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Numerical study of a kinetic detachment flow in the near-wake of an ahmed body

Abstract

To understand the impact of vehicle on the air pollution, it is significant to modelling a flow around it. For that we use a simplified car model Ahmed body. Numerical analysis was performed for a turbulent flow around an Ahmed body. A strong vortex structure in the near-wake could have a large significance on the atmospheric prediction, even on the power of a car. The turbulent model has been applied a standard $\kappa-\epsilon$ two equations model and the two-dimensional Reynolds Averaged Navier-Stokes (RANS) equations, are discretized with the second order upwind scheme. The SIMPLE algorithm, which is developed using control volumes, is adopted as the numerical procedure. Calculations were performed for different slopes of Ahmed body's rear window. The results reveal that, the takeoff zone is function to the rate of the flow. It is more prolonged upstream of the Ahmed body and less intense for 5 m/s and 40 m/s speeds. And more prolonged to the top and less intense for 25 m/s for the various slopes. Comparison of numerical results with the experimental plot available in the literature is satisfactory.

Keywords: ahmed body, wake, detachment, turbulent flow, CFD.

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Introduction

With the increase of world Automobile Park, the origin of automobile pollution becomes more and more extensive. In Europe, the contribution of the transport sector in the air pollution is 26% according to ACEA. Moreover, the sector is tributary of the petroleum products for more than 95% of its energy needs. According to,¹ the road transport sector accounts for approximately 80% of the goods traffic and 90% of the traffic of passengers in Africa. The total cost of the air pollution in some African's countries represents nearly 2 % of the GDP. The principal fields of research relate to the aerodynamics. Ahmed et al.,² performed a series of wind-tunnel experiments in order to examine the wake structure around typical automobile geometries. Author's identified three flow areas varying according to the slant angle α of the rear window ($\alpha < 12^\circ$; $12^\circ < \alpha < 30^\circ$ and $\alpha > 30^\circ$). Others authors³ show that generally, a detachment appears to 8% of the length L on the front part of Ahmed body. On both sides longitudinal plane of symmetry, the threads current lines to the wall wrap around two homes and escape from the wall forming two vortices counter-rotating.⁴⁻⁸ let show that, the upstream flow and the wake structure have a major responsibility in determining for drag model. This is based on determining of the equations drag and the turbulence model used. In most of the digital calculation, they use the two-equation model as discretization with finite volume method. We observed that these different studies presented a lack like to consider the upstream flow as purely laminar, which justifies the necessity to study the influence of the upstream turbulence inside the dynamic of downstream flow of a vehicle. This present work consists in doing a numerical study of kinetic detachment of a turbulent flow in the near-wake of an Ahmed Body. This study would help to well understand the effects of velocity fields on the pollutants dispersion. To lead well this study, we are going to present the mathematical formulation and the computation procedure employed. These methods have permitted

to calculate, the velocity fields around and in the near-wake of the Ahmed Body, and the characterization of the circulation zone, by using a model of bi-dimensional turbulence, isotropic, stationary and unsteady k-model (Figure 1).

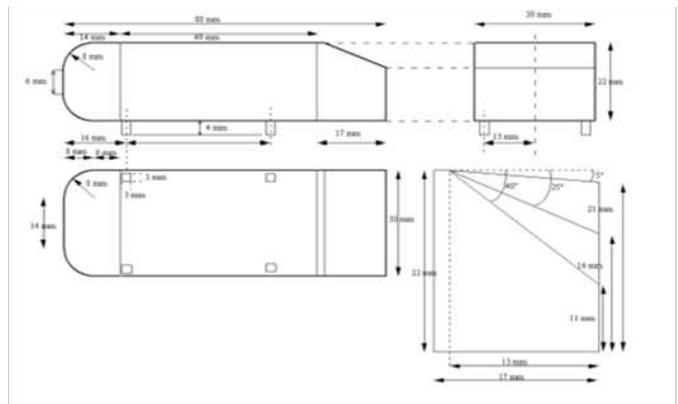


Figure 1 Geometry used for this simulation.¹⁰

Material and methods

The geometry used for 2D numerical simulation in the air is the Ahmed body (scale 1/50). The lower part is base and is positioned at a height $h = 4\text{mm}$ from the digital wind tunnel floor. The length L and the height H of the geometry are 80mm and 22mm.

The RANS approach of permitting a solution for the mean flow variables greatly reduces the computational effort.

$$\frac{\partial(\rho\varepsilon)}{\partial t} + \frac{\partial(\rho\kappa u_j)}{\partial x_j} = \frac{\partial\left(\left(\mu + \frac{u_t}{\sigma\kappa}\right)\frac{\partial\kappa}{\partial x_j}\right)}{\partial x_j} + G_\kappa + G_b - \rho\varepsilon - Y_M + S_\kappa$$

$$\frac{\partial(\rho\varepsilon)}{\partial t} + \frac{\partial(\rho\varepsilon u_j)}{\partial x_j} = \frac{\partial\left(\left(\mu + \frac{u_t}{\sigma\varepsilon}\right)\frac{\partial\varepsilon}{\partial x_j}\right)}{\partial x_j} + \rho C_1 S_\varepsilon - \rho C_2 \frac{\varepsilon^2}{\kappa + \sqrt{v\varepsilon}} + C_{1\varepsilon} \frac{\varepsilon}{\kappa} C_{3\varepsilon} G_b + S_\varepsilon$$

$$C_1 = \max\left(0.43 \frac{n}{n+5}\right), n = S \frac{\kappa}{\varepsilon}$$

$$S = \sqrt{2S_{ij}S_{ij}}$$

This approach is generally adopted for all practical engineering calculations, and is used with Realizable k–ε Turbulence Model.

