THREE-DIMENSIONAL SIMULATION ON RACING CAR REAR WING WITH AND WITHOUT DRAG REDUCTION SYSTEM

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This report is submitted
In fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Thermal Fluid)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MAY 2017

DECLARATION

I declare that this project entitled "Three-dimensional simulation on racing car rear wing with and without drag reduction system" is the result of my own work except as cited in the references.

Signature :...................................

Name :...................................

Date :...................................

SUPERVISOR'S DECLARATION

I have checked this report and the report can now be submitted to JK-PSM to be delivered back to supervisor and to the second examiner.

Signature :...................................

Name of Supervisor :...................................

Date :...................................

DEDICATION

I dedicate this project to my beloved mother, Mashita Binti Radzi and my beloved father, Nazifunnur Bin Md Ishak who giving their hard time to see their son success.

ABSTRACT

Drag reduction system (DRS) is commonly used is racing car event. DRS is installed on their rear wing for extra speed to overtaking their opponent. The main purpose of this study is to study the coefficient of drag acting on the DRS whether high drag coefficient can be achieved during overtaking process. The result will be compared with experimental result to check whether the result is difference or not. The analysis includes the meshing of rear wing and pressure distribution. This study was conducted by studying the drag and lift coefficient test at every 4° interval from 0° to 16°. The highest drag and lift are -10 and -2.5.

ABSTRAK

Sistem pengurangan seretan (DRS) biasanya digunakan adalah perlumbaan acara kereta. DRS dipasang pada sayap belakang mereka untuk kelajuan tambahan untuk memotong lawan. Tujuan utama kajian ini adalah untuk mengkaji pekali bertindak seretan pada DRS sama ada pekali seretan tinggi boleh dicapai semasa proses memotong. Hasilnya akan dibandingkan dengan keputusan eksperimen untuk memeriksa sama ada hasilnya adalah perbezaan atau tidak. analisis termasuk bersirat sayap belakang dan taburan tekanan. Kajian ini dijalankan dengan mengkaji drag dan lif ujian pekali di setiap 4 ° selang dari 0 ° hingga 16 °. Seretan tertinggi dan lif adalah -10 dan -2.5.

ACKNOWLEDGEMENT

First and foremost, I would like to praise Allah for His guidance and blessing, Alhamdulillah. Together with His blessing, I have been able to perform this PSM report within the time.

My deepest gratitude goes to Mr. Shamsul Bahri for giving me an opportunity to perform this final year project under his supervision with the title of Three-dimensional simulation on racing car rear wing with and without drag reduction system. Many thanks for his encouragement and guidance.

A high appreciation to my beloved mother and father for the moral support in completing this degree. Last but not least, thanks to all my friends whose share up some knowledge and supportive. Thank you very much.

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LIST OF ABBEREVATIONS

DRS	Drag Reduction System
AOA	angle of attack
CFD	Computational Fluid Dynamics

LIST OF SYMBOLS

C_D	=	Drag Coefficient
P	=	Pressure
ρ	=	density
V	=	velocity
β	=	yaw crosswind

CHAPTER 1

INTRODUCTION

1.1 Background

Aerodynamic drag of racing cars has perhaps received utmost attention over last five decades in experimental and applied field of fluid dynamics. Several researchers and authors have labelled altered forms of drag, potential reasons behind them and several ways of reducing the drag. (Katz's et al, 1995) work was fully devoted for the racing car aerodynamics and he described the different feature of car design starting from the first-generation automobiles to most recent models, but no mathematical or investigational process was explained to measure the drag. Computational analysis to reduce the drag is performed by (Barbut et al, 2011) (Rouméas et al, 2009) on road vehicle and by (Guilmineau et al, 2008) on the simplified car body (Ahmed body et al, 2009).

Drag Reduction System (DRS) is a new technology in F1 and is a form of driver-adjustable bodywork aimed at reducing aerodynamic drag in demand to increase top speed and help overtaking in motor racing. It is an adjustable rear wing of the car, which moves in reaction to driver commands. DRS often comes with conditions, such as the pursuing car need be within a second (when both cars cross the detection point) for DRS to be activated. DRS was introduced in Formula One in 2011. The use of the DRS is a concession to the rule prohibiting any moving parts whose major purpose is to affect the aerodynamics of the car. This sort of overtaking is brought about by a speed difference: the car behind going satisfactorily faster than the car in front to make a pass. The higher the speed difference, the easier the overtaking. As racing car cars are typically very closely matched on performance and braking distances are comparatively short related to other methods of racing, overtaking often involves a great deal of skill, commitment and courage. An innovation that makes the driver's job slightly easier is the DRS overtaking aid. Within designated DRS initiation zones, a driver within one second of an opponent car may initiate his DRS. This alters the angle of the rear wing flap, decreasing drag and thereby given that a temporary speed advantage. To ensure that overtaking is not too easy, the distance and position of DRS zones are cautiously controlled. Outside of the DRS zones, drivers can use several other methods to try to get past an opponent.

