Speedy, Lightweight MOTORCYCLE DESIGN

To achieve its amazingly light weight, the Vins Duecinquanta motorcycle uses a carbon fiber composite for its monocoque frame, rims, fork and bodywork. The aluminum frontal node is at the heart of the motorbike, sitting under the handlebars and connecting to the engine, frame, gas tank, radiator and suspension. Asotech engineers used ANSYS Mechanical topology optimization to develop an optimized design while changing both the basic shape and dimensions of the part to reduce its weight by 56 percent. Engineers then used ANSYS Mechanical fatigue analysis to achieve the product integrity balance needed to ensure that it will not fail under repetitive stress over time.

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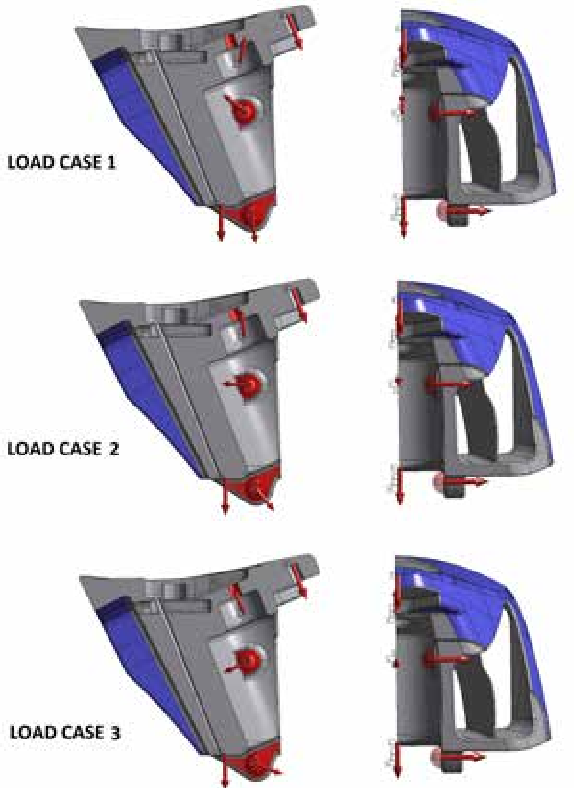
Using ANSYS structural analysis, the shape was altered to fix structural problems.

In its review of the new motorcycle, *New Atlas* said “The Vins Duecinquanta (250) is focused on weight reduction to a degree we've never seen before in a road bike.” With a 60-horsepower engine and a curb weight of 209 lbs (95 kg), the new bike, which costs 40,000 euros (US$49,621), goes 120 mph (299km/h) while meeting the latest emissions laws. A significant portion of that weight reduction was achieved by Asotech engineers who used ANSYS Mechanical topology optimization to reduce the weight of the frontal node from 40 lbs (18 kg) to 18 lbs (8 kg). They also used ANSYS Mechanical fatigue analysis to ensure that the node meets Eurocode fatigue life requirements.



Load cases analyzed with structural simulation

High-End Performance Motorcycle

The Duecinquanta uses an electronically injected 90-degree V-twin, two-cylinder, two-stroke engine. The radiator is aerodynamically integrated with the bike, so incoming air flows over the radiator and back through the hollow frame where it exits through the tail and swingarms. The Duecinquanta Competizione, the racetrack version, reduces the weight even further to 187 lbs (85 kg) by removing equipment required for street use. It delivers 80 horsepower and provides a top speed of around 149 mph (240 km/h). The racetrack version costs 50,000 euros (US$62,029). Vins is planning to build 20 to 30 of the new bikes per year.

The Vins engineering team is composed primarily of Ferrari alumni who have expertise in working with carbon fiber composites. Because the frontal node is one of the most critical metal components of the bike, Vins sought out the assistance of Asotech, a leading Italian mechanical engineering company with 110 engineers who deliver more than 200,000 hours of services each year and a focus on the automotive, motorcycle, amusement park and automated machinery markets.

The traditional approach to designing this component would have been to start with a regular solid shape that provided the required mounting surfaces. Then engineers would have simulated the design and looked for low-stress areas where material could be removed. Exploring designs one by one and manually varying their dimensions in this manner could have generated considerable weight savings, but the time required would be prohibitive. Even then, engineers would not have been able to reduce weight to meet their goals.

The frontal node sits at heart of the bike.

Topology Optimization Minimizes Weight

Asotech engineers addressed this challenge by using ANSYS topology optimization, which is integrated with ANSYS Mechanical structural software. Vins engineers provided four load cases for the frontal node: 1) engine, passenger and lateral static loads; 2) engine, passenger and lateral static loads plus loads related to a moderate bump in the road; 3) engine, passenger and lateral static loads plus loads related to a maximal bump in the road; and 4) a fatigue stress state obtained by combining the three previous load cases. Asotech engineers then defined the features that must be maintained in the final design, such as the outer boundaries and mounting surfaces. They assigned an optimization objective to minimize the weight of the part while holding stress to a specified maximum value based on the material properties.

Asotech engineers then executed the topology optimization, which ran for six hours. Engineers examined the resulting design and discovered areas where it could be improved by changing some geometrical constraints.

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Frontal node

They made these changes and ran the optimization again, this time starting from the previously optimized design. Engineers performed several more iterations — modifying the constraints and rerunning the optimization from the previous starting point — until they were happy with the design.

The Asotech team then imported the topology density distribution into ANSYS SpaceClaim Direct Modeler (SCDM) and used it to tweak the final design. SCDM makes it easy to edit and optimize complex models that often result from topology optimization. It enables users to seamlessly add or remove geometry, smooth rough faces or shrink-wrap sections of a model to remove unwanted features and characteristics.

Results of the ANSYS topology optimization

Fatigue Analysis Ensures Durability

Asotech engineers simulated the resulting design in ANSYS Mechanical to confirm that it could withstand the static loads specified by Vins. The engineers then used ANSYS fatigue analysis software to calculate high-cycle fatigue safety factors based on the Eurocode structural design standard. They imported the static stresses from the fatigue model, and combined the results with a material model and a description of the repetitive loading that the product is expected to undergo during operation. The ANSYS fatigue module captured the data, data flow and parameters, and performed a comprehensive fatigue analysis using the stress-life approach on the fatigue load case. The fatigue analysis showed that the design exceeded the 2-million-cycle fatigue life requirement by withstanding 5 million cycles. Based on these results, engineers ran another cycle of topology optimization that further reduced the weight of the part slightly.

The founder of Lotus cars, Colin Chapman, has said, "Adding power makes you faster on the straights. Subtracting weight makes you faster everywhere." Vins has taken this philosophy to its natural limits with the Duecinquanta motorcycle. Asotech played a key role in engineering this ultrahigh-performance motorcycle by using ANSYS topology optimization and fatigue life analysis to reduce the weight and ensure the durability of a key component.

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