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# CFD ANALYSIS OF AUTOMOBILE REAR DYNAMIC SPOILER

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**Abstract:** Over past few decades automotive industry focuses on aerodynamic characteristics of spoiler. Through this they succeeded running life of all the parts which has been integrated with the automobiles. On this we had designed a rear spoiler in a car that reduces the running distance after applying the break. Keeping in this mind, the present investigation is focused on the study of angular orientation of spoiler in order to reduce the stopping distance using Computer aided Engineering approach. The modeling software CATIA 5.0 is used to model the spoiler for different orientations and ANSYS 12.0 was for dynamic analysis in this current investigation.

**Keywords:** Spoiler**,** CATIA, ANSYS

## Introduction

In this paper the effect of spoilers on aerodynamic characteristics of an airfoil were observed by CFD. Airfoil section is designed with a spoiler extended at an angle of $20^0$ degree with the horizontal.HE total aerodynamic package of the race car is emphasized now more than ever before. The use of aerodynamics to increase the cars' grip was pioneered in Formula one in the late 1960s by Lotus, Ferrari and Brabham. Aerodynamics plays a vital role in determining speed and acceleration and thus performance. While drag reduction is an important part of the research, down force generation plays a greater role in lap time reduction. Ground effect aerodynamics of race cars is concerned with generating down force, principally via low pressure on the surfaces nearest to the ground. These phenomena happen when a wing is going near the surface. Airfoils or wings are used in the front and rear of the car in an effort to generate more down force. The front wing of a race car is an important piece to make safety at high speed and produces about 1/3 of the car’s down force, it has experienced more modifications than rear wing. The front wing assembly is the first part of the car to meet the air mass. The flow field here is better than at other parts of the car because the air here has been disturbed the least. The wing is designed to produce down force and guide the air as it moves toward the body and rear of the car. Flaps and winglets may also be used. In setting up the front wing assembly, engineers must consider what happens to the airflow as it travels toward the back of the car. (M.H. Djavareshkian,2011).

## Theoretical Calculation

### 2.1 Stopping Distance of the Vehicle for Various Speeds (Without Spoiler)

Stopping distance**, d =** $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$

If the spoiler not attached, $F_d = 0$

**Case (i)** If the vehicle moves 150km/hr,

Stopping distance, **d =** $\frac{v^2}{2\mu g}$

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$$\mathbf{d} = \frac{41.667^2}{2(0.7)(9.81)}$$

**d = 152.954m**

**Case (ii)** If the vehicle moves 165km/hr,

Stopping distance, $\mathbf{d} = \frac{v^2}{2\mu g}$, $\mathbf{d} = \frac{45.833^2}{2(0.7)(9.81)}$, **d = 152.954m**

**Case (iii)** If the vehicle moves 180km/hr,

Stopping distance, $\mathbf{d} = \frac{v^2}{2\mu g}$, $\mathbf{d} = \frac{50^2}{2(0.7)(9.81)}$, **d = 182.030** m

**Case (iv)** If the vehicle moves 200km/hr,

Stopping distance, $\mathbf{d} = \frac{v^2}{2\mu g}$, $\mathbf{d} = \frac{55.556^2}{2(0.7)(9.81)}$, **d = 224.732**m

**Table 1:** Stopping distance of the vehicle (without spoiler) in meters

| **Speed** | **150 (km/hr)** | **165 (km/hr)** | **180 (km/hr)** | **200 (km/hr)** |
|---|---|---|---|---|
| **Stopping Distance in m** | 126.412 | 152.954 | 182.030 | 224.732 |

