SIEMENS
Ingenuity for life

Consumer products and retail

EXEPT

Startup uses Simcenter Femap with Nastran to develop monocoque frame for road bikes in a virtual environment

Product

Simcenter

Business challenges

Build tailor-made monocoque road bikes

Reduce prototyping and engineering lead time

Optimize tooling costs for small production volumes

Keys to success

Use Simcenter Femap with Nastran to optimize design and prototype in a virtual environment

Results

Developed customized monocoque frame for high-end road bikes in a virtual environment

Moved from concept design to product launch in less than a year

Used FEM calculations to increase torsional stiffness by 150 percent

Achieved reliable simulation of complex mechanical events like falling or impact

Siemens solution enables EXEPT to go from concept design to product launch in less than a year

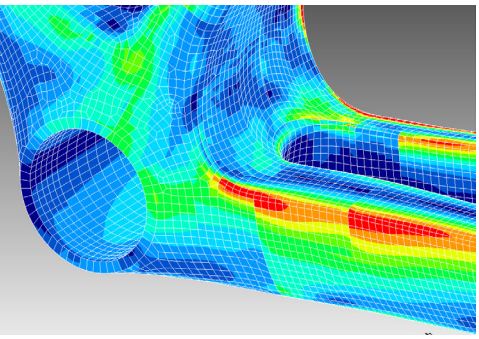
Developing the custom monocoque

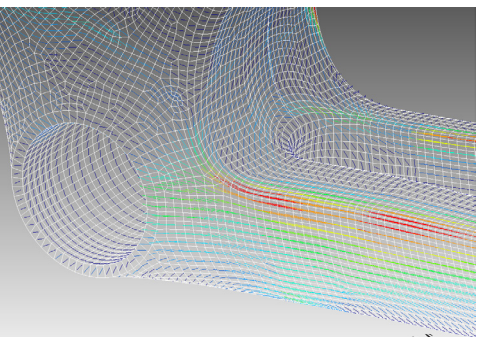
Until recently any cyclist who wanted to buy a new bicycle had two options: Either purchase one of the big brands with a monocoque frame that is available in a fixed range of sizes with performance based on stiffness by weight, or a tailor-made frame manufactured with the tube-to-tube technique. This kind of bike has tubes that are cut, welded and wrapped with carbon fiber around the joints (knots), with the inevitable drawbacks in stiffness.

Now the Italian startup EXEPT, which is based in Savona, is providing a third way. It has developed a process that combines the benefits of both traditional approaches to create tailor-made monocoque frames. The custom monocoque technique invented by EXEPT uses movable molds to cast monocoque frames without any carbon fiber discontinuity so it can be made to order for each cyclist.

"Compared to the initial stiffness of the nonoptimized prototype, we increased torsional stiffness by 150 percent while increasing the monocoque weight by only 12 percent."

Alessandro Giusto
Co-founder
EXEPT S.R.L





"The key to economic sustainability in bike production is the cost of tooling," says Alessandro Giusto, who is the co-founder of the company and the innovation and simulation manager. "A mold may cost up to €50,000 to 60,000, therefore only the big brands can reach volumes large enough to make a mold for each size. Instead, we have developed an innovative technology to build all sizes with one adjustable mold."

The biggest Italian brand makes 15,000 high-end bikes a year, while EXEPT's business plan calls for producing up to 3,000 pieces annually in five years.

All-round expertise

The movable mold concept was developed by the three founders and reflects their passion for bicycles. Giusto previously worked at Continental, a global leader in tire manufacturing, and also had experience in aerospace and the design of carbon components for the sporting goods business. The second business partner, Alessio Rebagliati, is a colleague from Continental, while the third founder, Wolfgang Turainsky, is a German engineer who used to work for a Spanish manufacturer of bike components.

It took two years and two prototyping cycles to make prototypes that proved the feasibility of the custom monocoque process. Prior to being analyzed with simulation and finite element method (FEM) tools, the first frame was given to a former cycling professional for testing. Once the firm received his technical approval, EXEPT presented the project to an investment fund (Focus Futuro), which provided the necessary resources to move on to detailed design, testing and certification.

