Titanium in the Automotive Racing Industry

In racing, weight is everything. Designers are constantly looking to shave a few extra grams of weight from their design and material choice plays very large part of the design equation. The discussion will focus on the use of titanium in the automotive racing industry. Several examples of titanium’s use in race cars include springs, transmission cases, uprights, fasteners, and engine components such as connecting rods, valves and rocker arms. Initial use focused on high end race cars such as F1 and the 24 hours of Le Mans but is becoming more common across many other forms of racing. In conclusion, we will take a look at how material cost is a relatively small part of a component’s overall cost for a low volume race car component made from titanium vs. high strength steel.
TITANIUM & MOTORSPORTS

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Why do we use Titanium?

The obvious answer is the light weight and high strength.

But it also has very good fatigue properties and a lower modulus than steel which allows Ti to be an very good spring material as exemplified by the anti roll bar blade shown below. Another good example of the Titanium Springs were used on this classic 962 Porsche suspension spring. The springs were wound with a varying pitch angle and a varying wire diameter.
Another useful aspect of Ti for racing applications is that it can be cast and welded. This has allowed engineers to take advantage of design flexibility that comes from a cast part and with advances in rapid casting technology cast Titanium will play an ever increasing roll in race car design.
Ti has even found its way into honey comb panel construction and chassis use. As exemplified by the MT-900. In this application, two thin titanium sheets are oven brazed to a Titanium honeycomb core to create a sandwich panel than can withstand up to 1000 degrees F. The high heat resistance allows the panels to live in an engine bay application that would not be possible for standard carbon fiber panels.
RACING FEEDS PRODUCTION

A great example of how racing contributes to production cars can be seen in the latest generation LS7 engine from General Motors. In early 1993, GM began using Titanium connecting rods and intake valves in the Corvette Racecar competing in the 24 hrs of LeMans.

The same material now finds a home in the production Z06 Corvette.
MASS INDUCED FORCES

The BIGGEST benefit that Ti brings is when the parts own mass contributes significantly to the forces involved. A great example of this is in the engine. This is probably where Ti first saw significant use and continues to lead the way in both racing use and more recently in wide scale production use.

LS7 (left) 56 mm titanium intake, and (center) 41 mm stainless steel sodium filled exhaust valves in ports showing top view of a CNC ported cylinder head. (right) Titanium intake and stainless exhaust valves seated in the cylinder head combustion chamber.
SUSPENSION COMPONENTS

Suspensions also see a wide use of Titanium. Most notably in the upright or knuckle component. Once again, titanium is a good choice since reducing unsprung mass on the suspension is even more critical than saving weight elsewhere on the car.

Paris-Dakar Rally Racer – The upright circled has to live through one of the most grueling races in existence.

Formula 1 – Cast Upright with Welded Close Off Panels
FABRICATION METHODS INCLUDE CASTING AND WELDING

Easily cast 6Al-4V titanium is used for many parts including a relatively simple coolant connection. The Formula 1 upright on the right is a good example of how Ti can be cast then the plates can be welded in place to close off the section to create a stronger part.
NEW MANUFACTURING PROCESS ARE IDEAL FOR MOTORSPORTS

The use of titanium in motorsports should see considerable growth in the future due to two very exciting technologies.

**Rapid Prototype Casting Patterns and Molds**

**Laser Sintered Rapid Prototype Parts**

Racers are always looking for an edge which results in constant refinement of parts and in many cases several design concepts needing to be tested over the course of single season.

Low quantities and a constantly evolving design are the norm for racing companies which is why these two technologies will open up an expanded array of design options.
RAPID CASTING

“Rapid Casting” is based on the combination of Rapid Prototyping technology, to manufacture the disposable pattern, and Investment Casting technology.
RAPID CASTING PROCEDURE

The RP disposable pattern is made using the Selective Laser Technology (SLS) through a consecutive overlapping of layers.

The system doesn’t require any support because the piece is held up by the non-sintered powders, therefore giving complete freedom of shape.

- A disposable pattern is made through RP technique and RP technique and polystyrene material
- The pattern undergoes wax infiltrations to increase its strength
- It is then immersed in a ceramic bath
- Slurries and stuccoing and exsiccation
- The lost pattern is evacuated: dewaxing with flash firing or autoclave and subsequent sintering of the ceramic shell
- Alloy casting with inductor or voltaic arc
- Pouring, cooling, reduction of the shell, shot peening, gate cutting, heat treatments
UPRIGHT EXAMPLE

Another fine example of what is possible with Rapid Casting Technology.

Disposable upright model made with Windform PS and Titanium Upright. Courtesy of CRP, Italy.

Pratt & Miller Cast Prototype

Formula 1 Upright
Direct Part Production Using Electron Beam Melting Process

Figure 1: Electron Beam Melting process.
ELECTRON BEAM MELTING – MATERIAL PROPERTIES

EBM Material properties are better due to a more refined grain structure.

The technology is destined for the International Space Station so any part can be replaced from a single box of powder. We may soon be able to print our racing parts in much the same way.

EBM IS A BIT MORE BRITTLE BUT HAS VERY GOOD GRAIN STRUCTURE
ELECTRON BEAM MELTING
RAPID PROTOTYPE MACHINE

EBM S400
AT A GLANCE

Max. build size:
200 x 200 x 180 mm (7.9 x 7.9 x 6.3 in.)

Build rate:
Up to 60 cm³/hour (3.7 in³/hour)

Layer thickness:
0.050 – 0.200 mm (0.002 – 0.008 in.)

EB positional accuracy:
±0.05 mm (0.002 in.)

Accuracy:
±0.40 mm (0.016 in.)

Output (electron beam):
4 kW max.

Size:
1.8 x .9 x 2.2 m (6 x 3 x 7 ft.)

Weight:
1,350 kg (2,976 lbs.)

Titanium parts produced by electron beam melting.
SUMMARY

TITANIUM HAS BEEN USED IN MOTORSPORTS FOR QUITE SOME TIME AND ITS USE WILL CONTINUE TO GROW.

PRODUCTION AUTOMOBILE USE WILL GROW DUE TO THE NEVER ENDING QUEST FOR LIGHTER, MORE FUEL EFFICIENT VEHICLES

NEW RAPID MANUFACTURING PROCESSES ARE BECOMING MORE COMMON WHICH WORK WELL IN THE FAST DEVELOPMENT CYCLES SEEN IN MOTORSPORTS

SOME DAY I MAY HAVE FULL MACHINE SHOP RIGHT IN MY OFFICE WITH A DIRECT LINK TO MY COMPUTER!!!