One is to exploit an aerodynamic 'tow' from the car in front. This is achieved by moving into an opponent's slipstream – a compact of low-pressure air behind a car through which the following driver can move more freely and gain a small speed lead. However, whilst advantageous on straights, this aerodynamic effect is problematic in corners as the reduced airflow acting on the wings of the second car will radically decrease aerodynamic downforce, and hence grip, meaning that the car behind will be forced to drop back, or to pick a different cornering line in 'clean air'. If a driver can't thorough a pass on a straight, he could designate to overtake into a corner under braking. This requires skill from the overtaking driver, not only is he probable to have had to move off line on to a more slippery part of the track, but he must also predict how late he can leave his braking. Get it wrong and he could overshoot the corner, spin off or worse, which is make unintentional contact with the car he's trying to overtake. As you might expect, tyre grip often plays a vital part in these positions with a driver on newer tyres having an advantage. Similarly, a driver on new tyres will stance a better chance of surpassing the car in front in the traction zone out of a corner, particularly if he’s set up the change in progress by winning a different racing line into the corner.

1.2 Problem Statement

The F1 racing cars need speed to be overtaking the other opponent. As racing car cars are typically very closely matched on performance and braking distances are relatively short related to other forms of racing, overtaking often needs a great deal of skill. We need to increase the speed so it’s easier to overtaking. By using different angle of attack, the speed may increase or decrease. So, we need to conduct a simulation to check whether the angle of attack is suitable or not for racing car.

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To determine and compare the drag coefficient with and without Drag Reduction System (DRS) on racing car rear wing.
2. To provide a complete analysis on the structural of DRS on racing car rear wing.
3. To compare simulation result with experimental data.

1.4 Scope of Project

The scopes of this project are:

1. Result of simulation using with and without DRS on racing car rear wing only presented in this report.
2. Racing car rear wing is simulated only for the side part of unit due to DRS part take effect.
3. To perform a simulation using software ANSYS based on the racing car rear wing to reduce the drag coefficient, C_D.

CHAPTER 2

LITERATURE REVIEW

2.1 Aerodynamic Design Affect the Drag Force

There are differences between aerodynamic on simple vehicle and racing vehicle like their design because the design affect the vehicle aerodynamic and difference drag force. Large turbulent wakes are formed at the rear and in many cases, contain longitudinal trailing vortices (Hucho, Wolf-Heinirch, 1987). On normal car concept of using aerodynamic isn't use much rather than used on racing car because below speeds of 80kmph (50mph), the aerodynamic drag is very less. According to the drag history of car we can see multiple of design affect the C_D.

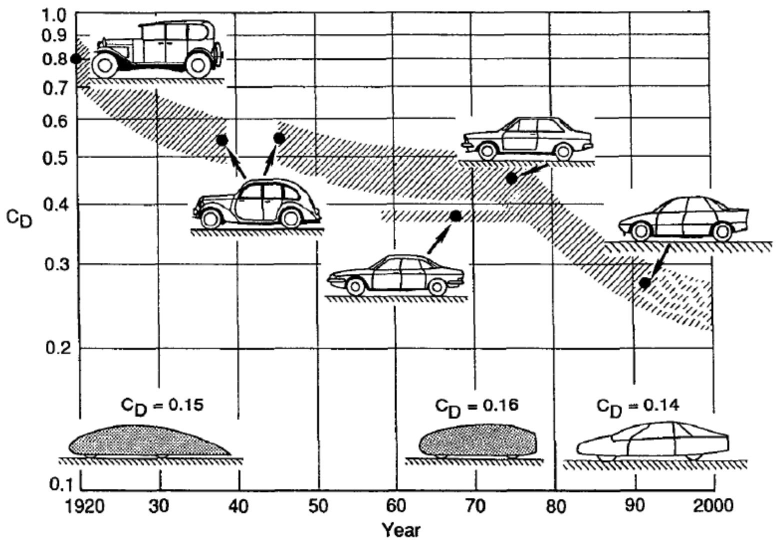

Figure 2.1: The drag history of cars. Using a logarithmic scale for drag emphasizes how difficult it is to achieve very low drag values. Research has been far ahead of what has been realized in production.

