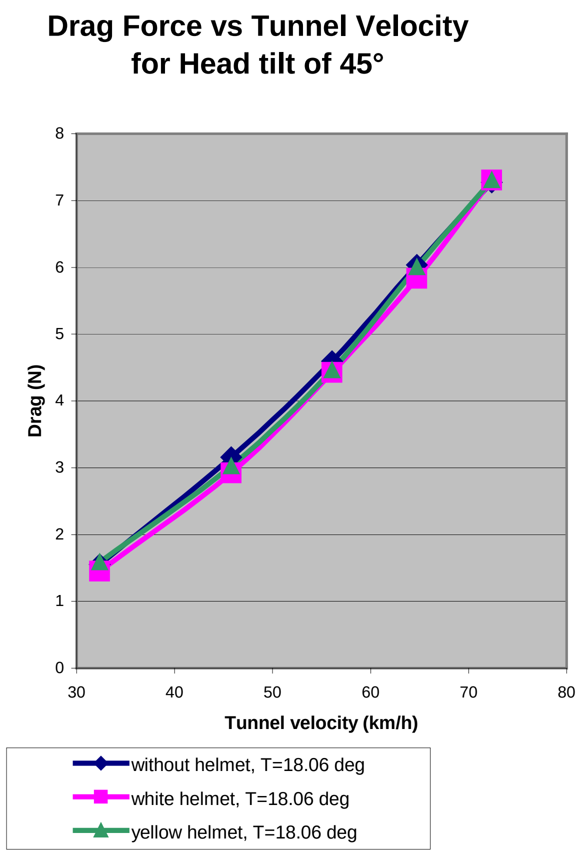

Figure 6

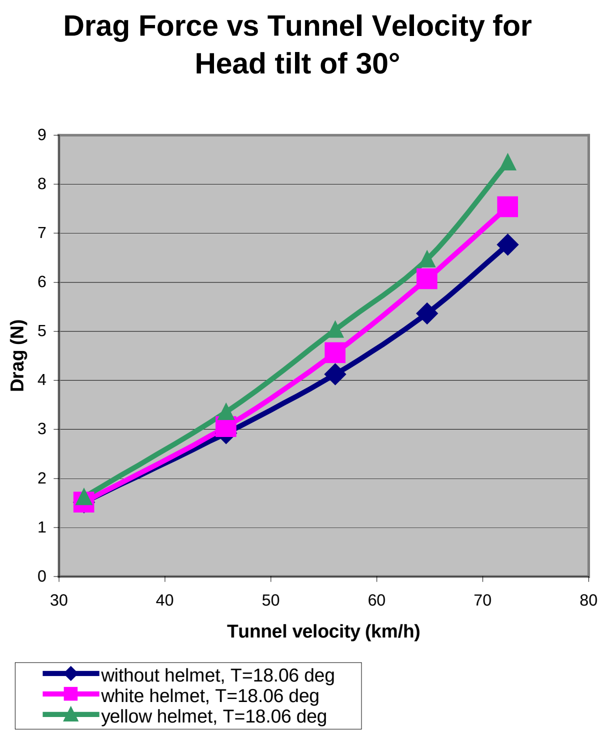

Figure 7

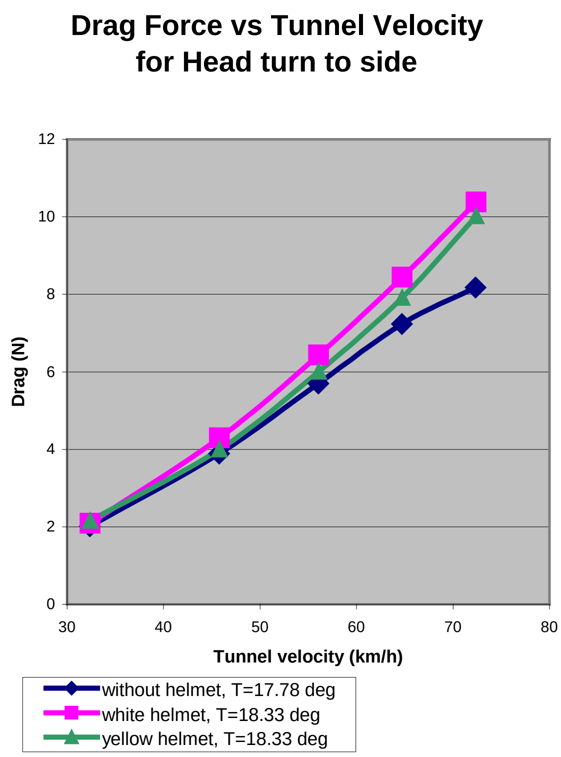

Figure 8

5. CONCLUSION

This paper readily shows some of the possibilities for the future. The results show that there are improvements that can be done on the helmets to achieve better performance.

By varying the designs of the helmets and the body size of the rider, the helmets will have different aerodynamics properties. The results show that the designs of the helmets are very important to the rider and a suitable helmet with a design provides efficient aerodynamics properties will enhance performance.

With further work, this could make aerodynamically efficient bike helmets a valuable research topic in the ever-competitive sports arena.

6. FURTHER WORK

In the near future, we are going to design a helmet with a flexible trailing edge. Lycra is a fabric that widely use in sports industries as suit because it is elastic, good for respiration, excellent surface roughness and good toughness. We can use Lycra as the shell of the trailing edge, thus no matter how the head turn, the lycra will stretch and stick to the cyclist head and body to streamline the profile in order to achieve the minimum frontal area.

We also intend to examine the effect of introducing riblets on the helmets for drag reduction. The Dutch skater use riblets on their suits, which they claim could reduce a lap time of 0.5 seconds. We could also increase the surface roughness.

7. REFERENCES

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