Results

The grid of different cases study is presented at the following.

Figure 2

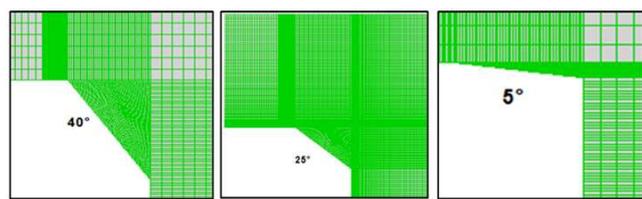


Figure 2 Grid distribution°.

Figure 3 below present the velocity profile around the Ahmed Body for different slack angle. We observe for different flow a detachment upstream Ahmed body like described by Ahmed at al.² The velocity of these zones go to $1.5U_\infty$.⁹ After comparison, we have to push calculations for three different speed range whose profiles are presented below. It arises of, more the angle is small, more turbulence is strong. And more the height of boundary layer is also low. We can conclude that: The volume of the takeoff zone varies function to the rate of the flow. It is more prolonged upstream of the Ahmed body and less intense for 5 m/s and 40 m/s speeds. And more prolonged to the top and less intense for 25 m/s for the various slopes (Figure 4).⁹ At the rear window, a conventional detachment bulb is observed. The flow takes off at the edge and then sticks a little farther (25 mm), enclosing a “dead zone” delimited by a boundary layer where the fluid returns back along the wall. The current lines do not entirely follow the surface of the body. The adverse pressure gradients involved in the recompression zones result in boundary layer detachment. These detachments then generate a wake of large size (which varies according to the angle of the rear window and the speed of the flow), preventing a total recompression of the flow. The difference in pressure between the front and the back of the body is then very important. The profiles speeds close to the leading edge are representative of the laminar boundary layers. However the flow inside the boundary layer remains laminar only at one certain distance starting from the leading edge and then become turbulent. Inside the turbulent boundary layer,

there remains, all against the wall, a very thin layer in almost laminar flow called laminar film. The distance between the leading edge and the point of transition where the boundary layer becomes turbulent is called critical length.¹¹

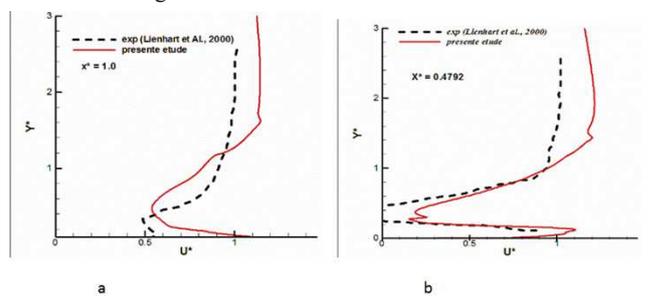


Figure 3 Velocity profile for Ahmed Body slack angle a) α = 5°, b) α = 5°.

Conclusion

The study shows that the vector field speed is the same as the one in experimental results. This result is satisfactory for a calculation completely in bidimension, unlike the experimental result that comes from the three-dimensional geometry.

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Conflict of interest

Teh author declares there is no conflict of interest.

References

- CEA–NU. *Rapport d'examen africain sur les transports*. Le secteur des transports en Afrique: importance, évolution et problèmes naissants. Commission économique des nations unies pour l'Afrique, Cameroun; 2009.
- Ahmed S, Ramm R, Falting G. *Some salient features of the time averaged ground vehicle wake 840300*. SAE technical paper series. Detroit, Cameroun; 1984.
- Spohn A, Gilliéron P. *Flow Separations Generated by a Simplified Geometry of an Automotive Vehicle*. Congrès IUTAM Symposium on Unsteady Separated Flows. Toulouse, France; 2002.
- Lienhart H, Stoots C, Becker S. Flow and turbulence structures in the wake of a simplified Car Model (Ahmed Model). *New Results in Numerical and Experimental Fluid Mechanics III*. 2002:323–330.
- Guilmineau E. Computational study of flow around a simplified car body. *Journal of Wind Engineering and Industrial Aerodynamics*. 2008;96(6–7):1207–1217.
- Chauhan B, Thundil R. Numerical Investigation of External Flow around the Ahmed Reference Body Using Computational Fluid Dynamics. *Research Journal of Recent Sciences*. 2012;1(9):1–5.
- Alonso–Estébanez A, Pascual–Muñoz P, Yagüe C, et al. Field experimental study of traffic-induced turbulence on highways. *Atmospheric Environment*. 2012;61:189–196.
- Deepak K, Paul A. Computational Study of Flow around a Simplified 2D Ahmed Body. *International Journal of Engineering Science and Innovative Technology (IJESIT)*. 2013;2(3):1–6.
- Tientcheu–Nsiewe M, Tcheukam–Toko D, Murzyn F, et al. Numerical

- Study of a Turbulent Flow in the Near-Wake of an Ahmed Body. *American Journal of Environmental Engineering*. 2016;6(6):157–163.
10. Gosse K. *Etude expérimentale de la dispersion d'un scalaire passif dans le proche sillage d'un corps d'Ahmed*. Thèse de doctorat / Faculté Des Sciences De L'université De Rouen, France. 2005. 177 p.
11. Tcheukam–Toko D, Kongue L, Koueni–Toko CA, et al. Numerical Simulation and Experimental Validation of Boundary Layer Generated by a Turbulent Flow on a hydraulically Smooth Bed. *Res J of Applied Sci*.2012;7(2):108–112.