



CRP Motorsport Case study

Rally-Raid 2007 Suspension Corner

The French crew of Stéphane Peterhansel and Jean-Paul Cottret won the event for the third time in four years in their Mitsubishi Pajero/Montero Evolution and beat their team mates and defending champions Luc Alphand and Gilles Picard by a margin of just seven minutes 26 seconds, after 15 days of bruising competition across Portugal, Morocco, Mauritania, Mali and Sénégal.

A winning synergy

A winning synergy allowed the optimization of the key components of the suspension corner, one of the critical corner for endurance and off road racing vehicles, such as Paris-Dakar Rally cars: **uprights and suspension levers in 2006 and uprights in 2007** gained reliability and lightness thanks to the special CRP custom process.



"Process and production of mechanical parts through investment casting made from 17-4PH H1025 steel did allowed us first to proceed for weight saving, second to obtain a structural behaviour with higher efficiency, as well as much better final quality" indicates Franco Cevolini, CRP Technology's Chairman.

The perfect synergy between the technical offices of Mitsubishi CRP has permit to re-design the component, obtaining an excellent mechanical answer and respecting the requirements of the foundry.

As soon as the 3D model is produced through the preliminary casting, the mechanical-structural quality is valuated, once more checked through different sessions of structural calculation: test are made with advanced workstations in order to check reaction at various load cases, simulating real stress from track.

After validation from Mitsubishi engineers, CRP has begun the productive cycle involving its internal Rapid Prototyping department, and after full inspection, these sintered lost models have been used for the casting process.

As part of the quality process from the inspection dept, CNC (Continuous Numerical Control) service has completed various test on the parts, including NDT (Non Destructive Test) inspection.

"The opportunity of being able to decide between different manufacturing process inside the same company is fundamental to guarantee the best result. The flexibility of an highly

CRP Group

Via Cesare Della Chiesa 21 - 41126 Modena, Italy
Tel./Phone +39-059-330544/821135/826025
Fax +39-059-822071/381148
www.crp.eu



selected and motivated organic assures, moreover, reliability and respect of the total timing” indicates Franco Cevolini. **“This is one of the reasons why Mitsubishi has decided to renew the winning synergy with CRP Technology”**

To deepen the technical background read below, otherwise jump the box and read from “EVOLUTION DETAILS...”

Engineering and manufacturing process

The required properties for the uprights are lightness (as a non-suspended mass), stiffness (any deformation compromises the kinetics of the suspension and braking) and reliability (as one of the safety components).

They were usually manufactured through forming and cutting of steel sheets, including welding, heat treatment, CNC machining and finally painting to protect against corrosion. Mechanical performance optimization was not possible, making the uprights heavier. Moreover, being a welded piece, they presented a structural anisotropy, shortening the lifespan and the reliability.

In 1998, CRP began to optimize the engineering process and the manufacturing process, studying the Titanium Rapid Casting, which is based on the combination of Rapid Prototyping technology, to manufacture the disposable pattern, and Investment Casting technology (lost wax casting) with Titanium alloys.

The RP pattern is made by Selective Laser Sintering technology, therefore giving a complete freedom of shape.

Rapid Casting procedure is composed of various steps:

- Disposable pattern made with RP technology and polystyrene material;
- Wax infiltrations (immersion and capillarity) to increase the pattern strength (to avoid handling breaks) and elimination;
- Ceramic bath for the pattern: Slurries, stuccoing and exsiccation;
- Evacuation: Dewaxing with flash firing or in autoclave and drying of the ceramic shell
- Alloy casting;
- pouring, cooling, reduction of the shell, shot peening, gate cutting, heat treatments.

The casting structure is formed of an aggregate of grains or polyhedral crystallites which produce isotropy compensation, while in a solid metal they are anisotropic: FEM calculations are very close to the real behaviour thanks to the isotropy of the piece.

Ti 6Al6V is made up of 6% aluminium and 4% vanadium, and is an excellent combination of and stiffness, with excellent resistance. Besides, solution Treatment and Ageing process (the STA) was developed to increase UTS.

Titanium casting has got a really high reactivity and that’s the reason why it needs the following in addition:

- Chemical milling, to remove the alpha case created when the metal touches the ceramic shell;
- HIP, Isostatic Pressure, to eliminate porosity from inside the material;
- TIG Weld repair to remove due to HIP;
- continuous X-ray inspection;
- shot peening, inducing surface compression stress to increase fatigue .



This technology was immediately highly appreciated by customers: it provided durability and reliability of the part (a casting is naturally isotropic for compensation), fewer design limitation to lightener (pockets) and get stiffer (adding ribs) the part during the racing season.

Evolution details from 2006 to 2007

The following analysis is regarding racing wheel upright for Rally Raid car, typical part holding the wheel hub bearing and formed with various mountings and brackets for suspension attachment (wishbones and damper), and as well various analysis sensors.

This component is defined as very critical part from the whole suspension as directly stressed by the vehicle dynamic and road profile.

The main issue is therefore the reliability, but also stiffness and lightness, being a racing component.

Wheel upright is also precious to maximise car handling feedback to the driver, but also to react to the various solicitation from the driver in respect to the grip available.

