High performance engineering

BACK TO THE FUTURE
AMILCAR C6 RESTORATION

Background

The epitome of Gallic automotive style, Amilcar was best known for small, inexpensive cars until 1925, when it launched something quite out of character; a small Grand Prix car series of the very highest specification. Designed to beat all opposition in the competitive voiturette class, Amilcar's family of race cars went on to win numerous trophies during the 1920s.

By 1929, the company was facing hard times and was forced to close its competition department. Amilcar only survived a few more years before being taken over in the 1930s. Indeed, the business stopped production entirely at the outbreak of the Second World War. With only 20 operational models of these cars in existence today, their rarity makes them incredibly sought after.

A prime example of a 1927 Amilcar C6 Voiturette, and one of only six imported to the UK in 1927/1928, came to the attention of KWSP via a vintage car collector who was restoring the vehicle. Almost identical to the models that had triumphed at the French Grand Prix (1,100cc class, 1928) – and chalked up second places at the 'Bol d'Or' in 1935 and 1936 – the six cylinder, 1,100cc twin overhead cam supercharged car had been brought across the channel by the agent Vernon Balls, who tried, unsuccessfully, to market it as a road going sports car.

UK-based KWSP is one of a new breed of disruptive engineering companies specialising in the emerging discipline of additive manufacturing, which includes 3D printing. The company was approached by the car's owner, who presented its engineers with an unusual challenge; to manufacture a one-off gearbox cover, using nothing more than an old black and white photograph as a reference!

The technology challenge

Following a period as a racing car, when Brian Twist had some success with the car at Brooklands and the legendary hill climb venue Shelsley Walsh, the C6 was acquired by an enterprising Russian engineer. Records suggest that sometime before the outbreak of war – probably 1933 – he made substantial changes to the car, lightening the vehicle and making other modifications such as a remote gear-change arrangement. This 'personalisation' included a unique gear linkage mechanism that provided a remote gear shift closer to the driver, presumably to improve comfort. This set up was unique to this particular example of the C6.

An extension to the original cover, it also incorporated an electric starter motor, which was specified on a handful of cars sold in England. Originally, the C6 had no electrics beyond its magneto, so these enhancements were presumably an attempt to attract the more discerning British motorist.

Project impossible?

Keen to re-create the cover and cradle for a starter-motor as part of the restoration project, the owner approached KWSP with a single black and white photograph of the bespoke casing and gearshift.

Clearly, this was a tough engineering challenge, even for proponents of the latest digital manufacturing techniques. While the remit was clear, not all of the data and technical information needed to complete it was readily available. KWSP was set the task of re-engineering and manufacturing a new casting for the gearbox cover to the same concept of the 1920's design – but now with subtle design influences of its modern day owner – based on little more than a grainy image, some hardware, no CAD data and the owner's intuition!

Using reverse engineering tools, KWSP design engineers measured and scanned the existing gearbox and then created CAD data of the complete historic assembly. The process of reverse engineering involved, firstly setting up the existing 1920's gearbox cover in the KWSP workshops and then scanning to create a 'cloud point' data model of the casting, including all of the mechanical interfaces.

Kieron Salter, managing director of KWSP, explained: "Using Solidworks Pro CAD software, we converted the scan data into useful CAD files that gave us the mechanical interfaces and geometry to begin designing the new cover. Because the original castings were manufactured from handmade patterns, there are not many exact features within the cover that can be predicted, so the scan data had to provide for a very accurate representation of the original.

"Also, the new position of the gearshift via the remote linkage was not easy to predict, so we not only had to reverse engineer the casing, but also its installation in the car and the hard objects such as the dash bulkhead in order to get the positioning correct. We also needed to design a linkage mechanism that could allow a simple retrofit to the existing gearbox mechanism that would be stiff, reliable and give good feel and feedback to the shifter."

"Crucially, the ergonomics of the cockpit of the C6 are what can only be described as 'cosy'. It is a tiny, lightweight race car. And with a driver and passenger, the cockpit space provides very little room for the shift mechanism. For that reason, it was felt necessary to build a prototype of the casing and mechanism to validate the ergonomic success of the new design.