**Stopping Distance of the Vehicle for Various Speeds (With Spoiler)**

**Table 2:** Pressure developed on the spoiler (for various speeds and various AOA)

| **SPOILER ANGLE/SPEED** | **150 Km/hr** | **165 km/hr** | **180 km/hr** | **200 km/hr** |
|---|---|---|---|---|
| **8°** | 821.97 | 1009.9 | 1200.5 | 1486.04 |
| **12°** | 839 | 1039 | 1241 | 1529 |
| **15°** | 884 | 1065 | 1268 | 1570 |
| **18°** | 947 | 1146 | 1332 | 1653 |
| **20°** | 1015.7 | 1237 | 1436.71 | 1797.93 |
| **22°** | 854.6 | 1030.17 | 1234.16 | 1506.46 |
| **23°** | 881 | 1056.57 | 1266.84 | 1561.24 |
| **25°** | 807 | 965 | 1152 | 1432 |

| | | | | |
|---|---|---|---|---|
| **$30^o$** | 815.6 | 986.24 | 1175.07 | 1434.23 |
| **$35^o$** | 789 | 953 | 1129 | 1391.78 |

**Table 3:** Force developed on the spoiler (for various speeds and various angle of attack) in Newton

| SPOILER ANGLE/SPEED | 150 Km/hr | 165 km/hr | 180 km/hr | 200 km/hr |
|---|---|---|---|---|
| **$8^o$** | 382 | 469.6 | 558 | 690.9 |
| **$12^o$** | 390 | 483 | 577.1 | 710.9 |
| **$15^o$** | 411.1 | 495 | 589.6 | 730.1 |
| **$18^o$** | 440.4 | 532.9 | 619.4 | 768.7 |
| **$20^o$** | 472.3 | 575.6 | 668.1 | 836 |
| **$22^o$** | 397.4 | 478.9 | 573.8 | 700.3 |
| **$23^o$** | 409.7 | 491 | 589.1 | 725.9 |
| **$25^o$** | 375.3 | 448.7 | 535.7 | 665.8 |
| **$30^o$** | 379.3 | 458.5 | 546.4 | 666.8 |
| **$35^o$** | 366.9 | 443.2 | 524.9 | 647.2 |

**Stopping Distance of the Vehicle for Various Speeds And Various AOA**

**If the Angle of Attack (AOA) = $8^0$**

**Case (i)** If the vehicle moves 150km/hr, topping distance**, d =** $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$Stopping distance**, d =** $\frac{41.667^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+382}\right)$, **d = 121.7 m**

**Case (ii)** If the vehicle moves 165km/hr,

Stopping distance**, d =** $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$

Stopping distance**, d =** $\frac{45.954^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+469.6}\right)$**, d = 146 m**

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**Case (iii)** If the vehicle moves 180km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$

Stopping distance, **d** = $\frac{50^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+558}\right)$

**d = 172.3 m**

**Case (iv)** If the vehicle moves 200km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$Stopping distance, **d** = $\frac{55.556^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+690.9}\right)$

**d = 210.1 m**

**2. If the Angle of Attack (AOA) = $12^0$**

**Case (i)** If the vehicle moves 150km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$Stopping distance, **d** = $\frac{41.667^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+390}\right)$, **d = 121.6 m**

**Case (ii)** If the vehicle moves 165km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$,Stopping distance, **d** = $\frac{45.954^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+483}\right)$

**d = 145.8 m**

**Case (iii)** If the vehicle moves 180km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$

Stopping distance, **d** = $\frac{50^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+577.1}\right)$, **d = 172 m**

**3. If the Angle of Attack (AOA) = $20^0$**

**Case (i)** If the vehicle moves 150km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$, Stopping distance, **d** = $\frac{41.667^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+472.3}\right)$

**d = 120.7 m**

**Case (ii)** If the vehicle moves 165km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$, Stopping distance, **d** = $\frac{45.954^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+575.6}\right)$

**d = 144.6 m**

**Case (iii)** If the vehicle moves 180km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$, Stopping distance, **d** = $\frac{50^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+668.1}\right)$

**d = 170.5 m**

**Case (iv)** If the vehicle moves 200km/hr,

Stopping distance, **d** = $\frac{v^2}{2\mu g}\left(\frac{m}{m+F_d}\right)$, Stopping distance, **d** = $\frac{55.556^2}{2(0.7)(9.81)}\left(\frac{9908.1}{9908.1+836}\right)$

