A new generation of reinforced engineering thermoplastics is fast becoming the standard for Tier 1 automotive applications - from engines to airbags.

One of the more recent application areas is the use of thermoplastics in oil sumps. With the help of DSM’s expertise, different Akulon® PA6 oil sumps were launched already in a variety of grades including Akulon Ultraflow K-FHG7, which delivers a significant improvement in flowability, without losing strength.

Next to the concept where the oil sump is made entirely from PA6, another concept will see its introduction in the coming years. The newest application is a unique hybrid concept for oil sumps – and oil sumps – that will enable the industry to reduce the weight by up to 30-40% and system costs by up to 20% - whilst at least matching the overall performance of metals, as well as enabling a reduced carbon footprint.

The hybrid structure integrates the oil sump with the structurally loaded bed plate that carries loads from the transmission system; not only the pan will be made entirely from PA6, but also the main part of the bed plate. The load of the transmission will be carried by a small aluminum bracket. The two plastic parts, meaning the pan and two-thirds of the bed plate, are joined together using different kind of welding techniques (vibration, hot air and infrared welding). These two welded parts together form the oil container.

This latest innovation is possible thanks to Akulon®, a revolutionary PA6 thermoplastic that not only outperforms many metals but also enjoys many superior qualities to PA66 (improved processing, long-term heat resistance and improved welding properties).
The company behind this innovation is DSM Engineering Plastics. In addition to inventing the Akulon® material, its global team of engineers and technicians has developed the hybrid system in partnership on this project with a leading Tier 1 and OEM. It’s been a huge engineering effort, totaling three years of extensive research and development and redesign that makes innovations like these possible.

**Why Akulon for automotive?**

Akulon - DSM Engineering Plastics’ industry leading PA6 material - now has 120 million system installations across 150 vehicle types worldwide. As different oil sump projects at e.g. Daimler and PSA have once again proven, Akulon is matching the bill perfectly. Providing incredible strength under duress (heat, chemical, impact) whilst also being incredibly flexible and pliable from a processing perspective. This material has been used for years already in areas such as engine covers and intake manifolds. This is particularly true for the premium grade Akulon® Ultraflow, which offers up to 80% improvement in flow and 25% reduction in injection molding cycle times versus regular PA6 grades.

Polyamides are much lighter than metal, which means lighter engines, less fuel consumption and a reduced carbon footprint. A weight reduction of 100 kg in a vehicle will save as much as 0.4 liters of petrol per 100 km traveled.

Furthermore, this same material has the ability to provide a superior finish to reinforced nylon components like engine covers, improving quality but with fewer processes. Importantly, for the automotive industry, Akulon also has a low carbon footprint next to its outstanding surface and flow properties. Despite being oil-based products, thermoplastics are more energy efficient than metals and can be recycled in several ways.

**The hybrid system: overcoming barriers**

Inventing a wonderful material is one thing. Actually finding viable commercial applications for it...is quite another.

Eventually the team began to think about oil sumps and how they could go beyond the norm and develop a hybrid system. The barriers, not surprisingly, were formidable.

**Oil sumps - and particularly oil sumps - must be able to provide dimensional accuracy and stability as well as strength and stiffness under the very toughest conditions. In particular there were two very simple reasons why plastics were rarely considered for oil sumps:**

**Heat:** These parts are exposed to top temperatures of up to 150°C and need to operate over long periods at 110°C to 140°C. Akulon has been successfully used in other oil management components, such as cylinder head covers for some years (which have very similar technical considerations).

**Strength:** Oil sumps and sumps need to be able to withstand sudden, violent impacts at high speed – as well as show extreme resistance to chemicals. There needed to be 100% certainty that the material would perform when it really matters.

Even materials with seemingly identical mechanical property profiles can perform very differently when subjected to the most extreme conditions. Therefore to prove beyond all doubt the performance and safety credentials of Akulon for oil sumps and sumps, DSM Engineering Plastics made a major decision: To embark on a three-year research and development project that combined its material and engineering expertise with outside validation from leading industry partners.

To this end, DSM Engineering Plastics is supported by an outstanding global knowledge team with expertise in materials science, processing, design, predictive engineering tools (particularly CAE), testing and other advanced engineering services for customers.
Simulation, prototyping and validation testing

Simulation
Before a prototype Akulon oil sump could be built, the material first needed to prove its capabilities in exhaustive studies with state of the art simulation techniques on actual parts. As the total performance of the sump is governed by material and design, we took design aspects into account to optimize performance.