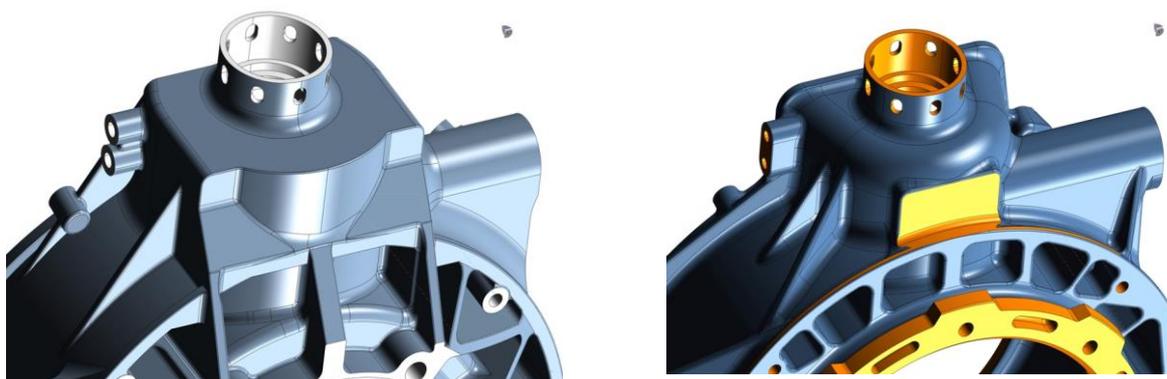
Usually made from weld/fabricated process, standard wheel upright have then a limitation in stress orientation due to their anisotropic structure, whereas wheel upright made from casting doesn't have such inconvenient due their isotropic quality.

As for cost factor, this is fairly compensated by the longer mileage, with low failure and number of cracked components, causing large reduction in spare parts. Obviously improvement in design and casting optimization have contributed to minimize scrapped parts, and reduced production cost.

UPRIGHT DESIGN TRENDS - Mitsubishi Pajero / Montero Evolutions (2007)

Lower mounting point:

New design for the cage to get uniform wall thickness all around in order to improve casting quality and save weight, together with new distribution of the ribs for better response to the mechanical requirement caused by stress. The "cap type" structure, is a direct response to the structural calculation made on the model, and thanks to this new morphology, the result was a more uniform stress distribution and obvious weight saving. This was especially the case in one of the key area of the upright (see picture 02_A/02_B)



Top mounting point:



Main target was the removal of a deep pocket which was causing large issues when building the ceramic shell. The refractory, stuck at the deep bottom of the pocket, was more over causing thermal barycentre, which in case of faulty feeding, would have create issue on the casting. In addition, all radius have been revised and adapted, ribs have been moved and an opening was created.



Before



After



Before



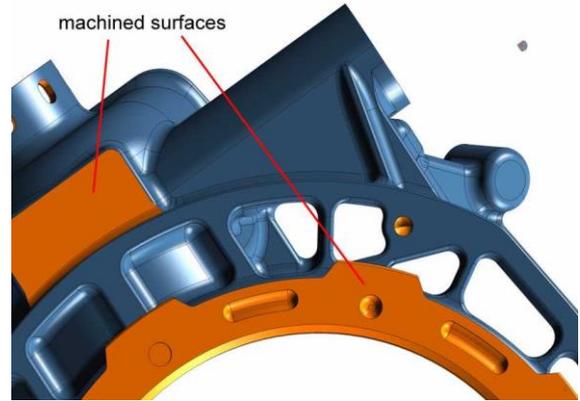
After

Lower mounting point side walls:

In order to minimize any issue with thermal barycentre, triangular and angular geometry made locally by the ribs has been enlarged. More over, a main rib join brake calliper fitting to the spool diameter, in order to compensate wall thickness reduction in the lower mounting point area.



Before

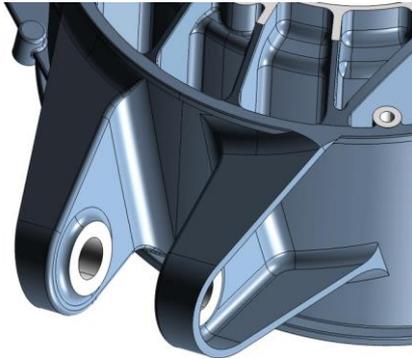


After

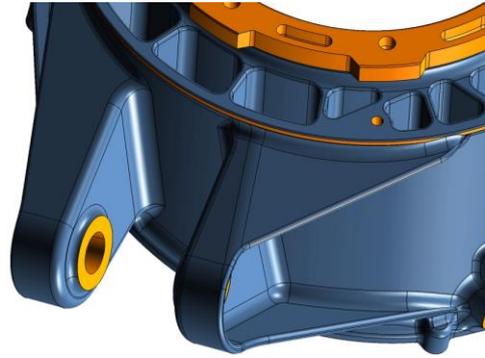
Trackrod clevis:

Improvements were made in order to get a more efficient casting process with better quality as result, but also fairly increasing stiffness in camber load (up by 25%) and steer load cases (up by 58%).

Optimizing FEM result, some more weight saving was made in the low stress area, with a gain of 6 % respect to previous year .



Before



After