

RAPID MANUFACTURING AND CONTINUED DEVELOPMENT OF HIGHLY STRESSED FIBRE-REINFORCED PLASTIC PARTS: MOTORBIKE DASH ASSEMBLY MADE BY WINDFORM® XT AND SLS TECHNOLOGY

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Abstract

The follow paper illustrates one of the latest high-tech RP and RM applications, made by Laser Sintering Technology and WINDFORM® materials, on a 125GP Honda racing motorbikes. In particular it describes the benefits coming from the use of WINDFORM material and the Rapid Manufacturing technology to produce a special Dashboard to host the motorbike's electronic system developed internally by CRP Racing (the racing department of CRP Technology), which had to be light and stiff at the same time, and above all, the new design of the Dashboard support, developed for the 2008 season in order to ease its substitution when crashed and saving some money as well.

Completely different from the original one, a new support was created in several modular parts to allow a good cost saving.

Introduction

Key elements in producing parts for Motorsport racing is how the part performs and the possibility to produce a new high quality component in a very short time. When modifications are needed, Rapid Manufacturing gives the advantage of saving time, weight and cost even when only few parts are produced; thus allowing the shape to be more complex. This is a big step ahead compared to the aluminium and magnesium parts used in the past which needed to be welded and machined.

It was necessary to produce a special Dashboard (light and strong) to contain the motorbike's new electronic system developed internally by CRP Racing and it was also necessary to study a fairing support which had to be modular, in order to allow easy substitution after a crash.

CRP Technology's RP Department developed the project of a motorbike dashboard and its support made with selective laser sintering technology in collaboration with CRP Racing.



Figure 1 – The rider Riccardo Moretti on track

CRP Racing Department

CRP Racing was founded in December 2006, as CRP Technology's Racing Department. Its first goal is to bring its innovative way of working into a very conservative world - the Motorcycling Racing World - as already done in other top categories, from F1 to Rally Raid and from Le Mans Series to WRC. More than 30 years of experience in Motorsport at the top levels allows CRP Racing the chance to jump the boundaries of the motorcycles sector, and test its engineering staff to try new solutions.



Figure 2: CRP Racing logo and team

The Racing department can utilize the technical and logistic support of CRP Technology and is taking advantage of its Hi-Technology for the racing market.

The competitive spirit of this team started with the 2007 Road Racing Italian Championship (CIV). The bikes were first tested and set up on the CIV tracks and then on RS 125GP Honda Trophy tracks, utilizing two Honda RS 125GP bikes, developed inside the Italian factory. This included designing and testing these motorbikes on the dyno.



Figure 3: Our rider in action

Motorbike case Study: Dashboard and Support made by Windform® XT and Ls Technology

The Dashboard

The new dashboard made by SLS has been big news for the CRP Racing team: it is an all-in-one ECU, DATALOGGER and CONTROLLER box!

The Goals

The dash board must be water proof and must resist vibrations, crashes, high and low temperatures as well as speeds of 240km/h (150mph). The component has to be stiff enough to protect the internal fragile components. Moreover, its shape is optimized to fit the small space inside the upper fairing and not obstruct the rider's view.

All these characteristics are important for the final part performance: if the electronic components of the motorbike don't work, then neither does the motorbike!



Figure 4 – The new Windform XT dashboard made by SLS on the bike: it is an all-in-one ECU, DATALOGGER and CONTROLLER box

One of the projects followed by CRP Technology's RP Department in collaboration with CRP Racing has been the dashboard and support for the 125GP Honda to race in the above-mentioned championships with excellent results.



Figure 5: The new dashboard used on the CRP Racing's 125GP Honda

The new dashboard used on the CRP Racing's 125GP Honda has a data logger for recording the operations of the vehicle, and has an integrated engine control unit completely "open" for tuning.

It was necessary to have a very powerful system for the calculations and a large quantity of channels at the teams' disposal in order to ensure the development of the whole system (bike/engine/electronics) which is why this solution was chosen.



Figure 6: Dashboard and support

The dimensions and the weight of the system are very important. Normally, the boxes are made of Aluminium or Magnesium alloy for racing and in ABS or other plastics for production motorcycles.

In order to minimize its weight and reduce its influence on the bike's balance, the characteristics of the Windform XT material were employed to create the ECU/DASHBOARD box and its support that mounts to the frame of the vehicle.