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**d = 207.3 m**

**Table 4:** Stopping distance of the vehicle (for various speeds and various AOA) in m

| SPOILER ANGLE/SPEED | 150 Km/hr | 165 km/hr | 180 km/hr | 200 km/hr |
|---|---|---|---|---|
| **8°** | 121.7 | 146 | 172.3 | 210.1 |
| **12°** | 121.6 | 145.8 | 172 | 209.7 |
| **15°** | 121.4 | 145.7 | 171.8 | 209.3 |
| **18°** | 121 | 145.2 | 171.3 | 208.6 |
| **20°** | 120.7 | 144.6 | 170.5 | 207.3 |
| **22°** | 121.5 | 145.9 | 172.1 | 209.9 |
| **23°** | 121.4 | 145.9 | 171.8 | 209.4 |
| **25°** | 121.8 | 146.3 | 172.7 | 210.6 |
| **30 °** | 121.8 | 146.2 | 172.5 | 210.6 |
| **35 °** | 121.9 | 146.4 | 172.9 | 210.9 |

## CFD Analysis

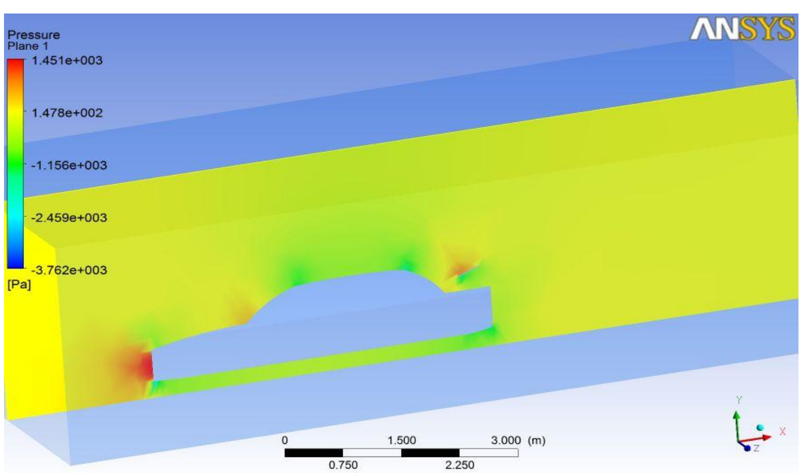

**Figure: 1** Analysis of spoiler in ***20*** ***0*** AOA and 150 km/hr speed

From **Figure:**1 the minimum and maximum pressure created is -3762Pa and 1451Pa, the maximum pressure created at spoiler is 1015.7Pa.

