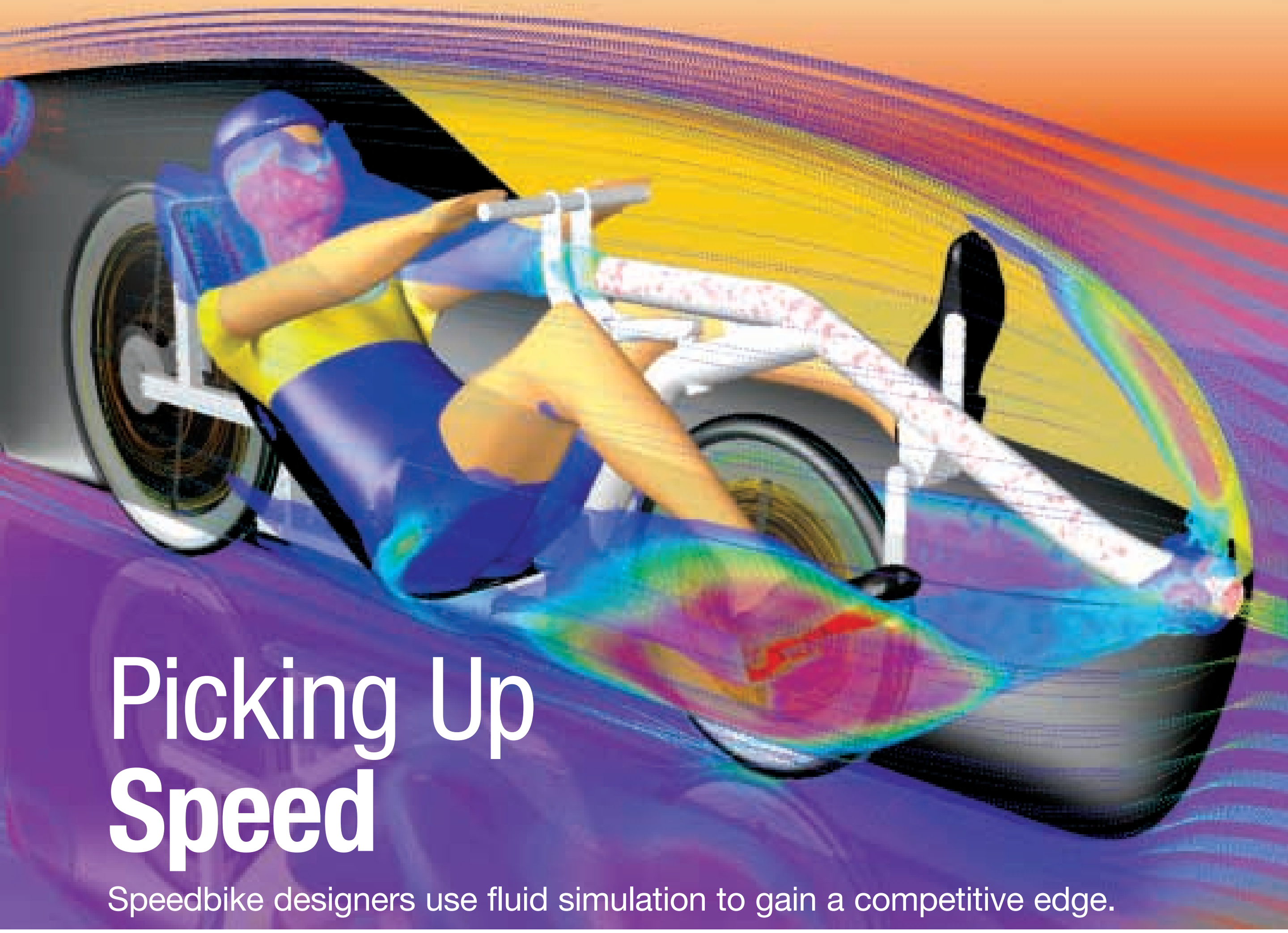
Speedbike designed in a cooperative effort between VRT-Speedbike e.V., ANSYS Germany GmbH, and Adam Opel GmbH



Picking Up **Speed**

Speedbike designers use fluid simulation to gain a competitive edge.