Figure 7: Dashboard and support

In detail the box has been designed with a of 1,2 - 1,5 mm thickness and "wraps" tightly to the electronic boards.

The first designs consisted of 4 parts: the container, the cover, the tachometer support and the internal cap.



Figure 8: In the picture you can see the particulars of the CRP ECU

The Manufacturing technique

The Dashboard was made by the same SLS (Selective Laser Sintering) Technology used to manufacture Rapid prototypes in many industries.

The SLS manufacturing process utilizes a layer additive system. A powder is rolled out in a gas inert chamber at 0.10mm (0.004”) layers. After the layer of powdered material is applied a CO2 laser is used to melt or sinter a Two dimensional cross section of the part. This process continues layer upon layer with each successive layer of powder being sintered on to the next creating a Three dimensional part. The non sintered powder areas of the chamber support the part being built and are removed from around the component when the build is complete.

The Material

To gain an understanding of how the Windform® XT would work for this type of application a comparison was made to PA6 BG-35. (A material for injection molding used for production of the final parts for Automotive Industry.) In testing it was found that the prototype material has a lower overall strength when compared to PA6 BG-35, but it mirrors the rate of change per degree temperature. It was also seen that it maintains the strength of the base PA12 material at higher temperature exposures. This testing gave confidence to the design team to move forward with the development of the part using the SLS technology and the carbon filled material.

Tensile Strength evolution on a function of temperature

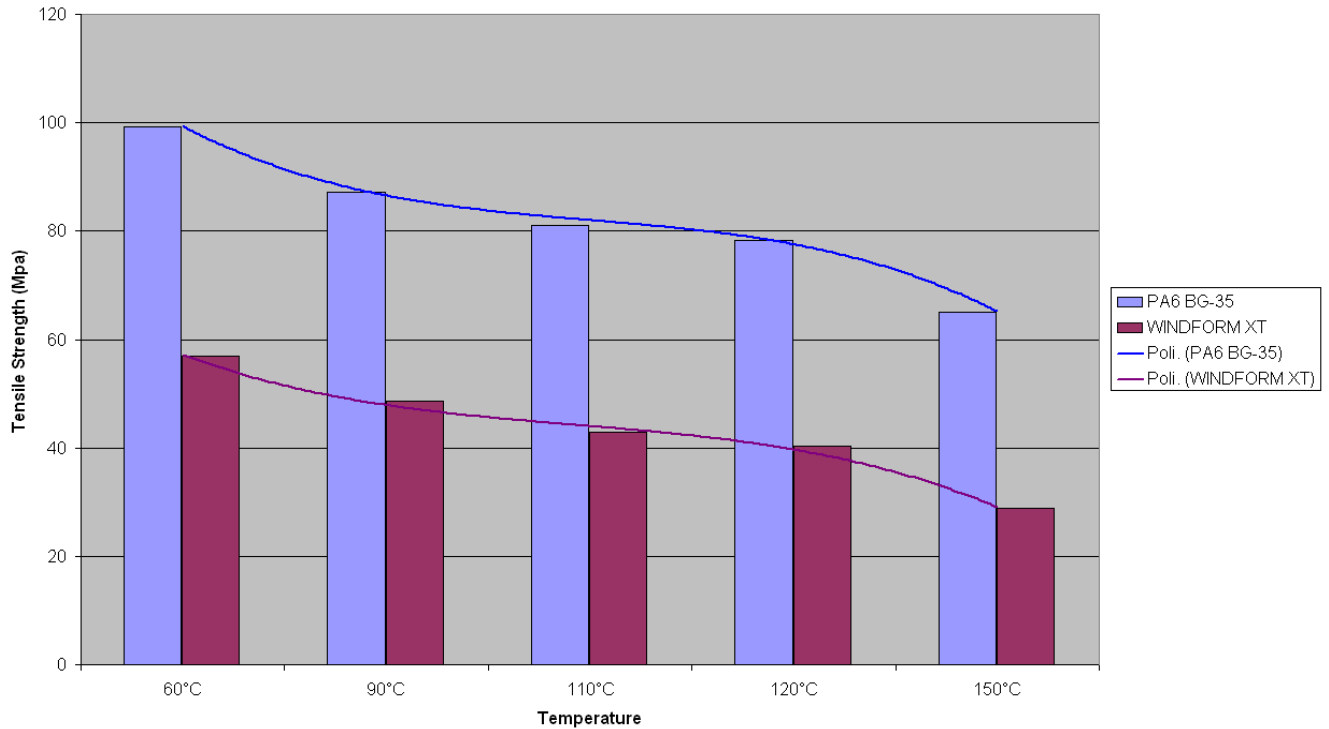


Figure 9: Windform XT and PA6 BG-35

The high performance carbon composite SLS material allows the components:

- To obtain an extremely light part in a very shorter time, as only RM can offer;
- To realize a more complex shape when compared to metal fabrication; and
- To save money and avoid tooling costs of moulding the part in plastic.

