Commentary
Volume 14:1, 2023

Journal of Physical Mathematics

ISSN: 2090-0902

Open Access

Analyzing the Effects of Wind Tunnel Interference on Numerical Wheel Aerodynamic Prediction

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Description

OEMs strive to improve the energy efficiency of their fleets in order to meet customer demands for reduced CO_2 emissions or extended vehicle driving range, as well as new legislation. Aerodynamic drag is a passenger vehicle's greatest resisting force at speeds greater than 80 kilometres per hour. It is common knowledge that a vehicle's wheels can account for 25% or more of its total drag, making them an important consideration when reducing aerodynamic resistance. The wheels' rotation, detailing, and bluff-body shape create a complicated flow that is difficult to comprehend and simulate. Nevertheless, experiments and computational fluid dynamics (CFD) are frequently used together or in conjunction to gain a deeper understanding of these regions [1].

However, these kinds of simulations are typically carried out in virtual domains that resemble open road conditions. In these domains, a large computational box with minimal obstruction and a fully moving ground plane are utilized. In contrast to wind tunnel tests, which are used for vehicle development, certification, and numerical model validation, this is more representative of what happens on the road. Additionally, wind tunnels continue to be an essential tool for automobile manufacturers because numerical simulations require hours or even days for each new design, whereas wind tunnel results can be obtained in minutes for new designs. As a result, it is essential to comprehend how the flow around the wheels is affected by the interference caused by the wind tunnel's moving ground system and the geometry of the wind tunnel [2].

Numerous studies on the flow around wheels have previously taken into account a simplified isolated wheel. The effects associated with the encapsulation of the wheels within the wheelhouses were missing from these works, despite the fact that they provided valuable insight into the complexity of the phenomena. Numerous studies on the difference between stationary and rotating boundary conditions for passenger vehicle wheels have demonstrated the significance of wheel rotation and its significant impact on drag. By comparing stationary and rotating wheels and identifying the predominant flow characteristics in both instances, this was further established [3].

Used wind tunnel tests and numerical simulations to examine how tyre patterns affect the drag of a full-size car. They discovered that the numerical simulations accurately reproduced the effect of adding rain grooves to a slick tire, whereas the prediction of the effect of adding lateral grooves, particularly for the closed rim, was less accurate. In a study involving a variety of rim designs, it was also discovered that the wind tunnel results of a fully closed rim could not be accurately simulated. The conditions of an open road simulation were used in both works. When a notchback scale model was simulated with the geometry of an open jet wind tunnel included, flow predictions generally improved. The wind tunnel was also found to be more in line with the experiments when comparing various under body configurations. Compared to open road simulations, modeled a slotted wall wind tunnel and obtained a better prediction of absolute drag values [4].

However, there was not always an improvement in the delta coefficients between configurations. The areas of strong acceleration like around the wheels and between open and closed rims, saw the largest differences between the two domains. The ability to predict wheel flows has only been the subject of a few studies that have examined the effect of including the wind tunnel geometry in numerical simulations. Struts held the wheels in place and separated them from the body of the vehicle. They discovered that the rim differences could be accurately predicted by comparing experiments and numerical simulations that included a portion of the wind tunnel's geometry. Despite the absence of open road simulations, the inclusion of wheel struts had a significant impact. Using a DrivAer full-scale model, the current work aims to determine how including the wind tunnel geometry and its ground simulation system affects the accuracy of numerical simulations. The ability of the CFD method to predict changes in drag for various tyres and rim combinations is the focus of the work. The physical measurements taken in the wind tunnel are compared to the results of the computations [5].

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Received: 02 January 2023, Manuscript No. jpm-23-90420; **Editor assigned:** 04 January 2023, Pre QC No. P-90420; **Reviewed:** 16 January 2023, QC No. Q-90420; **Revised:** 21 January 2023, Manuscript No. R-90420; **Published:** 28 January 2023, DOI: 10.37421/2090-0902.2023.14.410

Conclusion

In terms of open and closed rims, it was discovered that open road simulations were three times more accurate than wind tunnel geometry simulations for predicting changes in drag, particularly for slick and rain grooved tires. The tyres with lateral grooves and open rims with slick and rain grooved tyres exhibit the greatest disparities between the two simulation setups. The predicted flow fields and forces are influenced by the ground simulation system and tunnel walls. The ground simulation system affects the interaction between the front wheel wakes and the rear wheels, while the blockage alters the separations at the tyre shoulder and outer rim surface.

Acknowledgement

None.

Conflict of Interest

None.

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How to cite this article: Zuijlen, Giorgio. “Analyzing the Effects of Wind Tunnel Interference on Numerical Wheel Aerodynamic Prediction.” *J Phys Math* 14 (2023): 410.