ALTAIR

Using HyperWorks® to Optimize Structural Strength for Argon 18 High-performance Bikes

ARGON 18

Key Highlights

Industry
Sports, track cycling

Challenge
Development of a lightweight, high performance bike

Altair Solution
OptiStruct for structural analysis, AcuSolve® for CFD, Virtual Wind Tunnel

Benefits
Greater degree of stiffness than carbon fibers, higher degree of reliability, reduction in aerodynamic drag - 16% increase in mean rigidity, and a 6% reduction in aerodynamic drag.

Customer Profile

Since its debut at the summer Olympics in 1896, track cycling has gained tremendous popularity among cycling enthusiasts over the years. A short track event with high peaks, this aggressive, indoor sport usually held on specially built banked tracks known as velodromes requires both endurance and high-speed by the powerful riders.

Argon 18 is a bike manufacturer founded in 1989 by retired cyclist Gervais Rioux in Montreal, Quebec. Developing and engineering high-performance bikes using state-of-the-art technology, Argon 18 is an active sponsor of professional cycling teams with global distributorship in over 70 countries. Argon bikes are designed for professional riders as well as the general public seeking best performance from their bikes to provide a superior riding experience for both.

Argon 18 recently partnered with the ÉTS Research Chair on Engineering of Processing, Materials and Structures for Additive Manufacturing to manufacture a new track bike for Lasse Norman Hansen, one of the athletes competing for the Danish team in track cycling at the 2016 Rio Olympic Games. Their aim was to develop a bike that was stiffer, highly integrated, more aerodynamic, providing greater efficiency.

The Lightweight, Structural, Performance Equation

The events at the track cycling competition have their own individual rules for the athletes' equipment; the design must keep within the restrictions under consideration, while keeping the athlete's performance optimal.

The quest for lightness has driven the biking industry for a long time now. Making

Keywords: Argon 18, HyperWorks, OptiStruct, AcuSolve, Virtual Wind Tunnel, Linear Stress Analysis, CFD, Track Cycling

Argon 18 Customer Story

"Our main goal is to enhance the performance of the rider by providing the best bike possible. Improving the structural design and aerodynamic performance by using Altair HyperWorks greatly streamlined our product development process for this project"

Martin Faubert
R&D Manager
Argon 18

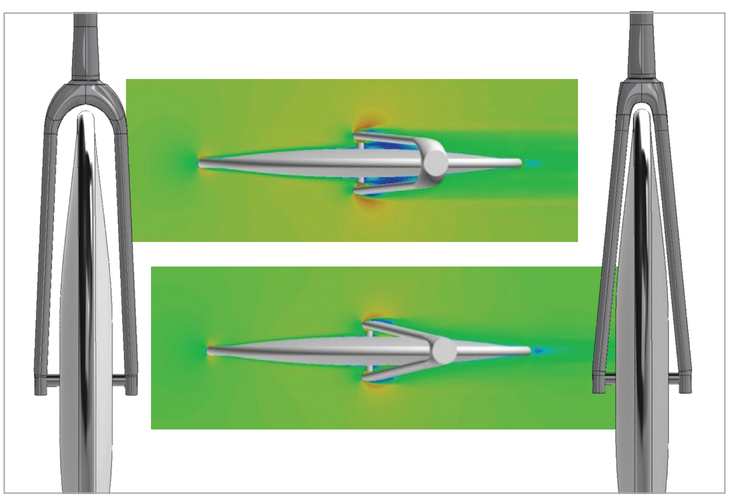
a lightweight bike, while maintaining the structure, without losing power, is the challenge that manufacturers must meet. The weight of the product can be the defining difference.

The team's requirement was for the stiffest bike possible while getting the best aerodynamic results, as the rider would expend a huge amount of power during the track event. When making the bike more aerodynamic, it often results in making the shape thinner. Hence the challenge was to make the frame stiff while at the same time balancing the structure's strength and the rigidity.

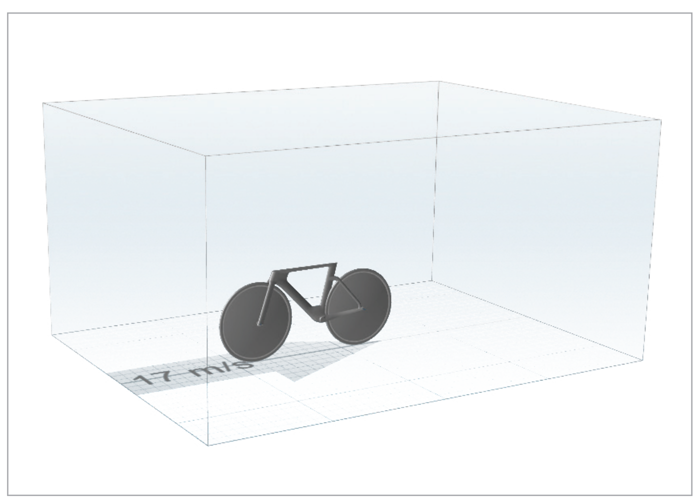
An important aspect of the project was the development of a new aluminum stem to be used by Mr. Hansen in the Flying Lap event which is achieved by the fastest lap from the moving start. Manufactured using Additive Manufacturing (AM) technology, in order to maximize the aerodynamic performance of the athlete, the stem would need to be seamlessly integrated to the bike frame, while being firmly fixed to the fork insert. By customizing the design of the stem, it would also be possible to guarantee the optimal position of the athlete. In addition, the bracket would also need to be sufficiently rigid (better than its carbon fiber counterpart) and lightweight.