The material comparison and testing show that it can perform in the varied environment, where ambient temperatures can range from 2 to 35 degrees Celsius, and track temperatures can reach as high as 46 C.

PROPERTIES WINDFORM® XT	Test Method	SI Unity	WindForm® XT
GENERAL PROPERTIES			
Density (20° C)		g/cm ³	1,101
Color			DARK
THERMAL PROPERTIES			
Melting Point	ASTM D 3418	°C	179,33
HDT, 1.82 Mpa	ASTM D 648	°C	175,4
Vicat 10N	ASTM D 1252	°C	178,1
MECHANICAL PROPERTIES			
Tensile Strength	UNI EN ISO 527-1(97) UNI EN ISO 527-2(97)	Mpa	77,85
Tensile Modulus	UNI EN ISO 527-1(97) UNI EN ISO 527-2(97)	Mpa	7320,8
Elogation at break	UNI EN ISO 527-1(97) UNI EN ISO 527-2(97)	%	2,6
Flexural Stregth	UNI EN ISO 14125: 2000	Mpa	131,52
Flexural Modulus	UNI EN ISO 14125: 2000	Mpa	6248,5
Impact Stength - Charpy Unnotched [23°C]	ASTM D 256 - UNI EN ISO 179:1998	KJ/m ²	32,4
Impact Stength - Charpy Notched [23°C]	ASTM D 256 - UNI EN ISO 179:1998	KJ/m ²	4,73
Impact Stength - Charpy Notched -30°C	ASTM D 256 - UNI EN ISO 179:1998	KJ/m ²	4,66
SURFACE FINISH			
After SLS Process		Ra µm	6,0
After finishing		Ra µm	1,8
PROPERTIES PER DENSITY UNIT			
UTS per density unit		Mpa * g/cm ³	70,71
Tensile modulus per density unit		Mpa * g/cm ³	6649,2

Note: These are all indicative values, data was generated from the testing of parts produced with the Windform® XT materials under optimal processing conditions.

Standard Technical Details for Accuracy versus Tolerance:

For parts up to 6" (150 mm) the standard tolerance is: +/- 0.012 inch (0,3 mm)

For parts more then 6" (150 mm) the standard tolerance is: +/- 0.002 inch per inch (0.05 mm per 25m)

Figure 10: Windform XT data sheet

Many RP Technology solutions have permeability issues. As a precaution the external box and the cap are impregnated by resin, so that the Dashboard becomes waterproof.

To finish the product, it is necessary to install the clear plastic on the cover: it reduces glare and covers the gauges in the Dashboard.



Figure 11: CRP ECU ready to be assembled

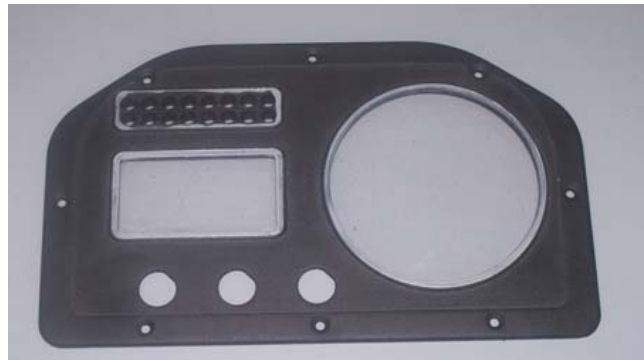
During the 2007 Road Racing Italian Championship's race at Monza, the weather conditions were quite poor during the race weekend. This was a test of the waterproof qualities of the Dashboard.

On one motorcycle, there were small water leaks during a practice session made under heavy rain. After further examination, it became clear the water was penetrating around the instrument faces and not through the mounting cover.