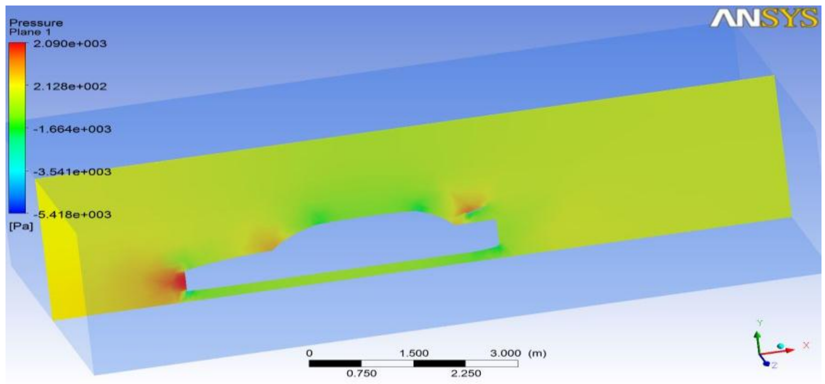


**Figure: 2** Analysis of spoiler in ***20*** ***0*** AOA and 180 km/hr speed

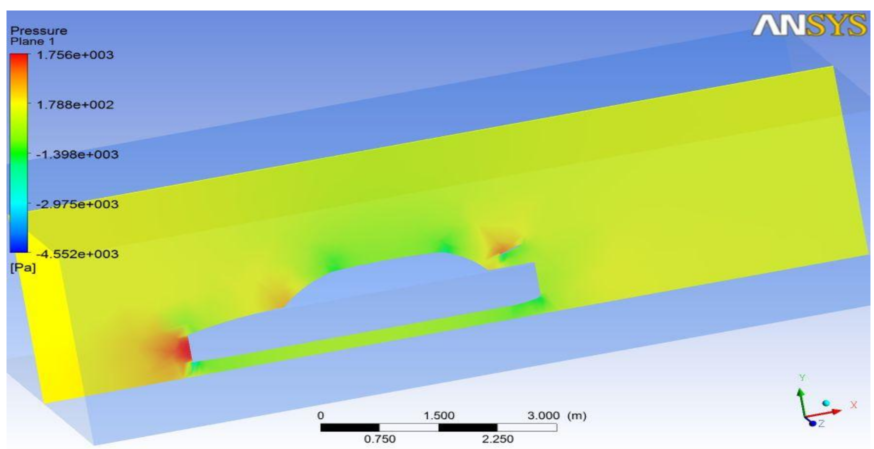


**Figure: 3** Analysis of spoiler in ***20*** ***0*** AOA and 165 km/hr speed

From **Figure:**2 the minimum and maximum pressure created is -4552Pa and 1756Pa, the maximum pressure created at spoiler is 1237Pa.

**Percentage reduction in stopping distance Vs Spoiler angle**

The graph below shows the % Reduction in stopping distance Vs spoiler angle. The keeping the reference as stopping distance of car model without spoiler, the percentage of stopping distance for car model with spoiler has been calculated. At angle $20^{o}$ the percentage of stopping distance is maximum compare to other values. The graph above shows the stopping distance Vs spoiler angle. With the help of pressure value which has been found from the analyzed model the stopping distance has been found, by solving the theoretical calculation the stopping distance has been found.

The stopping distance at angle $20^{o}$ for speed,

1. 150 km/hr = 130.7 m
2. 165 km/hr = 144.6 m

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3. 180 km/hr = 170.5 m
4. 200 km/hr = 207.3 m

## Conclusion

From the analysis part it is have found that the maximum downward pressure created at an angle $20^o$ and at angle $8^o$ where the minimum pressure has been produced. The stopping distance of the car model with spoiler has been reduced at an angle $20^o$. When the car is in running, at initial condition the spoiler angle kept is $8^o$ and the spoiler moves to angle $20^o$ when the brake is applied which is manually attached to break pedal. The effect of spoiler has become effective when the angle of spoiler increases downward. The stopping distance of car has been reduced to 4.52 % at a speed of 150 km/hr, and the friction between the tire and road has been increased due to the pressure acting downward which is considered as mass acting on rear of car at particular condition.If this technique is implemented in the day to day life the no of accidents can be prevented and reduced due to stopping distance of the vehicle.

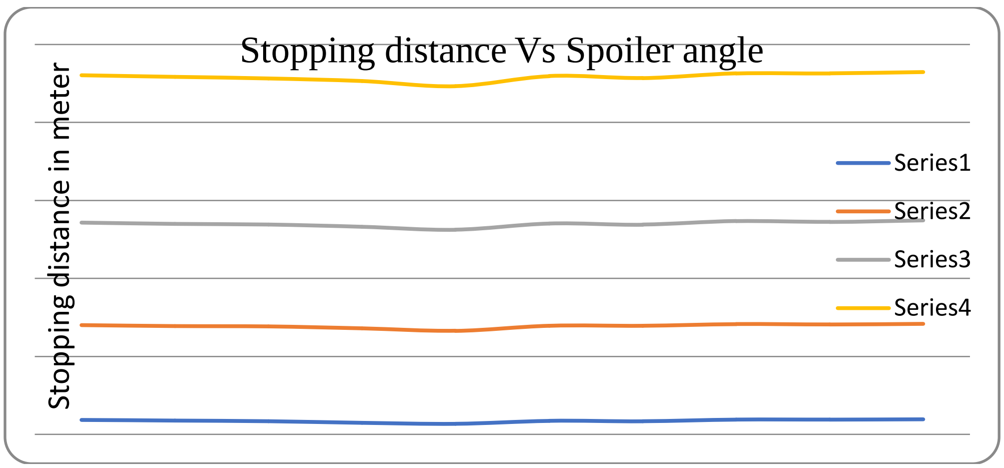


**Figure: 4** Stopping distance Vs Spoiler angle

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