By Ralf Siber and Frank Werner, Adam Opel GmbH, Rüsselsheim, Germany
Guido Mertens, VRT-Speedbike e.V., Bergisch Gladbach, Germany and Marco Lanfrit, ANSYS Germany GmbH, Darmstadt, Germany

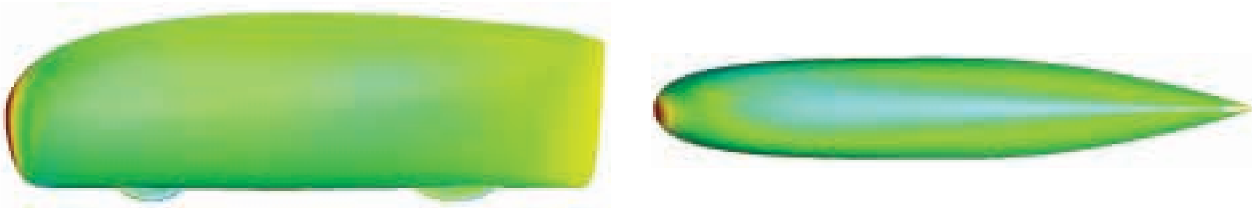
Speedbikes are the Formula One equivalent for human powered vehicles (HPV). They owe their ability to be faster than any other HPV to aerodynamics that are better than all other earth-bound vehicles. In order to achieve this state of the art, it is necessary to investigate both global and local aerodynamic effects and their interactions, in addition to analyzing the human factor (cooling, breathing, vision for navigation, safety). The similarities to automobile development are striking.

In 1994, the collaboration between Guido Mertens of VRT-Speedbike e.V. and the Institute for Plastics Processing (IKV) at RWTH Aachen University (notably Johannes Dyckhoff) led to the creation of the Speedbike Tomahawk 1. It was designed to surpass the existing distance record over one hour. Its development revealed that speedbike design in general had to address not only aerodynamics but also ergonomics and driving stability. The results of this development process were several long distance records between 1996 and 1999, including a record of over 82 kilometers in one hour set by rider Lars Teutenberg.

It became evident that, to further improve designs, each competitor would have to decrease the frontal area, due to asymptotically improved drag values. The project Speedhawk was launched as a cooperative effort between VRT-Speedbike e.V., ANSYS Germany and Adam Opel GmbH. The initial hull design for this new vehicle failed dramatically at the Speedchallenge 2004, which took place at the Opel proving ground in Dudenhofen. This led to a significant redesign that used simulation to evaluate both internal and external factors.

The aim was to derive a new aerodynamic hull from the old one through the use of digitized point data. The team converted point data from a 3-D digitization that was performed at the Adam Opel GmbH Styling Center into regular surfaces with Autodesk® SurfaceStudio™. Parts without a direct effect on the air flow (redirection gear under seat, chain and chain sheet) were neglected.

The simulation efforts that followed used FLUENT software. Researchers chose the RNG k-ε turbulence model because it offers a good compromise between



Pressure contour on exterior side (left) and top (right) of a speedbike, assuming a 4-degree diagonal flow

Revised ventilation designs (left) compared with earlier ones (right) led to greatly improved rider comfort; contour plots represent temperature.

computational accuracy, storage requirements and computing time. The mesh consisted of a five-tier prism surface layer on both the interior and exterior surfaces of the vehicle, while a hexcore mesh created in the TGrid tool filled the volume. Ground, tire, interior hull surface and rider clothing roughnesses were taken into account, while the outer hull was regarded as being hydraulically smooth.

Earlier tests showed that disk wheels themselves are very aerodynamic, whereas in combination with wheel housings, the close proximity of these components makes the parts act together like a friction pump. An enlargement of the wheel housings would disturb a large portion of the clean lower hull flow. As a compromise, the physical vehicle was designed using aero spokes.

For the correct computation of the complete model, the engineering team had to compute the external and internal flow in combination. This included simulation of the bow areas, the underbody and the rear of the vehicle. Researchers optimized the bow and underbody profiles to minimize air congestion between the lower leading edge of the craft and the ground. The length of the tail was driven by the necessity to create a gentle transition from the broadest part of the hull to the tail and to offer balanced control behavior in cross-wind conditions. In addition, the team simulated various wind conditions to mimic real driving conditions.

An equally important emphasis for speedbike development was safety and comfort. While safety aspects can be considered by carry-over preventive measures (Kevlar inlays within the fiberglass/CFK skin or using the hood frame as a safety cage), taking rider comfort into account during development required a substantial effort. For this, air ventilation constructions had to be inserted and tested on a suitable test track at running conditions for each case. All information was acquired subjectively from the rider.

The team designed the ventilation to occur passively, reducing interior cabin humidity and supplying cooling air to the rider. In the Speedhawk, air flows into the ventilation system at a stagnation pressure point on the vehicle, is distributed through the interior and later escapes from the tail area. To simulate this effect, researchers computed the interior and exterior volumes in a coupled way so that both the flow resistance of the interior and the flow change resulting from the addition of a passive ventilation system in the front were accounted for simultaneously.

Lars Teutenberg fits tightly into the initially designed Speedhawk prototype.
Image courtesy Berndt Photography

In simulating the entire interior and exterior of the Speedhawk together, the team intended to significantly improve performance when compared to their 2004 demonstration. The corrections made to the design have resulted in a 10 percent improvement in drag performance so far, as well as much more significant driver comfort, boding well for the future performance of the vehicle. The molds for lamination will be produced by Gaugler & Lutz oHG in August 2008 and the team looks forward to a finalized vehicle in September 2008. ■