Testing, Testing and More Testing – to Strike the Right Balance

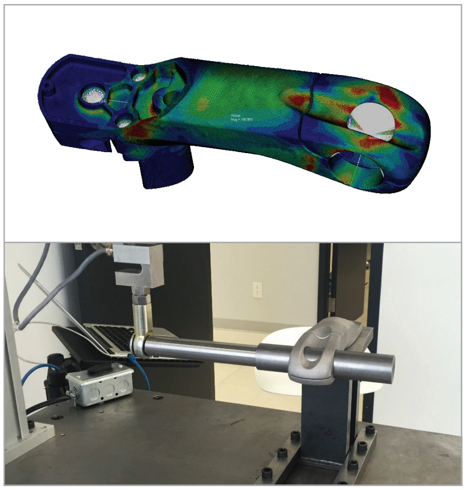
As the rider expends a tremendous amount of power output for the track event, it is not only important to have a stiff and lightweight design for the bike but also the best aerodynamic performance to minimize the drag. Various tests are required to measure and improve the base line performance of the existing bike design. Striking the right balance between weight, structural strength and stiffness is challenging while also considering the essential component drag area of the bike.



V6 far from the wheel (left) and Fork V7 close to the wheel (right)

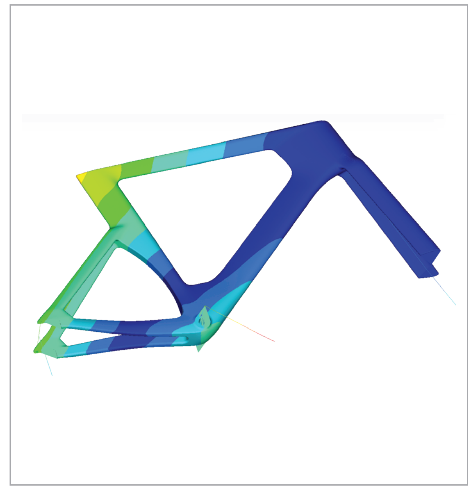


Frames and forks CFD analysis setup in Altair Virtual Wind Tunnel



Stress analysis testing using OptiStruct and fatigue test benchmark

The final stem design



FEA frame structural testing

Finite Element Analysis (FEA) was employed to understand the structure of the product, improve and optimize it. CFD analyses and virtual wind tunnel simulation helped to improve upon the aerodynamics aspect. Several iterations between FEA and CFD processes followed, trying different configurations of the components, making the blade wider, thinner, and taking it far from the wheel, bringing it closer, while keeping a close watch on the CFD and FEA data. The approach to improve the design followed the sequence as below.

- Aerodynamic (drag area) first, then rigidity
- Smaller tube profile and if too soft, modification of the thickness and length.
- Study of existing competitor bike frames tubes dimensions to have baseline/ references.
- CFD analysis in Altair Virtual Wind Tunnel with multiple configurations to maximize the benefits of each design attribute. The fork shape, wheel sizes, downtube attachment, and the entire frame were analyzed.
  - Fork and wheel (different configurations/ sizes tested)
  - Fork, wheel and downtube
  - Finally, fork and frame

The design improvements resulted in a significant reduction of the aerodynamic drag (CdA), a critical parameter in making faster bikes

- Initial (existing) design CdA (drag area) = 0.0199
- Final design CdA (drag area) = 0.01864
  - FEA to verify and adjust the rigidity of each bike frame components in OptiStruct®
- Comparison between fork V6 and V7 rigidity
- Physical EN/ISO (ISO 4210-6) rigidity (displacement) tests to validates the FEA results and compare to the initial (existing) design:
- Mean rigidity increase 16%

	Chain Stay	Bottom Bracket Vertical	Bottom Bracket Horizontal	Head Tube
Initial Design	3.5mm	9.7mm	4.5mm	12.4mm
Final Design	3.1mm	8.3mm	3.9mm	9.1mm
Rigidity Increase	11%	14%	13%	26%

Linear stress analysis was conducted using Altair OptiStruct for validation of the stem body and clamp design.

- Stress limit established at 100 MPa, based on material properties and summary knowledge of fatigue behavior, which is influenced by many microstructural aspects
- Loads determined by Argon 18 based on experiments

The stress analysis demonstrated a greater stiffness, about 9%, than the typical carbon fibers stem. It also identified several dimensions to be adjusted in order to preserve the integrity of the parts, such as the thickness of the tubular section and the handlebar clamping section.

To ensure its reliability, a fatigue test was performed on the final design. It was carried out with success: no significant loss of rigidity or cracking was noticed and good correlation with the stress analysis was observed. The stiffness proved to be greater than the fiber-reinforced composite bracket.

- 650 N and -650 N load
- 1 Hz frequency
- 60,000 cycles

The final design of the personalized stem is shown in the figure above. It is composed of a plastic cover, the stem body and the stem clamp.