A study on unsteady vortical structures and substantial drag reduction

Project Representative

Keiji SUMITANI

Vehicle Engineering Development Division, TOYOTA MOTOR CORPORATION

Authors

Yusuke SUGITA[*1], Kazuhiro MAEDA [*1], Keiji SUMITANI [*1], Chisachi KATO[*2],
Yoshinobu YAMADE[*2], Yasumasa SUZUKI[*2], Yuichi HIROKAWA[*3], Hitoshi UEHARA[*3]

＊1 Vehicle Engineering Development Division, TOYOTA MOTOR CORPORATION

＊2 Institute of Industrial Science, the University of Tokyo

＊3 Japan Agency for Marine-Earth Science and Technology

Abstract

The aerodynamic drag has the unsteady fluctuations in time line due to the various sizes of vortices which are appearing, growing, separating and vanishing around a vehicle. In this paper, we analyze the unsteady flow using Large Eddy Simulation (LES), and we clarify the fluctuating flow structure around a vehicle with the new reduction method of aerodynamic drag. From the analyses of vehicle model with wheel, it is clarified that (1) the vortex ring behind the vehicle is periodically appearing as well as in case of vehicle model without wheel, and (2) the wake of front wheel interferes with rear wheels and forms large separation, which causes the aerodynamic drag fluctuations with increasing the mean aerodynamic drag. And, it is clarified that the following are effective as method of controlling the fluctuations for aerodynamic drag reduction: (1) increasing the distance between the vehicle and vortex ring by uniformly controlling the boundary layer thickness of the rear end of the vehicle, (2) suppressing the interference with flow structure around front and rear wheels.

Keywords: Vehicle, Aerodynamic, Unsteady Flow, LES, Drag, Wheel