A new racing bike designed with ANSYS CFD won Commonwealth Games Gold and Ironman New Zealand.
In a sport in which every fraction of a second counts, the Chrono Evo II and Pista Evo II are Avanti Bikes’ fastest racing machines ever. At the 2010 Commonwealth Games, Alison Shanks rode her Avanti to capture gold in the women’s 3,000 meter individual pursuit; Cameron Brown rode his to victory at the Ironman New Zealand Triathlon in 2011. The project recently received the highest honors at the New Zealand Best Design Awards and a prized 2012 International Red Dot Design Award.

Frames for the time trial/triathlon (Chrono) and track (Pista) racing bikes were developed with fluid dynamics software from ANSYS. To help design the bikes, Dynamics Sports Engineering (DSE) engineers first used ANSYS CFD-Flo computational fluid dynamics (CFD) software to optimize the aerodynamics of individual components, such as the head tube, fork, bottom bracket and seat stay attachment. Next, engineers performed a systems simulation as they combined components into a full structure and tested the aerodynamic performance of the assembly at crosswind angles from −20 degrees to +20 degrees. Engineers manually iterated through a series of designs to an optimized solution that provided about a 20 percent reduction in drag compared to previous models. This drag reduction could decrease a rider’s time by approximately one minute over one hour of race time.

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LEADING RACING BIKE MANUFACTURER

Avanti released its first bike in 1985 and now offers more than 110 models, distributed primarily in New Zealand and Australia. Avanti contracted DSE, a small New Zealand engineering consulting firm that comprised two engineers at the time, to help design its new bike from an aerodynamic standpoint. Founding DSE engineer David Higgins has since gone to work for Avanti.

DSE engineers used CFD-Flo, which is specifically geared to product designers and driven by the power of ANSYS CFX. The software provided direct access to the initial design of the bike produced in Pro/ENGINEER®. A wizard guided engineers through the simulation physics setup, including specification of boundary conditions, and verified that all necessary information was entered. CFD-Flo includes leading-edge technology that provides fast run times and quick project turnaround to efficiently integrate CFD into a design process using the ANSYS Workbench environment.

DSE began working on the aerodynamic properties of the components in the approximate order that these bike parts meet the airstream. The Union Cycliste Internationale (UCI), the governing body of bicycle racing, specifies that frame tubes must be no more than three times as long as their width with a maximum depth of 80 mm and a minimum width of 25 mm. The frame design consists of two connected triangles, one toward the front of the bike and the other toward the rear. The key difference between the time trial/triathlon and track bikes is that the former is designed for typical outdoor wind conditions while the latter is designed for the zero-wind conditions experienced indoors.

FORK AND FRONT JUNCTION DESIGN

To create each fork blade, the company first evaluated a proprietary fork design consisting of paired airfoil sections; engineers determined that this was not the optimal solution for the bike. The proprietary design directs the airstream away from the wheel. In reality, track bikes like the Avanti Pista Evo II use disk wheels, for which it is desirable to attach the flow to the back side of the wheel (so the flow envelops the wheel). Engineers decided to use a conventional fork and evaluated different fork depths and evaluated at a number of different airstream angles, targeting the optimized angle at about +10 degrees. Based on the results, they developed a series of new fork designs. The end result: The company delivered a design that provided an isolated drag force of 27 grams of force (gF), compared to 36 gF for the proprietary fork design (which had, to this point, been considered state of the art).

Engineers then moved on to other frame components, starting with the front junction, where the front tube attaches to the top tube just below the handlebars. In the previous-generation design, the brake was attached to the rear of the fork, the handlebars were above the top tube, and the top tube slanted toward the front of the bike. Based on analysis results, engineers evolved the design so that the handlebars aligned horizontally with the top tube, and the brake was internal to the fork. Housing the brake inside the streamlined fork structure reduced the turbulent effects of the brake. Additionally, both the time trial/triathlon and track bikes are much deeper front to back. The new design improves handling wind coming from the side of the bike, converting it into side force rather than drag.

REAR JUNCTION DESIGN

Next, engineers addressed the rear junctions of the bikes, where the seat tube, top tube and seat stays come together. The previous-generation bikes had a relatively wide frame member with the rear brake attached near the top of the seat stays. CFD showed relatively poor aerodynamic performance for this area, so they redesigned it from scratch, reshaping the seat tube to match the rear-wheel profile. The team tried nine different ways to attach the seat stays to the seat tube, ending up with a symmetric National Advisory Committee for Aeronautics (NACA) profile. Engineers also redesigned the bottom bracket area, where the pedals connect to the frame. Housing the rear brake behind the bottom bracket and under the chain stay greatly reduced drag compared to having it in a conventional road bike position at the top of the seat stays.

Engineers also provided complete internal cable routing, making both versions of the Evo II the first bikes to have every cable integrated with the frame. The cables are routed internally from the levers, through to the derailleurs and brakes including through the handlebars and stem. Internal cables offer reduced drag as well as enhanced visual aesthetics.

COMPLETE STRUCTURE DESIGN

Once the engineers were satisfied with the bikes’ individual elements, they combined the components as a system and analyzed the entire structure. It took approximately eight hours to solve each complex full-bicycle model. The initial results were good; still, the team made further improvements with some additional fine-tuning at the systems level. The first prototypes were then built and tested in a wind tunnel at various wind angles. Testing confirmed that the new bicycle designs developed with ANSYS software delivered 20 percent less drag than the previous-generation designs.

Testing confirmed that the new Avanti Evo II bicycle designs developed with ANSYS software delivered 20 percent less drag than the previous designs. This could reduce a rider’s time by one minute for every hour of riding.
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Avanti’s resulting Evo II bikes have received rave reviews from the bicycle press. Biking Australia reported, “The result is a fantastic-looking bike that is a far cry from Avanti’s previous models. Avanti has taken advantage of the latest technology available to bring to the market a bike wanting for nothing. The carbon fiber frame is the result of an exhaustive design process. It takes the concept from sketch to reality via numerous steps that, no matter how seemingly insignificant, can be crucial in the way the final-functioning bike behaves both in response to riders’ commands and to the environmental conditions.”

The judges of the product category from the New Zealand Best Design Awards described Avanti’s award-winning bike as “a world-class product demonstrating the highest standards of build, technology and New Zealand design ... This amazingly light performance machine demonstrates meticulous attention to detail. The design confidently represents New Zealand in one of the world’s most demanding and exacting sport and recreational arenas.”

Reference
www.dseng.co.nz

The bicycle components were simulated individually and as a complete system so that design tweaks could be made to optimize performance.
The Avanti Evo II bicycles — Chrono (top) and Pista (bottom) — were designed using simulation to deliver the performance required by world-class athletes.

Wind-tunnel testing correlated well with simulation predictions.

Avanti Riders

Avanti Triathlon and Time Trial Riders

Hamish Carter
Olympic Champion and Commonwealth Medalist

Cameron Brown
10-time Ironman Champion

Bevan Docherty
Olympic Medalist

Avanti Track Riders

Alison Shanks
World Champion and Commonwealth Gold Medalist

NZ Women’s Pursuit Track Team

Hayden Godfrey
World Champion