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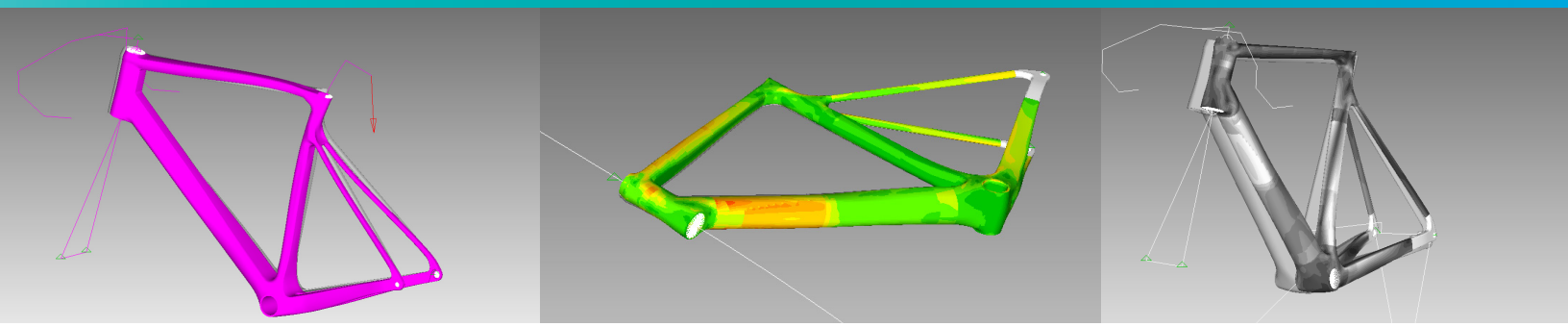

"The bike was designed from the very start according to the new concept," Giusto says. "However, we did not focus on carbon fiber initially, as composite material design is a complex activity that is a full-time job. Once we got the funds to finance our innovative idea, we could quit our previous jobs and plunge into the new enterprise."

The pretest on the first prototype in May 2018, which was developed with just three months of design, confirmed the results of simulation and reassured Giusto and his partners they were ready to launch the bicycle at the Eurobike show in July, 2018.

Foolproof decision

In his experience in engineering companies in the aerospace and sporting goods industries, Giusto had the opportunity to learn and appreciate Simcenter™ Nastran® software, specifically the finite element modeling, and the pre- and postprocessing environment of Simcenter Femap™ software from Siemens.

"In aerospace, Simcenter Nastran is a de facto choice and we also used Simcenter Femap in our company," Giusto remembers. "In six years, from 2007 to 2013, I acquired advanced skills with these tools, then I was in charge of the calculation department at Continental, where nonlinear analysis is performed using totally different tools."

As a result, when the EXEPT project began, Giusto immediately reactivated his contacts with Siemens. "We did not need comparative analysis or benchmarking," he says. "I knew we needed Simcenter Nastran, and the quality/price tradeoff for Simcenter Femap was excellent. All I had to do was call Siemens to explain our requirements and get an adequate offer, which we accepted immediately."

EXEPT purchased a node locked bundle that incorporates Simcenter Femap with Nastran Basic in a single, integrated solution.

The EXEPT team initially worked with pencil and paper, proceeding by increasing levels of complexity to identify the loads that acted on the structure. The next stage was the development of the first simplified FEM model.

"We made a very simple model; in aerospace, they call it Global FEM, which is made up of one-dimensional elements (bars), and we investigated the load properties of these tubes in different riding, braking and impact conditions," Giusto

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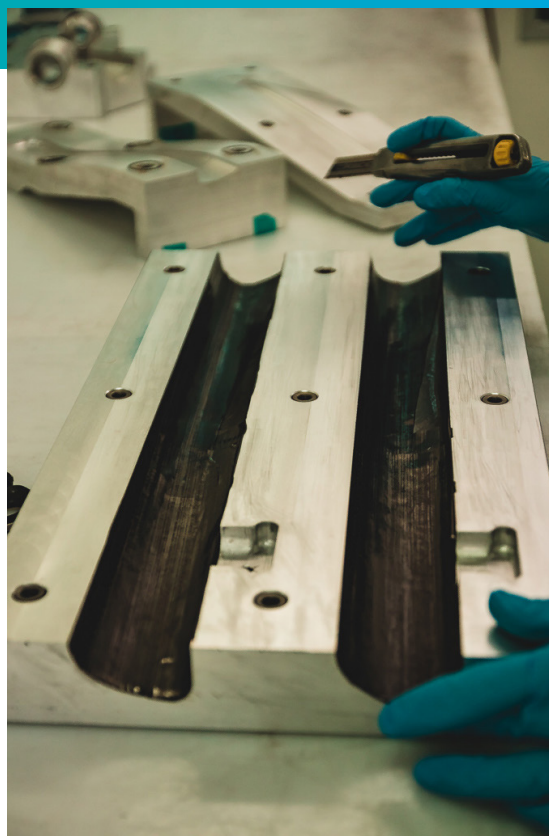

