HyperWorks

Nippon Sharyo Uses AcuSolve Simulation to Make Japan's Bullet Trains Safer, More Comfortable

NIPPON SHARYO

Key Highlights

Industry
Rail

Challenge
Increase railway vehicles comfort and safety through evaluation of aerodynamic pressures

Altair Solution
CFD simulation with AcuSolve

Benefits
- A single application for comprehensive CFD analysis
- Better designed railway vehicles

Customer Profile

Nippon Sharyo, based in Nagoya, Japan, has been building trains since the late 19th century. Today it is one of Japan's most prolific manufacturers of railroad cars; its 1,100 employees build various types of trains such as express, commuter, metro & subway and light rail vehicles for railroad systems all over the world. The company also designs and produces cars for the growing fleet of bullet trains in Japan. Since the development of the first bullet train, which traveled at more than 200 kilometers per hour, in 1964, Nippon Sharyo has manufactured more than 3,200 cars for the pacesetting trains, with 8 to 16 cars for each train. The latest versions of the bullet train are capable of carrying passengers at speeds of 300 km/h.

The Challenge: Aerodynamic pressures

If only one bullet train whizzed across a clear landscape, its aerodynamic design would be a relatively uncomplicated matter. But Japan's bullet trains speed into and out of tunnels on their routes, and they pass other bullet trains in open areas and within tunnels. When a train runs into a tunnel, the pressure wave traveling in front of the leading car can cause a very loud noise and vibration, so designers are challenged with trying to make the change in pressure smaller when entering and exiting the tunnel by shaping the nose of the lead engine.

The issue becomes even more difficult when two trains pass by each other inside a tunnel. Each train has built up a powerful bow wave,

Keywords: Rail, Nippon Sharyo, HyperWorks, AcuSolve, CFD, Bullet Train

Nippon Sharyo Success Story

“AcuSolve allows us to build better products. The bullet-train program grows more complex every year; with the physics problems growing more complex, simulation helps us find the best answer.”

SATO Tetsuro
Manager of Root Technology Group, Technology Integrating Dep., Rolling Stock Div.
Nippon Sharyo, Ltd.

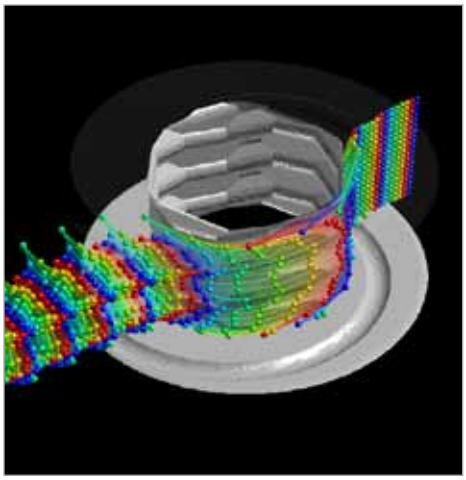
and the collision of these waves when the trains pass can produce a tremendous force. One train actually is pushed away from the other and then, when the pressure equalizes, is pulled back toward the other train. If these forces are not carefully considered in the design phase, the train can actually derail. At the least, it could be a jarring experience for passengers.

Other forces must be accounted for as well, if passenger safety and comfort are to be maximized. These include unsteady loads when the trains pass in open landscape, the impact of crosswinds on the high-velocity vehicle, and noise originating from the door frame, along with less exotic issues like providing optimal air flow from heating and air conditioning systems.

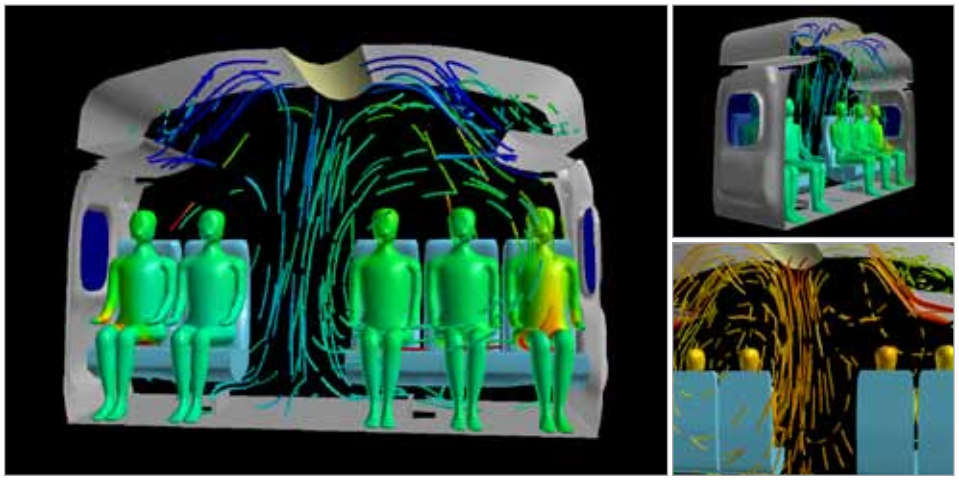
The Solution: CFD simulation with AcuSolve

Building physical prototypes of these trains is an expensive proposition, so Nippon Sharyo uses Altair’s AcuSolve computational fluid dynamics (CFD) software to examine the complex airflows that impact the train and its passengers in three areas:

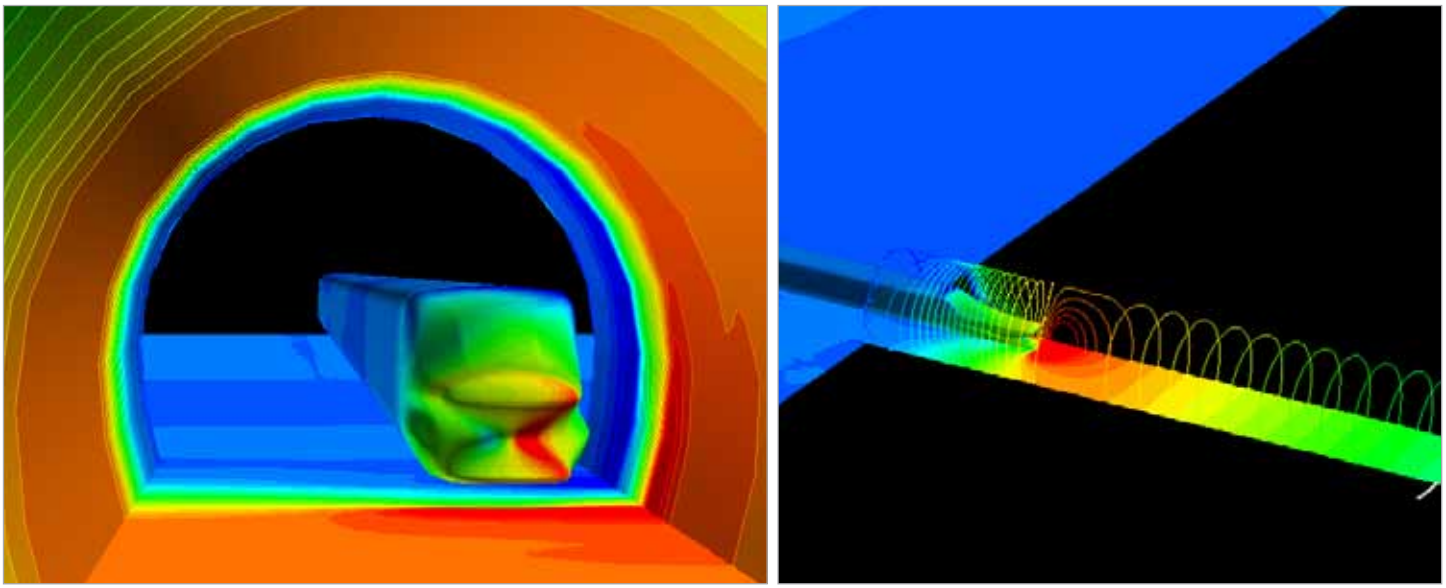
- Safety: Estimating crosswind loads, wind velocities at ground level and the aerodynamics of passing trains
- Amenities: In addition to tunnel entry noise, HVAC flow and aeroacoustics, excitation of the train structure can lead to vibration in the car that trails the engine. AcuSolve allows engineers



Simulation of the Friction Stir Welding (FSW) tool



HVAC flow simulation inside a passenger car



Tunnel entry noise evaluation with AcuSolve

to break down the trailing vortices and analyze their flow.
- Manufacturing: Designing the friction stir welding (FSW) joining process used in constructing the car.

Nippon Sharyo was one of the very first companies to use AcuSolve, following its development in 2002. Today, the company's focused group of simulation engineers relies on the HyperWorks suite, particularly AcuSolve, and HyperMesh to help design the company's trains to make them more comfortable for occupants and to continue to extend their safety features.

"AcuSolve allows us to build better products," said Sato Tetsuro, Manager of Root Technology Group with Nippon Sharyo. "The bullet-train program grows more complex every year, with quality and performance objectives measured on several criteria with different materials. With the physics problems growing more complex, simulation helps us find the best answer." On the external body, the company designs its trains not only to reduce drag but also to reduce noise from such phenomena as tunnel entry and rattling of the sliding passenger doors. Inside the vehicle, Nippon Sharyo uses AcuSolve to study complex air flows associated with the cabin's heating and cooling system and even ventilation in smoking areas. Heat from the human body and solar radiation are factored into these calculations with AcuSolve.

Results: A single application for comprehensive CFD analysis

Designers in other companies often use different software for examining external aerodynamics and airflows inside the cabin. AcuSolve, however, lets Nippon Sharyo use a single application to study both regimes—one code for both environments. As a result, costs can be reduced and vehicles brought to market faster and more efficiently.

With AcuSolve, train shapes have been optimized to minimize the noise of tunnel entry, and finite-element analysis to study aeroacoustics and the flow model has allowed the noise from the door frame to be significantly reduced.

To improve cabin flow, simulation with AcuSolve has enabled engineers to design HVAC inlets and outlets that are suitable for both summer and winter environments. Among the phenomena incorporated into the AcuSolve modeling are forced-air convection, free convection, radiation, turbulence, heat transfer, heat loads and solar radiation.

AcuSolve also has enabled engineers to optimize the friction stir welding tool and the welding parameters to improve productivity in the welding of train car sections.

"Numerical simulation conducted by AcuSolve is useful for getting ideas in making decisions," observed Tetsuro. "It helps us improve our railway vehicles."

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HyperWorks

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