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# Multi-objective aerodynamic shape optimization of a streamlined high-speed train using Kriging model



**Key words:** High-speed train, Aerodynamic force, Optimization, Surrogate model, Streamlined area

- With continuous changes to energy-saving requirements, the task of train aerodynamic optimization becomes important.

- Traditional aerodynamic optimization of a high-speed train is carried out assuming the same shape of the head and tail cars, which ignores the combined effect of the two cars on aerodynamic forces

- The streamlined structure of the train has different effects on the aerodynamics of the head and tail cars. In-depth study of these effects will help engineers improve their shape design capabilities.

# METHOD

## Multi-objective aerodynamic shape optimization

- **Surrogate model**
- **Train aerodynamics**
- **NSGAIII optimization algorithm**

Build a surrogate model and combine the distribution of the Pareto solution set to determine the design variables that have a greater impact on the aerodynamic performance of the head and tail cars

From the point of view of mechanism, study the specific influence of each design variable on the aerodynamic force of the head and tail cars

Propose a new train shape optimization scheme and compare it with the traditional optimization scheme

# RESULTS AND CONLUSIONS

- The geometric characteristics of the streamlined area shape have different effects on the aerodynamics of the head car compared with the tail car. Using the premise that the shapes of the head and tail cars remain the same, there will be many restrictions and contradictions in the aerodynamic optimization process of high-speed trains. This makes it very difficult to optimize all of the objectives (drag force of head car, tail drag, and lift force of tail car) to an optimal level. If this premise is discarded, optimization will be much better.

- The width of the nose has a great influence on the resistance of the head car, and a wider nose will reduce the resistance of the head car. However, as the nose width increases, both the drag and the lift of the tail car first decrease and then increase sharply. This leads to the optimization directions for reducing the resistance of the head and tail cars being largely opposed.

- The two objectives of reducing the drag of the tail car and reducing the lift of the tail car have greater consistency in the optimization process. Reducing the curvature of the driver's cab window, reducing the curvature of the lateral control line at the lower part of the streamlined area, and appropriately reducing the nose width are all helpful for reduc-ing both the drag and lift of the tail car. Increas-ing the vertical height of the nose junction can also significantly reduce the lift of the tail car.

- The aerodynamic shape optimization design of the train must consider not only the conventional operating conditions, but also many other factors. It is very common for trains to run in a crosswind environment, tunnel environment, or intersecting. Under these circumstances, how to adjust the shape of the head and tail of the train is still worthy of further study.