explains. “This approach is very useful as it provides quick feedback for each frame section. Then we moved on to a model of isotropic material, simulating an aluminum frame with constant thickness, and using the information from the Global FEM, we identified where we should decrease or increase the cross sections to optimize stiffness and weight. Finally, we worked on the geometry, which was re-meshed with four modifications to increase stiffness by 27 percent. This was done by just addressing the geometry!”

The carbon challenge

After optimizing the frame stiffness, the EXEPT’s engineers focused on carbon design. To define the ply book, also known as the lamination sequence, Giusto adjusted the structure 82 times, achieving extraordinary results.

“Compared to the initial stiffness of the nonoptimized prototype, we increased torsional stiffness by 150 percent while increasing the monocoque weight by only 12 percent,” Giusto says. “In this phase, Simcenter Femap offered huge benefits in terms of time and costs, enabling us to test and analyze the layering and direction of fibers only in the virtual domain, without increasing the quantity of material used.”

EXEPT executed an in-depth comparative analysis of the performance of more than 800 stock frames (in standard sizes) developed and sold in the past three to four years in order to identify and achieve high-end stiffness and weight targets.

“The first nonoptimized frame we made was the third-best in terms of stiffness out of 800 frames we analyzed,” Giusto says. “We pushed stiffness so far that we decided to reduce it afterwards for road tests, to find the best tradeoff between stiffness and rideability. You know, reducing an optimized parameter is much easier than increasing it.”

At the end of June 2018, the excellent performance of EXEPT’s custom monocoque and the reliability of Simcenter Femap simulations was confirmed and certified with tests by an independent German laboratory: The deviation between real test and simulation was below 5 percent.

Giusto highlights how using Simcenter Femap accelerated the development of new frames:

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Solutions/Services

Simcenter Femap
siemens.com/simcenter-femap

Simcenter Nastran
siemens.com/simcenter-nastran

Customer's primary business

Founded in 2016, EXEPT S.R.L. offers a new cycling experience with high-end road bikes built with tailor-made monocoque frames using an innovative movable mold technology.
www.exept.cc

Client location

Savona
Italy

delivering the ply book at the end of March. With Simcenter Femap, it took less than three months for over 80 iteration cycles. Just consider the average lead time for a brand bike is two years. We launched our model in July, having started to work on it less than one year before.

"All of this was possible only thanks to simulation; we made no physical iterations. No one in the cycling industry in Italy currently has comparable tools. At the beginning we contacted the engineering departments of big brands to present our concept; they have a conventional approach because they never develop a frame from scratch. They start with the expertise of their carbon supplier and rely on external partners for the subsequent development."

Combining software and services

Giusto has no doubts when asked to list the key benefits of Simcenter Femap: "The key success factor is postprocessing. Simcenter Femap is definitely the best of all postprocessing engines I have used in my career. Simcenter Femap with Nastran has a complete environment for linear stress analysis of composites structures, which is suitable for our tasks. The Siemens software allows us to query the model and extract as much information as possible from structures like our frames; for instance, using free-body analysis to identify the interplay of forces inside the structure."

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"When I started to work full time with Simcenter Femap and Simcenter Nastran to simulate our frames, I did not start from scratch, but still I needed some training to refresh my memory after seven years using different software. Anytime I have a problem, I just have to pick up the phone and the engineers are always ready to answer questions to my full satisfaction. They can indicate the best way to approach analysis with a limited budget while using the best-fitting software configuration for our needs, regardless of the situation."

With the advanced FEM capabilities of Simcenter Femap, EXEPT can execute sophisticated and critical simulations, static and dynamic tests, and simulations of complex mechanical events like falling and impact.

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