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Software and Services Enhance the Design-to-Manufacturing Process for the Renault F1 Team

By Ian Goddard, Renault F1 Team

In Formula One, there are two races. One is the familiar race on the track, a colorful and loud two-hour test of driver and machine.

You are probably less familiar with the second race, a 16-week period in which F1 teams must completely redesign, manufacture, analyze, and test their vehicles for the upcoming season. While this race may seem to lack the drama of the one on the track, given the time constraints for those of us charged with designing and manufacturing the race cars, there is no shortage of excitement.

To ensure efficient resource usage and productivity during this period, the Renault F1 Team relies on established procedures for maximum confidence. That's especially the case with the software we use to design and manufacture the car. We have never introduced new software into the production environment the first time we are using it. In fact, there has been some software that it took us several seasons to get comfortable enough with before we counted on it during the production cycle.

But that changed this year. Based on our success with previous versions of VISTAGY's FiberSIM® composites engineering software, we were confident that it could enable us to reduce product cycle time, enhance the precision of our composite parts design, and increase the manufacturability of those parts. We took a leap of faith and put it into the production environment straightaway for building a new car, the R29, for the 2009 season.

Here the composite design is laid over the chassis, cockpit and the roll hoop of the race car, putting some of the composite components used to build the car into the context of the finished product.

And we did one other thing. We brought in a VISTAGY technical consultant (TC) to work with our design team for a month, so that she could get an intimate understanding of what is involved in designing a Formula One car, which, in turn, would enable us to get the most out of the software.

Both decisions proved fortunate. We found that taking a comprehensive view of VISTAGY's software and services — considering them as a complete solution—gave us the tools and knowledge to maximize our design-to-manufacturing process and significantly contributed to our ability to build the best possible race car.

Te Renault F1 Team used earlier versions of FiberSIM to manufacture its race cars' composite chassis, but this time we used it from the very beginning of the design process right through manufacturing, on the new 3D CAD system used to produce the entire car, CATIA V5. We were able to take advantage of many of FiberSIM's capabilities and doing so gave us a heightened appreciation of how they could be applied in our environment.

Not only did it help with design and manufacture of the chassis, but it also was used to design a number of other composite parts, such as the gearbox, floor, side pods, and wing main planes. In every case, we found that the software saved us a day or two in the time it took to design these parts, which is impressive when you consider we had just implemented the new version of the software, and were working with a new User Interface. What's even more impressive is this represents a 20-30 percent time savings in the design of these parts. That makes a big difference in the 16-week period, but it is even more critical during the racing season, when a part needs to be produced and shipped in time for the next race.

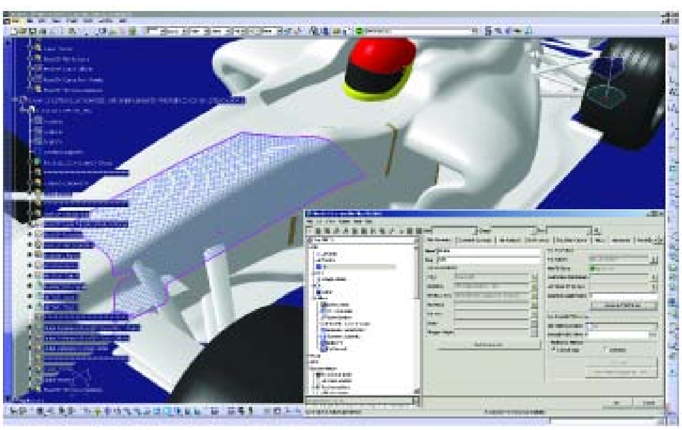
The gearbox is challenging to develop because it has extremely complex curves and is made up of small plies—many just a few inches long and identical to the eye—so it is a bigger job to manage the plies. The gearbox is comprised of over 700 plies of carbon fiber and also plays a structural role, integral with the whole rear end of the car, dealing with extreme power transmission, suspension loads, and rear-wing aerodynamic loads.

The gearbox design presented a number of manufacturability issues:

- Complex curves over 3D contoured surfaces. These complicate ply layup, and can cause fabric deviation and deformation.
- Maximum part strength throughout at minimum part weight. Fabric deviation can cause unexpected weak points in composite parts.
- Long flat-pattern creation times. Manual pattern creation is time consuming, and often involves rework.
- Long layup times. Manual layup time is slow and error-prone compared with FiberSIM controlled laser-ply placement.
- Tight production deadlines. A slip in the schedule would delay other work on the car.

Once the 3D CAD model of the gearbox was complete, team engineers used FiberSIM to enter ply specifications such as material, sequence, start point, and orientation of the ply layup. Then the FiberSIM software was used to simulate actual layup and check for weak points caused by fiber deviation over the gearbox curves, thus determining the optimal layup starting points and directions. Once that was done, the team was ready to create flat patterns.

Traditionally, technicians create these by laying sheets of paper and tape on the completed gearbox mold, cutting the paper by hand to the shape of the different ply patterns, and adding necessary darts and splices. Many manufacturing engineers manually entered the pattern data into templating software for the cutting machine. The process was laborious and time-consuming, and frequently required rework.



This picture shows the simulation result for one 45 degree woven ply in FiberSIM®. The ply simulation is used to highlight areas where manufacturabilty issues will occur so they can be fixed in the design phase and subsequently used to generate an accurate flat pattern for each composite ply. Understanding manufacturability issues during the design phase rather than on the shop floor saves valuable time, a critical concern for the Renault F1 Team given the aggressive deadlines they must meet. Here, the original design has been altered so that all manufacturability issues have been addressed, as indicated by the blue lines which show the true orientation of the fibers as they conform over the complex curvature.

