Putting the Pressure on Roller Coaster Riders

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Courtesy of Vekoma Rides Manufacturing BV, Vlodrop, the Netherlands

Vekoma Rides Manufacturing BV is a market leader in the global amusement industry in the design and manufacture of family coasters, thrill coasters, and family attractions. Boasting a wide product range, Vekoma is responsible for such all-time favorites as the Boomerang, the Invertigo, the Suspended Looping Coaster, and the Junior Coaster. Vekoma's latest developments, the LSM coaster, the Flying Dutchman, the Giant Inverted Boomerang, the Suspended Family Coaster, and the Tilt Coaster, are driving the roller coaster industry of the future by setting new standards for quality and innovation.

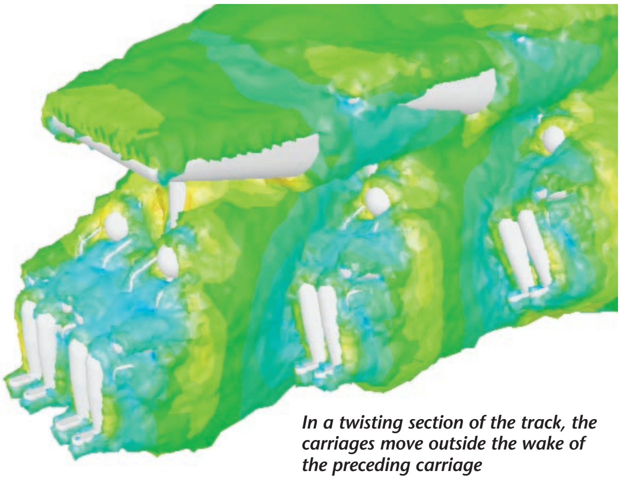
Vekoma has sought the assistance of FlowMotion for the optimization of their High Speed Suspended Looping Coaster Train. FlowMotion is a Dutch engineering consultancy firm specializing in fluid dynamics. Having gained experience with several CFD codes, FlowMotion has selected FLUENT for its ease-of-use in various industrial applications.

A roller coaster is essentially a gravity-powered train. When the train is pulled up the first hill, gravitational potential energy is transferred to the train. Once the train begins to descend, the gravitational potential energy is transferred to kinetic energy, the energy of motion. During the ride, there is a continuous conversion of energy back and forth between the two forms, but gradually energy is lost to friction and air resistance, and the latter can affect the speed and length of the ride. As modern roller coasters become faster and the rides longer, the structures increase in size. Because wind conditions are often more severe at greater heights, wind loading is particularly noticeable on taller roller coasters. To account for high speeds and wind loading, aerodynamics must play an essential part in the design of a modern roller coaster.

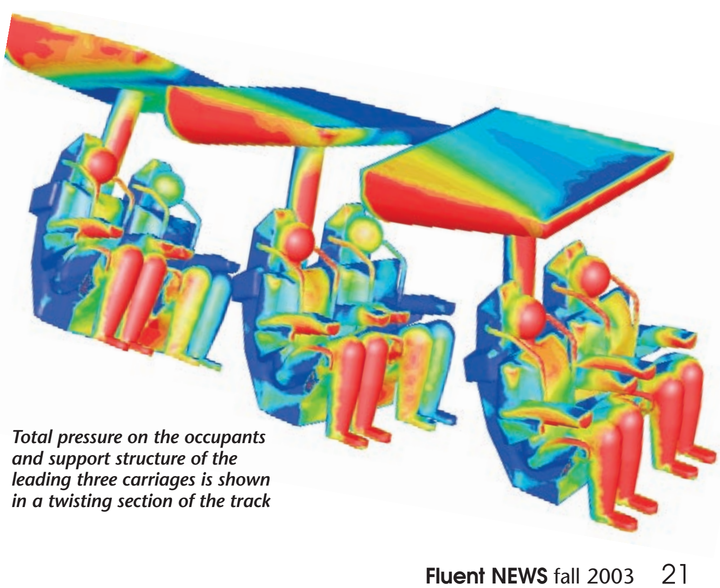
The CFD investigation was divided into two parts, in which a train with empty seats or filled with passengers was modeled. The geometry of a single two-seat carriage was created and copied into a short row to form a representative train. A volumetric mesh of tetrahedral cells was used. Steady-state simulations using the k-ε turbulence model were performed for several wind speeds and directions. Based on the CFD results, the aerodynamic coefficients were calculated.

The FLUENT simulations indicated that for the Suspended Looping Coaster, the size and shape of the wake behind the leading carriage is critical for the overall aerodynamic drag of the train. While extensive streamlining of the first carriage may reduce its wake, it can also lead to more exposure of the second carriage to the undisturbed wind, resulting in a higher overall drag. Also, in high speed twisting parts of the track, the drag is increased considerably when the individual two-seat carriages fan out and more frontal area of the train is exposed to the wind. Based on the CFD results, a redesign of the seat shape was done that balanced the operating requirements and resulted in a significant performance improvement. At Vekoma, CFD simulations using FLUENT have generated a new understanding of the behavior of their roller coasters and have given the designers new inspiration to develop even more exciting rides in the future. ■

The Jubilee Odyssey ride at Fantasy Island, Lincolnshire, England is one example of a Suspended Looping Coaster



In a twisting section of the track, the carriages move outside the wake of the preceding carriage



Total pressure on the occupants and support structure of the leading three carriages is shown in a twisting section of the track