CASE STUDY

Material Characterization

Renault F1® Team: Stronger and Safer with PerkinElmer Analysis

RENAULT F1 TEAM
TECHNICAL PARTNER

Believe the Unbelievable

The first time a person sees a Formula One race car in action they usually cannot believe their eyes. The cars thunder through the race track like lightning through the sky – there one moment and gone the next! It's no wonder that more than four million fans enjoy Formula One races.[1] Who can resist the thrill of seeing these drivers hurl their cars through hairpin turns and along the straights at blistering speeds?

These amazing machines are capable of some extraordinary feats. They can accelerate from 0 to 190 mph in 10 seconds and decelerate by 60 mph in less than one second. As drivers negotiate high-speed turns, they experience g-forces similar to an astronaut re-entering the Earth's atmosphere.[2] You may be wondering what kind of car can perform at this level and do so throughout the entire race. Let's look at Renault F1 Team's car as an example.

The Renault R.S.19 race car is roughly 5.5 m long, 2 m wide, just under one meter high, and weighs approximately 740 Kg. Its engine is a 1.6 L V6 that provides approximately 950 horsepower.[3] Formula One's regulations severely restrict some car design parameters but there are areas engineers can explore to maximize performance. Today, Formula One cars are made of composite materials that, while being very strong, account for up to 85% of the car's volume but only 20% of its weight.[4]

F1 cars are redesigned and built anew every year, with each team hoping to make the next great technological advance that will allow them to leap ahead of their competitors. Even within a racing season, engineers strive to push innovation to improve vehicle performance and adjust it to the characteristics of individual tracks. For example, courses with tight corners require a lot of downforce and softer tires with good grip, while a track with more straightaways needs minimal drag and harder tires.[2]

The Heat is On

One aspect of F1 racing that requires vigilant monitoring is the thermal stability of each car component. The fuel combustion temperature in an F1 engine can reach up to 1,250 °C (~2,250 °F).[5] Add to that the heat produced from moving parts, friction, and contact with the road, and you begin to realize just how much heat an F1 car generates during a race.

Every part of the F1 car has the potential to degrade or be otherwise altered by the sustained, intense thermal stress during the race. That is why racing teams conduct exhaustive thermal analysis of every component of their cars: body components, mechanical parts, resins, adhesives, brakes, tires, lubricants, fuels, and more. Dr. Tim Mann, PerkinElmer Thermal Analysis Product Specialist, explains, "*The need to ensure thermal stability is a consideration during all aspects of the F1 team's operations, from R&D to race planning and post-race forensics.*" This is where Renault F1 Team wins the checkered flag!

PerkinElmer®
For the Better

PerkinElmer has been helping Renault F1 Team's Enstone Technical Center with their analytical needs for nearly 30 years. PerkinElmer began by outfitting the team's testing lab with the analytical instrumentation needed to conduct materials testing. Today, a dedicated PerkinElmer scientific laboratory operates within the team's Enstone facility where the latest thermal analysis, infrared spectroscopy, and imaging technologies are being utilized for proactive monitoring, issue prevention, and performance enhancement of the team's single seater. PerkinElmer offers analytical expertise in helping Renault F1 Team master the thermal stability challenge. For example:

- Confirming resin quality meets thermal stability and performance specifications
- Gaining insights from composite stiffness and dampening properties
- Establishing proprietary adhesive resin meets manufacturer's specifications
- Monitoring vehicle components under various thermal conditions

Resin Quality

Renault F1 Team manufactures its car chassis as a molded carbon fiber and aluminum honeycomb composite monocoque. It is designed for maximum strength with minimum weight.[3] Commercially available epoxy resin impregnated composite materials (or "pre-preg") are used in race car production. Each batch of pre-preg is tested to ensure thermal stability of the epoxy resin before being used in the chassis laminate. PerkinElmer conducts thermogravimetric analysis (TGA) of the resin using their TGA 8000™ instrument to confirm the resin meets the manufacturer's specifications for stability and performance under the thermal stress levels the car will experience.

Composite Stiffness and Dampening Properties

The chassis is cured in an autoclave at elevated temperature and pressure. The curing process must conform to strict standards of temperature, pressure and time to ensure the composite meets design and safety specifications. In addition to post-cure TGA analysis, material test samples prepared alongside the cured chassis also undergoes dynamic mechanical analysis (DMA) using the PerkinElmer DMA 8000™ instrument. DMA provides valuable information on stiffness and dampening properties of the resins and composites.

Proprietary Adhesive Resin Specs

When the chassis passes all of these tests, the sections are bonded together using proprietary adhesive resins. Prior to use, PerkinElmer conducts TGA and differential scanning calorimetry (DSC) analysis of the adhesive to ensure it conforms to the manufacturers specifications for use in high-performance automobiles.

Temperature-Controlled Component Monitoring

The expansion or contraction of a component at different temperatures also affects car performance. PerkinElmer uses the TMA 4000™ instrument to conduct thermomechanical analysis (TMA) of the vehicle's components across the range of thermal conditions experienced during the race.

These are just a few of the analyses performed by PerkinElmer to help Renault F1 Team design, build, and operate these incredible single seaters. Other thermal testing applications the team relies upon include anomaly investigation, failure analysis, post-race forensics, and more.

Renault F1 Team – PerkinElmer Collaboration Continues

The recent extension of collaboration between Renault F1 Team and PerkinElmer is a testament to the success of this partnership. As described by Jerome Lafarge, Head of Material Science at Renault F1 Team, "*Quality control is of paramount importance in a sport where components are frequently operating close to their structural limit, and for many years now the team's Materials Lab has drawn benefits from the technical collaboration with PerkinElmer. The mutual commitment to continue this collaboration will increase our understanding of the materials we use and have positive repercussions on safety, reliability, and performance.*"

PerkinElmer is committed to providing Renault F1 Team with innovative thermal stability and related analytical services and support that will push them to the head of the pack and the top step of the podium.

References

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