

Investigation of the Effect of Automotive Tire Tread Patterns on Vehicle Aerodynamic Drag

Shingo Ida¹⁾ **Masahiro Nagase**¹⁾ **Satoru Yamada**²⁾ **Ikuo Tanaka**²⁾

1) Sumitomo Rubber Industries, Ltd.
3-6-9 Wakinohama-cho, Chuo-ku, Kobe, Hyogo 651-0072, Japan (E-mail: s-ida.az@srigroup.co.jp)

2) Dassault Systemes
ThinkPark Tower 20F, 2-1-1, Osaki, Shinagawa-ku, Tokyo, 141-6020. Japan

KEY WORDS: Heat • fluid, aerodynamic performance, computational fluid dynamics, tire tread pattern [D1]

Vehicle aerodynamic drag reduction is increasingly important for improving fuel economy and reducing environmental impact, and tires can account for a substantial portion of total drag (reported up to $\Delta C_D = 0.015$ in prior work), although most existing studies have focused on tire cross-sectional shape or grooves aligned circumferentially/axially. This study used CFD based on the lattice Boltzmann method to quantify how tread-pattern differences, especially oblique V-shaped grooves, affect vehicle drag. Two vehicle models were analyzed with tires sharing the same cross-section but different tread patterns: a summer tire with connected circumferential main grooves, a V-groove tire, and a V-groove tire with one central main groove. Tire deformation under inflation and load was reproduced by FEM; tread rotation was modeled by morphing plus an immersed boundary method, sidewall rotation by boundary conditions, and wheel rotation by a sliding mesh method. At 140 km/h over an infinite moving ground, drag changes were evaluated as ΔC_D relative to the summer tire, using vehicle frontal area even for tire C_D . As shown in Fig. 1, V-groove tires reduced front-side pressure but also lowered rear-side pressure due to stronger wake vortices behind the tire; adding a central main groove retained the front-pressure benefit while mitigating rear vortex strength and increasing rear pressure. For both vehicles, tread-pattern differences changed tire contribution by up to $\Delta C_D = 0.003$ for four tires. Table 1 further indicates that lower tire C_D does not always translate to lower vehicle C_D , and Fig. 2 shows that tread-pattern changes alter the strength and position of rear-vehicle vortices. Overall, tread design influences both local tire aerodynamics and whole-vehicle drag, with vehicle-level ΔC_D impact up to 0.006.

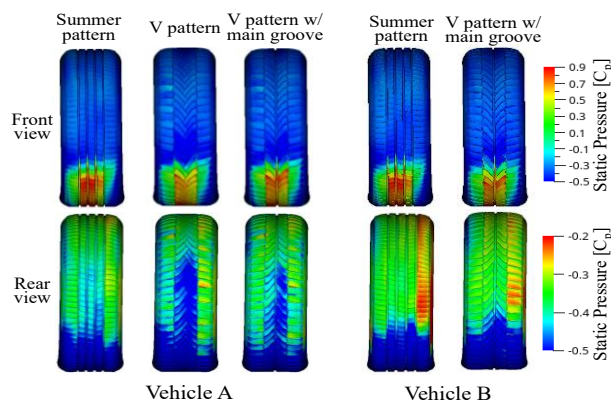


Fig. 1 Pressure Distribution on the Front Left Tire

Table 1 ΔC_D of Summer Pattern and V-Pattern with Main Groove for Each Vehicle Configuration

Vehicle	ΔC_D		
	Tire	Other	Total
Vehicle A	-0.003	+0.004	+0.001
Vehicle A Modified spoiler	-0.002	-0.002	-0.004
Vehicle A Modified spoiler Closed wheel	-0.002	-0.004	-0.006
Vehicle B	-0.003	0.000	-0.003

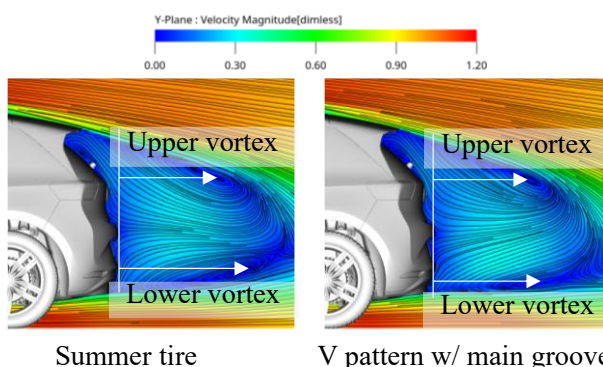


Fig. 2 Velocity Distribution and Wake Vortices of Vehicle A with Different Tire Models