The weak point was the clear plastic sheet, especially the adhesive. An incorrect choice had been made in using a generic glue and in high humidity it failed and allowed the water to infiltrate inside the dashboard. (Despite some water inside the ECU, the official practice session was completed.) The solution was to add additional screen covers integrated into the face plate. In the first cover, the clear plastic sheet was bonded with a specific adhesive for the composite material, while in the second a housing modification was created to allow a Plexiglas to be sealed from the inside of the cover.



first solution



second solution

Figure 12: ECU/Dashboard covers

Both solutions gave positive results.

The Support

The dimensions of the dashboard were different compared to the standard ones and this is why we had to use a special support, made using SLS and then fixed to an aluminium pipe utilizing 4 screws.

In combination with the dashboard made by the CRP carbon composite material, CRP Racing has studied and developed the support connecting the dashboard to the bike (see the images below).



Dashboard Support (front view)



Dashboard Support (side view)



Dashboard support (lower view)



Dashboard and support on the bike

Figure 13: Dashboard support

The support is fixed to the pipe by a “clamp” system, and a small pin was studied to avoid the rotation of the whole system along the axle. This small shear pin, in case of a crash, breaks and allows the dashboard to move and minimizes the risk of damage.

The efficiency of this system was checked during the winter tests, when the rider violently crashed as he was busy forcing the rhythm to verify the set up of the bike.

In this case, the small pin broke itself allowing a rotation of the dashboard as predicted. The related damage was limited to the perforation of the external serigraphy without any damage to the internal hardware.

The New 2008 support design

For the 2008 season of the Italian Champ (CIV) and the Honda Trophy series, CRP Racing has further improved the support in order to optimize the design. This continued development is showing excellent results.



Figure 14: Crash during 2007 Honda Trophy

After some tests and a race where the rider crashed (see the images above), even though the damage was not bad, and while the pin described above saved the Dashboard, the fairing support was broken and they were forced to change out the full Dashboard system. In the last race of 2007, Riccardo had a very bad crash and even if the support's damage was limited to only a small area it had to be replaced and being a one-piece part they had to change the entire support. It was decided to optimize its design in order to ease its substitution when crashed and saving some money as well (Not needing to replace the entire Dashboard unit).

At the beginning of the 2008 season, CRP's CAD and R&D Departments, in cooperation with the CRP Racing staff, tested a new design, made of more than 1 piece, to allow easier assembly and disassembly on the bike. In the future, when a crash occurs it will require replacing only individual parts and not the whole Dashboard system, both a time and cost savings.

Below, the CAD images of the new 2008 support made of multiple parts.