The drag can be reduced by streamlining the vehicle so it can have smaller lift. The designed multi winged race car can move easily through the air because of the streamlining is important for aerodynamic downforce (Katz, Joseph, 1995). The streamlining on the racing vehicle design is more than on simple vehicle because to reduce drag and lift to create more speed and more stable. Within couple of years in market, drag will be main thing that will be considered for some specialty vehicle. Drag coefficients less than 0.20 are feasible. However, the development process will be of increased difficulty because there appears to be significant interaction between the local flows in different areas of a car body at these low drag levels (Hucho, Wolf-Heinirch, 1987). Those solid connections the middle of the stream fields of the car's fore-body and back end. Those low drags of a long-tail model might have been supported just when those stream around the fore-body might have been great appended. Those drag enhanced essentially the point when the stream differentiated toward the soak windscreen. (Hucho, Wolf-Heinirch, 1987).

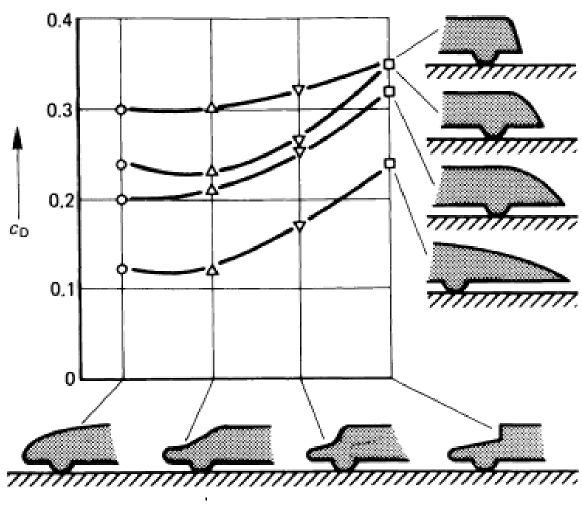

Figure 2.2: influence of main body parameters on the drag of a car and their interactions

The reduction of the drag coefficient from $C_D \approx 0.8$ for cars in the 1920s to an average value of 0.45 for the cars of the 1960s and 1970s occurred in two stages. First stage is on period between the two world wars, the car was designed with rounded bode while sustaining significant characteristics like projecting fenders and headlight will lowering the C_D approximately 0.55, the frontal area also been decrease because to reduce total aerodynamic drag. The second stage is reduction of drag is achieved with the introduction of body design like notchback, fastback and squareback. By using the design with the fenders and headlight in a closed body shape will significantly improve the flow of air around the vehicle, with this design drag coefficient were achieved of 0.4 to 0.5 but depend on the detailed design of it vehicle. This scatter range of drag coefficient has remained unchanged since about 1960. However, it is hard to decide whether the reduction in drag resulted from the impact of aerodynamics, from styling or from more advanced manufacturing techniques (Hucho, Wolf-Heinirch, 1987).

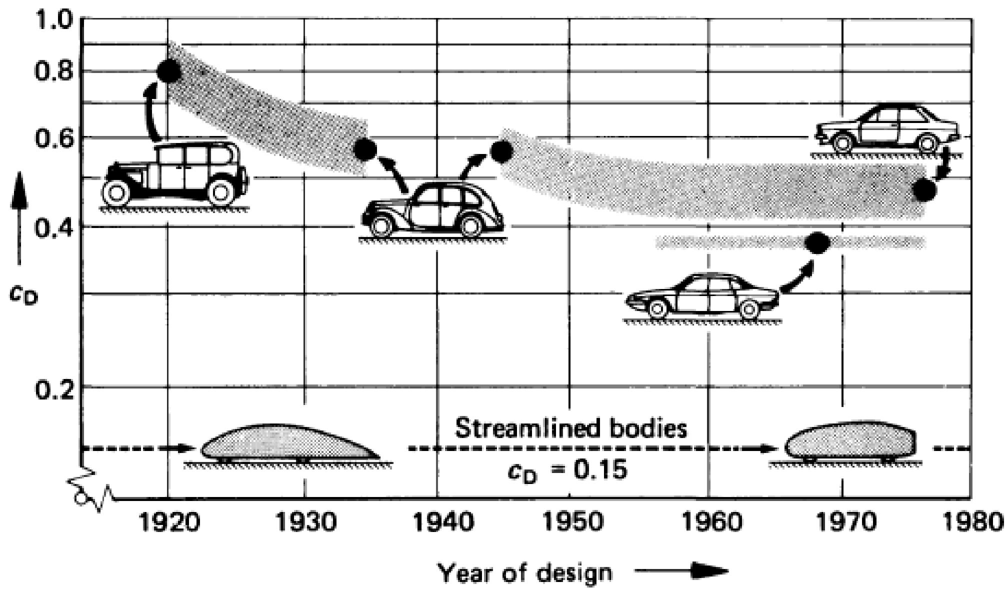

Figure 2.3: Trend in aerodynamic drag coefficient C_D against time, from 1920 to the mid-seventies

The effectiveness of vehicle performance is clearly important for racing car to reduce drag and to increase the downforce (Katz, Joseph, 1995).