With the new software, the engineers created the flat patterns digitally from the completed 3D ply data, and then exported ply layup patterns to an automated cutter and a laser projection machine that ensured accurate and rapid ply layup. One of the key issues for us was capability to capture the design intent. Since we do some outsourcing of the manufacturing, it is very important for the person doing the layup to be clear on what we want. This also gives us consistency in the design from car to car, a critical consideration if you want to be able to make the most precise performance evaluation.

When we were thinking about how to approach the development of R29, we decided to bring in a VISTAGY TC and make them part of our design team, so they could actually learn our processes and approach to designing the race car. VISTAGY has always provided us with excellent support, but there is no way a TC could know the inner workings of F1 unless they spent time with us. For one thing, F1 geometry tends to be quite complex. We figured if they really knew what we did, we could get even more value out of the new version of the software.

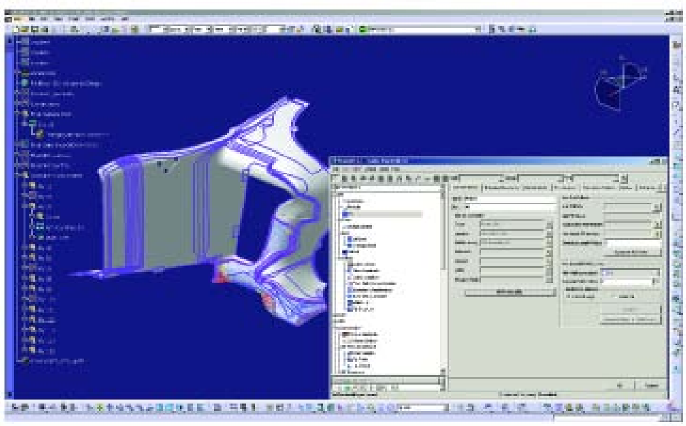
Usually you bring in a consultant to teach the basic software skills and run the materials training. While this can be very useful, it doesn't translate into a true partnership. Keeping the TC on the premises for a month changed the dynamic in a very positive way. For instance, if you run into a design scenario that you're not sure how to deal with, it's much better to have the TC right there so they can immediately apply their knowledge of the software. While talking on the telephone to someone in technical support is very helpful, it is impossible for the remote tech support rep to have the same depth of understanding of that particular issue as the person who is working with us face-to-face.

The good thing about having a technical consultant here was that we were able to pick up lots of pointers about FiberSIM. It moved us away from just using the most basic functions, and enabled us to get the most out of the software. It was also good to be able to have a dialogue with someone who was knowledgeable about both the software and what the team is doing.

The TC's first step was to train two designers on FiberSIM. Then we got her up to speed on doing concept design work on CAD. By working with us, she was able to get a much better understanding of the evolution of the car.

Working with the TC allowed us to learn while working and apply the lessons-learned immediately. We found the on-the-job training quite beneficial. By the end of the process, while the TC had been trained as an F1 designer, we benefited from having a lot of advanced FiberSIM work done.

One of the major benefits of having the TC in-house was that together we identified ways to further enhance software functionality, which will be useful for future product development and result in an even better solution for our application.



Pictured is a simulation of a single composite ply for the side pod of the Renault F1 Team race car. The purple lines indicate the boundaries of the plies. Within the ply being simulated, the blue lines represent an area that will not present manufacturability issues, yellow indicates an area of mild material deformation over the complex curvature, and the red highlights where there will be wrinkling and bridging issues that need to be corrected in the design phase prior to being manufactured.

I don't think it is any exaggeration to say that those of us who work in Formula One racing are absolutely obsessive about being precise. It might only be a slight overstatement to say that we would be willing to spend tens of thousands of dollars to find a way to save an ounce of weight so we could increase vehicle speed and enhance our performance on the track.

So the Renault F1 Team technical staff was more than a little impressed when we took an R29 chassis and tested it to see if the software had given us a precise picture of what our chassis was really made of. We analyzed over a thousand plies of carbon fiber and found that the data FiberSIM had provided on a ply-by-ply basis for the analysisto-design stage and the design-to-manufacturing phase was 100 percent accurate.

We were even more impressed when we took the chassis to our lab with the most up-to-date testing equipment and used ultrasound to determine if FiberSIM accurately predicted the thickness of each ply. Once again, the software was 100 percent spot-on. There is no question that achieving that kind of precision—knowing exactly what you have in terms of plies, orientation, etc.—is absolutely critical to continuously improving the car.

The Renault F1 Team Succeeds in the Long Run

For over three decades, Renault has competed at the pinnacle of Grand Prix racing, enjoying success as both an engine supplier and constructor. Renault introduced the turbo engine to Formula One in its first car, the Renault RS01, at the British Grand Prix in 1977. Although the Renault team won races and competed for world titles, it was as an engine supplier to the Benetton and Williams teams in the 1990s that the team first achieved a world championship. Renault contributed to five driver's world championships and six constructor's world championships between 1992 and 1997.

Pictured is Fernando Alonso in the Renault R29 leading Lewis Hamilton in his McLaren MP4-24 Mercedes in the 2009 British Grand Prix at Silverstone, Northamptonshire, England in June, 2009.

Renault returned to the category as a constructor in 2001 by taking over the Benetton team, which was renamed Renault in 2002. By 2005 it had emerged as the team to beat with Fernando Alonso taking seven race victories en route to the Drivers' World Championship, while the team won the Constructors' World Championship. That feat was repeated in 2006 as the team and Fernando Alonso won consecutive double world championships to confirm Renault's position among the preeminent teams of modern Formula 1.

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