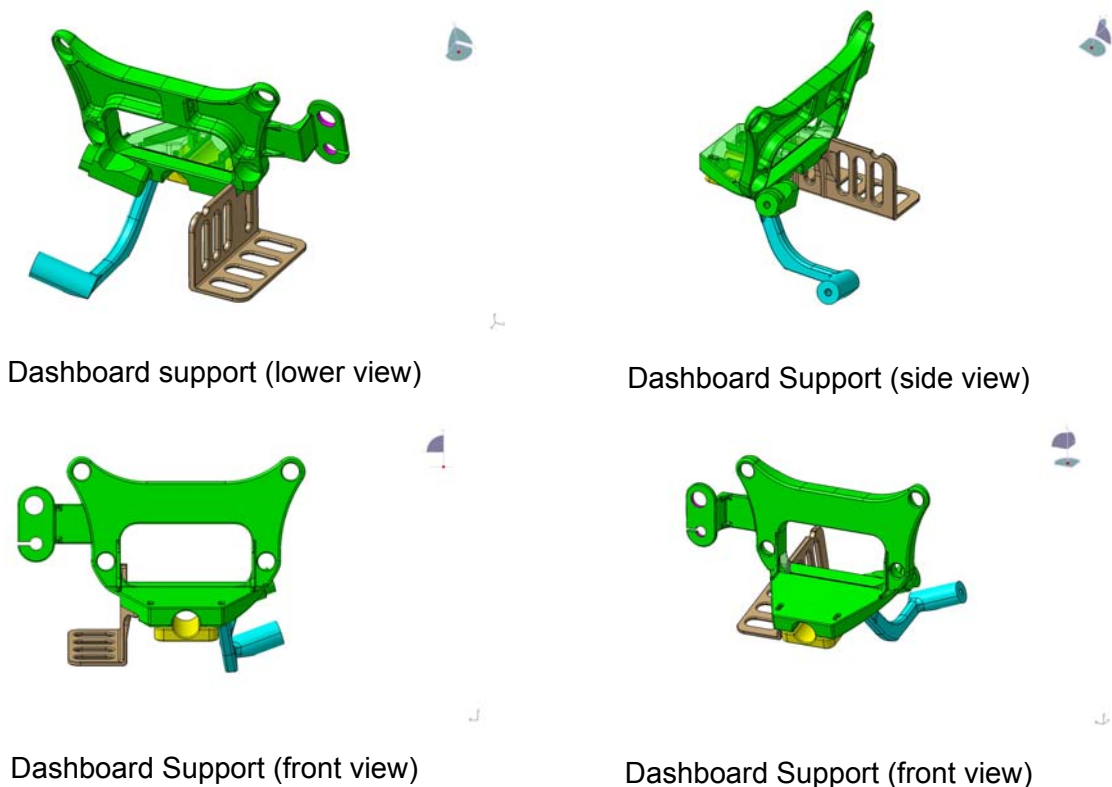


Figure 15: New Dashboard support 2008 revisited

The support is made of 3 parts assembled together creating a perfectly stiff and stable support.



Figure 16: Support and fixing system

As it can be seen in the pictures both the Dashboard and the support are assembled mechanically through the use of screws and helicoils. This guarantees the disassembly and re-assembly of the various components again and again.

The Dashboard support also holds the exhaust servo motor and the fuel tank solenoid valve. In spite of the violent accelerations and decelerations, the support always goes on working in the right way and can even resist the vibrations transmitted to the ECU.

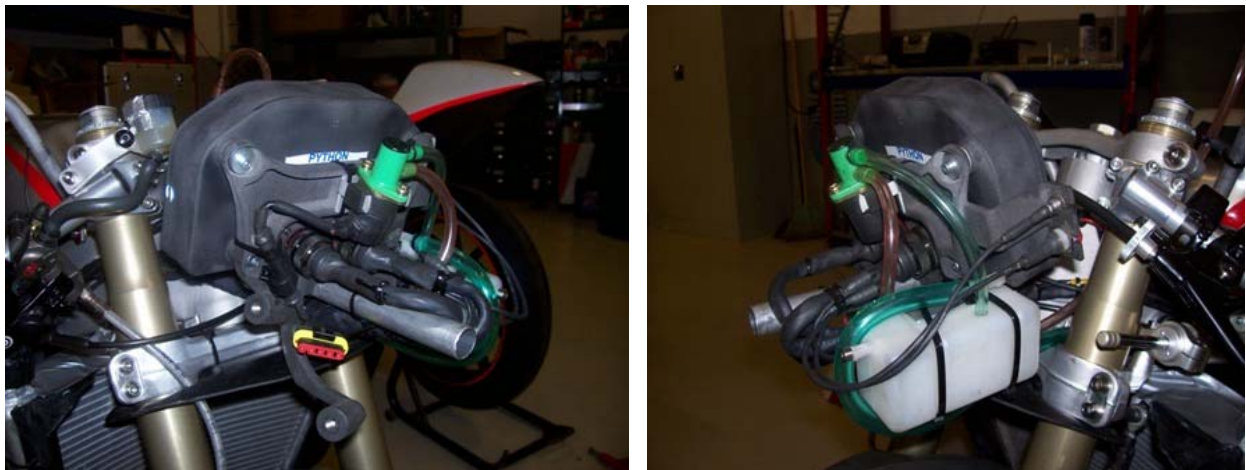


Figure 17: Complete assembly

Conclusion

One of the most important things in Motorsport racing is the final performance. The possibility to produce a high quality functional component in a very short time is the key to moving toward Rapid Manufacturing. When modifications are needed, Rapid Manufacturing allows them to happen, and can save time, weight and cost when only few parts are produced. The use of advanced materials coupled with Rapid Prototyping machines is allowing the creation of complex shapes that are durable and perform to the level of a production part: a step forward when compared to the aluminium and magnesium parts used in the past, which needed to be fabricated and machined. The testing of these materials in conjunction with racing helps to expand the knowledge of the material capability and to build confidence in what can be done in the expanding area of Rapid Manufacturing. This Dashboard is only a beginning.