2.2 Wing Design on Racing Cars

The basic design used on racing car wing is aerofoil shape because aerofoil shape has better aerodynamic other than shape. Wings in ground effect possess many aerodynamic features of both useful and vital importance. In general, the lift and drag forces of a wing will considerably change near the ground. When an airfoil moves near the ground, flow around the airfoil is viscous and has many viscous interfaces with the ground. In the analysis of ground effect on the aerodynamic properties of the airfoils, the boundary layer on the airfoil must be considered. In contrast, estimate of position of the onset of the transition phenomenon, as an example of boundary layer characteristics, is also necessary in order to predict the drag because the skin friction related to a laminar boundary layer is lower than that of a turbulent one (Venkatesan et al, 2014). The plane design also use a same design of aerofoil and method use in race car wing. Aerodynamic for plane is for to standard aerodynamic practices, the pressure coefficient of the subplots is presented with the negative axis upward. The area trapped by the upper and lower-surface pressure-distribution curves is equivalent to the local sectional lift coefficient (Vassberg et al, 2002).

Fig. 4 shows a sample velocity plot for the rear wing with 0˚ angle of attack and indicates, in general, the higher velocity magnitudes on the bottom surface of the airfoil, as expected due to the inverted setting of these airfoils. Figs. 5 and 6 depict a sample of the variation of the velocity and pressure distribution at 0˚ angle of attack (AOA), respectively. For the inverted airfoils, the low-weight suction territory is on the lower surface of the airfoil, with the positive weight side being on the upper surface of the airfoil (Kieffer et al., 2006)

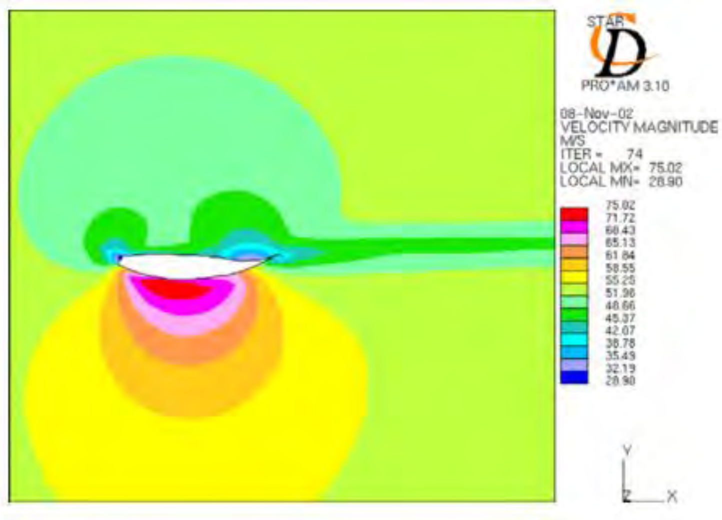

Figure 2.4: rear wing with 0˚ angle of attack

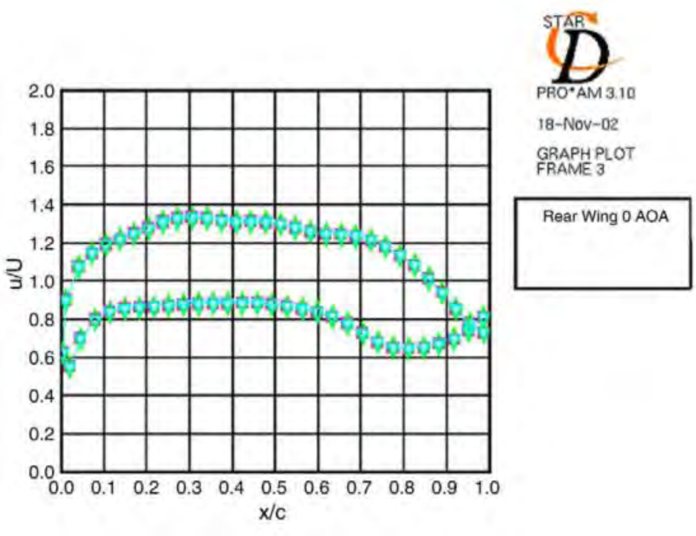

Figure 2.5: Rear wing with 0˚ AOA—velocity distribution.