Kieron continued: "We designed three concepts of mechanism that were evaluated for performance, cost and manufacturability and finally concluded on a dual rod linear mechanism.

"The project was a cross between an advanced automotive project and a Poirot detective story. It has been a fascinating and hugely rewarding challenge to use the latest in digital fabrication to recreate a unique component, using modern manufacturing design techniques that interface with an assembly that was handmade in the 1920's.

"This is where advances in 3D printing really bring value. But it's not just about pressing a button and producing an object in three dimensions. The real added value is in the design validation and final manufacturing element of the process. Our team has worked hard to create a one-off component part that exactly matches the original bespoke gearbox cover, while performing reliably from a modern engineering perspective."

Scan of the gearbox (L) and a 3D render of the finished casting (R)

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Kieron Salter, managing director, KWSP

Technical capability

Using its in-house FDM (fused deposition modelling) additive manufacturing capabilities and the CAD data of the redesigned part, KWSP manufactured a low cost, functional thermoplastic prototype which was manufactured to be modular and adjustable to validate the final installation prior to committing to final tooling for the castings.

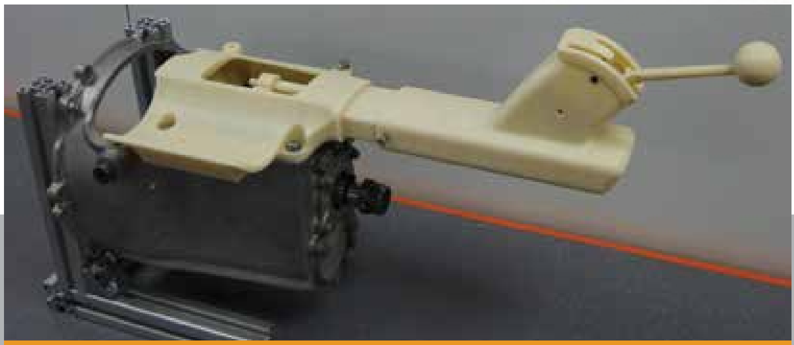
Building a full size prototype in ABS (a strong and durable thermoplastic), KWSP undertook bench test validation of the mechanism and also assessed the part for fitting in the car for ergonomic testing. From creation of CAD data to functional parts manufacture, the build of the new cover took less than 24 hours.

Kieron Salter comments: "The reverse engineered ABS model was not only vital in the design process, it acted to validate the casting pattern, thus saving time and cost by avoiding expensive re-design or rework. All data used and collected remains in the digital world, so it is highly repeatable and multi-functional.

"We used the same digital CAD model to conduct finite element and kinematic analysis on the linkage mechanism, the ABS plastic model and the final aluminium casting. Using the CAD model rendering tools, we were also able to create photo realistic images of the new parts for the customer to review and sign off prior to manufacture, which saved us a huge amount of time and gave our customer confidence in the final design."

The digitally made prototype enabled KWSP to confirm the design at low risk and low cost before proceeding to the next stages – the design and manufacture of the gearbox cover in metal alloy.

This example of reverse engineering, additive manufacturing and modern engineering design demonstrates the huge potential for disruptive engineering techniques in the historic car market, as well as other industries such as medical devices, aerospace and wider automotive applications. This fusion of traditional engineering skills with the latest digital manufacturing know-how opens up exciting new opportunities for VSCC competitors – and those involved in wider restoration projects - to source bespoke parts that were previously never viable.



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The final aluminium casting of the extended gear shift mechanism

The benefits of digital...

Using these advanced engineering techniques, KWSP was able to work with a client who was abroad and on a car that was not even based in its UK workshop. Other key benefits of this pioneering methodology provide the ability to:

- Recreate and manufacture parts for a car with no original CAD data to work with and no spare parts available as reference sources
- Create a kinematic simulation using SolidWorks CAD
- Create photographic renderings of the completed design to share with the customer
- Rapidly print at low risk and low cost a functional prototype in ABS
- Adjust the design following the fitting of the prototype in the Amilcar

In the final analysis, this type of one-off design and fabrication of unique vintage car parts would be very challenging to achieve without the development of additive manufacturing techniques. Kieron Salter concludes:

> “We think there's a hugely exciting future for this kind of high precision, added value engineering in the global classic car market.”

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