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REVIEW OF CFD STUDIES FOR ANALYZING PASSENGER TRAIN AERODYNAMICS

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Summary: This review paper examines the application of Computational Fluid Dynamics (CFD) in the aerodynamic analysis and design optimization of passenger trains. Over the past few decades, CFD has become an indispensable tool in evaluating and improving the aerodynamic performance of train designs, particularly in the context of energy efficiency, operational safety, and passenger comfort. As passenger trains operate at increasingly higher speeds, understanding the aerodynamic forces acting on the train becomes essential for minimizing drag, enhancing fuel efficiency, and reducing environmental impact.The primary aim of this review is to summarize the current state of CFD studies applied to medium- and semi-high-speed passenger trains, focusing on key areas such as drag reduction, flow control, crosswind stability, tunnel effect, and the impact of train shape and configuration on overall aerodynamic performance. The paper discusses the different turbulence models and simulation techniques used in these CFD studies, including the commonly used k-ε, k-ω and Reynolds-Averaged Navier-Stokes (RANS) models, which are essential for capturing the complex flow patterns around train bodies at high speeds. Additionally, the review highlights the importance of advanced mesh generation techniques, boundary conditions, and turbulence modeling in accurately predicting the aerodynamic forces and ensuring reliable results. One of the key areas covered is the study of aerodynamic drag, which significantly affects the energy consumption of passenger trains. CFD simulations have been widely used to study the effects of train body shape, such as the streamlined design of the front nose, the shape of the rear, and the train's undercarriage, on drag reduction. Another critical issue addressed in this review is the tunnel effect, which occurs when a train travels through a tunnel, leading to a rapid increase in pressure and creating a pressure wave that can cause discomfort to passengers and increased stress on the train structure. CFD has proven to be a valuable tool in predicting and mitigating the tunnel effect, allowing designers to optimize train shapes and minimize abrupt pressure changes. The study also covers crosswind stability, which is a significant concern for high-speed trains traveling through open, exposed areas.CFD enables the design of trains that can operate more efficiently, reducing fuel consumption and minimizing the environmental impact of passenger rail transport. In conclusion, CFD plays a crucial role in the aerodynamic optimization of passenger trains.

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