Various aspects in Computer Aided Design (CAE) are instrumental in designing oilpans and more specifically the hybrid system proving its performance at all levels:

- **Simulation of stiffness and strength**: To determine the short term and long term deformations and optimize design layout, for example under seal loading and thermal loading.

- **Simulation of noise radiation (NVH)**: To characterize the expected noise levels.

- **Dynamic simulations**: To establish natural frequencies and response to external (engine and transmission) excitations.

- **Fatigue analysis**: To establish the durability of the part under dynamic loading conditions.

- **Simulation of Impact situations**: To check the structure’s mechanical integrity in real-time using impact situations.

The prototype
Having successfully put Akulon through its paces, the real proof is in designing a working prototype of the hybrid oil sump in cooperation with the TIER1. Three initial designs were produced joining oil sump and bed together using vibration welding techniques.

Validation testing
The fully simulated prototype of the hybrid design was then evaluated using various validation tests, including:

- **The engine ‘drop’ test**: How would the Akulon oil sump stand up to unexpected impact, like an engine drop. This test was formulated to find out.

- **The stone impact test**: A functional test that simulates stones and other hard objects striking the oil sump - using a ball-bearing fired at high-speeds, up to 230m/s.

To give the project added gravitas and credibility DSM Engineering Plastic then took a further major step – inviting the OEM to validate testing of the engine at its labs, complete with detailed technical reports and product files.

Akulon passed all tests with flying colours.

Bottom line: Benefits to tier 1 & OEM suppliers
What does a hybrid system in a re-engineered engine mean to the OEM/Tier 1? Akulon PA6 for oil sumps provides superior price/performance over a wide range of competitive materials, including steel, aluminium, metal-elastomer laminates, and indeed PA66.

Specifically, the Akulon-based hybrid system:

- Provides a cost reduction ranging from 20% for an aluminum oil sump to as high as 50% for silent steel, ie Bondal® metal oil sump. The component is quicker and more efficient to produce and more flexible to process from an engineering standpoint.

- Reduces weight by 20% compared to a traditional aluminum oil sump, rising to 40% in comparison to an aluminum bed plate and Bondal® oil sump. It results directly in lighter vehicles, reduced fuel consumption and lower carbon footprint.

- Enables innovation. For example, further simplification of engine design and production could be achieved through integration of the oil sump with various engine parts – from dipstick and oil pump to filter and suction pipe.

- Performs with high mechanicals at a temperature range between -30c degrees and -150c degrees. Akulon, a PA6, is able to perform in extreme heat for far longer than PA66 grade plastics.
It's sustainable: The clock is ticking not just for the automotive industry but for the entire planet. An Akulon oil sump could be recycled either conventionally or through innovative sustainability methods like feedstock recovery, which involves the shredding and separation of complex plastics.

Next steps: Tomorrow and today
DSM Engineering Plastics has proven that a fully integrated hybrid oil sump made from PA6 is not just possible, but also commercially viable.
- Short term: Akulon® oil sumps launched already this year in a variety of grades including Akulon Ultraflow K-FHG7, which deliver a significant improvement in flowability, without losing strength.
- Longer term: In the coming years the organisation will commit even greater time, budgets and resources to bringing the hybrid oil sump to market: We expect it to be commercially available by 2015.

The future has begun.
DSM Engineering Plastics delivers innovative opportunities for customers who design or produce electrical applications, electronic equipment, cars, barrier packaging films as well as many mechanical and extrusion applications.

These markets are served with a broad portfolio of high performance materials including Akulon® 6 and 66 polyamides, Arnitel® TPC, Arnite® PBT and PET polyesters and Stanyl® high heat 46 polyamides.

Most recently, DSM Engineering Plastics has introduced the first new polymer of the 21st century: Stanyl® ForTi™ and EcoPaXX®, a bio-based, high performance engineering plastic. DSM Engineering Plastics had sales in 2013 of EUR 1,261 million and employs some 1800 people worldwide.

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And what of the day after tomorrow? Beyond oil sumps, DSM Engineering Plastics is already thinking about new applications – such as a plastic gearbox and even major parts of the car body structure. In fact, we believe that the amount of plastic used in the average automobile will double over the next 10 years.

Akulon is only part of the puzzle. We are already using various engineering plastics in bold new areas such as the steering wheel (in this case made of Arnitel®, a sister material to Akulon).

Meanwhile, a new generation of materials has been developed that tap into the growing, critical need for the automotive industry to take sustainability to the next level. EcoPaXX® is a bio-based, high-performance engineering plastic for high-tech applications that is 100% carbon neutral from cradle to grave and is already commercial in many automotive applications like engine covers and crankshaft covers.
DSM Engineering Plastics

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