TRENDS AND NEEDS IN AUTOMOTIVE MATCHED BY VARIOUS PLASTIC SUSTAINABLE SOLUTIONS

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Abstract

An overview is given of the various drivers, needs and trends in the automotive industry and how these are matched by various new plastic solutions, which in the end all significantly increase the sustainability of various car components and of the cars in total.

Introduction

Major drivers for most trends in automotive today are quests for lower total cost of ownerships by consumers and for higher profitability levels (lower system costs) by the OEMs/T1s, for more green solutions (less emissions, lower fuel consumption, better recyclability, lower carbon footprints) and for higher safety and comfort levels. Some of these needs do originate from specific governmental regulations/legislations regarding CO2 emissions, NOx and particulates emissions according Euro V and Euro IV, use of biofuel, ELV directive, pedestrian safety and others.

Figure 1. CO2 emission regulations in Europe and estimated attainable levels for various technologies.

The various technology developments of OEMs/T1s focus therefore mainly on following activities:

- downsizing of engines resulting in an increased use of turbo systems
- optimization of efficiency of clutch and transmission systems resulting into more CVT and DCT transmissions and friction optimized systems
- weight reduction via various metal-to-plastic conversion projects for powertrain and exterior/interior components
- electrification of subsystems
- development of hybrid propulsion concepts and electrical vehicle concepts
- introduction first of more passive safety systems (air bag systems), later more and more replaced by more active safety systems

Next to that, more and more use is made of smarter plastic materials (high flow/high productivity plastics; materials with enhanced functionalities such as improved W&F behaviour or with laser structuring compatibility or with increased thermo conductivity), of smarter designs in plastic (integration of functions in case of metal-to-plastic conversion) and of lower development cost (increased use of very sophisticated CAE tools instead of application tests reduce also development times) in order to reduce system costs.

The development activities of DSM for automotive concentrate therefore on the following themes:

ECO-EFFICIENCY: WEIGHT and COST down:

- metal-to-plastic conversion projects for in thermoplastics as PA6, PA46, PA4.10, PET and in composites: examples are oil sumps, ducts, air bag inflators, gears, turbo parts, oil seals, throttle valve bodies, pump housings, floor pans, body panels, fenders, wheel suspension beams
- high flow and high productivity PA6 and PA46 materials and RTM composites
- optimal and more reliable part designs via the use of specific CAE calculation methods as Digimat and/or the use of specific data sets such as high speed tensile and dynamic burst pressure data

ECO-EFFICIENCY: LIFE TIME EXTENSION:

- high LT temperature resistant PA46 grades for turbo components
- various new blow moldable PA6 and TPC grades for ducts
- wear&friction optimized PA46 types for gears and MTD parts
- improved resistance against more aggressive fuels (bio fuels, EGR blow by) and oils

**NON HAZARDOUS SUBSTANCES:**
- wire and cable insulation in halogen free TPC
- solvent free coating resins

A lot of emphasis at DSM is furthermore directed towards the development and market introduction of **green materials** such as recycle based grades and bio based plastics as PA410 and specific thermoplastic or thermoset polyesters and to applications in **green cars** such as hybrid and/or electrical cars. In the next paragraphs various solutions of DSM for the various sustainability areas will be elucidated in more details.

**Weight Down.**

Fuel consumption and emission levels can be lowered by lowering the weight of the cars. This can be achieved by switching from metal to plastic solutions as much as possible. Metal-to-plastic conversion is nothing unusual as has been demonstrated already for multiple applications such as air inlet manifolds, air ducts, charge air cooler end caps, air bag containers, pedals and many more. New opportunities for metal-to-plastic conversion are currently being explored for oil sumps, ducts, air bag inflators, gears, turbo parts, oil seals, throttle valve bodies, pump housings, floor pans, body panels, fenders and wheel suspension beams.

One of the most pronounced metal-to-plastic-conversion developments in thermoplastics is that of the oil sumps and pans for passenger cars. Depending on the design (1 or multiple piece; pan or sump) weight can be reduced by 20-50% (up to 1.5 kg) when switching from Aluminium and/or Steel to PA6 or PA66. DSM has developed in cooperation with various tiers and OEMs various concepts in PA6, where important requirements like NVH and stone impact have been addressed via sophisticated CAE modeling models in conjunction with the relevant application tests. Highest productivity levels have been ensured by using DSM’s Akulon Ultraflow technology. Calciumchloride requirements for Japanese OEMs can be addressed via PA410 (tradename: EcoPaXX™). Also specific thermoset solutions for truck sumps are available.

Interesting metal-to-plastic conversion development projects in thermosets are to be found in areas as floor pans, body panels and wheel suspensions. Here sometimes up to 80 kg weight can be reduced.

**Performance Up.**

The trend towards downsizing of engines implies the use of more and more turbo charging. Depending on the actual air pressure temperatures can raise up to 220°C. In order to cope with these temperatures for 5000 hours and longer, DSM has developed a special PA46 grade (Stanyl Diablo) which as been approved already for various turbo parts as charged air ducts and resonators.

Another way to reduce emission levels and fuel consumption is to optimize the efficiency of the engine and transmission by reducing friction as much as possible, either by making use of smart application designs (like the special bearing cage in PA46 used in the new Toyota Prius) or of wear&friction optimized specialty PA46 grades (enable also the use of grease free components in subsystems as MTD).
More Green Materials.

A lot of emphasis at DSM is furthermore directed towards the development and market introduction of green materials such as, halogen free flameretardant grades, recycle based grades and bio based plastics as PA410 and other specific thermoplastic or thermoset polyesters.

Arnitel C and Arnitel XG are halogen free flame retardant TPC grades, which can replace PVC and ETFE for automotive cables and tubes. Arnitel C has been approved for class D (150 C) automotive cables: compared to ETFE cable, Arnitel® C provides a 50% cost reduction per length of cable for a standard 0.35mm² automotive cable.

DSM recently introduced PA410 (tradename EcoPaXX ™), a aliphatic polyamide based on diaminobutane and sebacic acid. PA410 is a green, bio-based material: the polymer consists for ca. 70% of building blocks derived from renewable resources, i.e. castor oil. Castor oil is a unique natural material and a very versatile building block for all kinds of chemicals: among all fats and oils, castor is the only one having a high proportion of ricinoleic fatty acid, a hydroxyl fatty acid that is highly valued within the chemical industry. Mother Nature still proves to be an inimitable architect!

Castor oil is derived from the Ricinus communis plant, growing in tropical areas. It can grow on relatively poor soils, and the production of castor oil is not competing with the food-chain. PA410 has been shown to be carbon neutral from cradle to gate, which means that the carbon dioxide which is generated during the production process of the polymer, is fully compensated by the amount of carbon dioxide absorbed in the growth phase of the castor beans.

PA410 is a polyamide with excellent mechanical properties in the range of PA66. It has a beneficial combination of a relatively high melting point of ca. 250°C, together with a high crystallization rate. Additionally it has low moisture absorption and excellent chemical and hydrolysis resistance, which makes it very suitable for all kinds of automotive under-the-hood applications, for example. Because of its low moisture absorption it will keep its good mechanical properties (e.g. stiffness) also after conditioning. PA410 has a lower density than PA66.

Plastics in Hybrid and Electrical Cars.

A lot of OEMs are increasing significantly their activities in the development of hybrid cars and electrical vehicles. The basic drivers for that originate in the emission legislation (CO2 emission allowance levels to be reduced extremely in 2020 to 95 g/km: see graph 1), in a fear for a potential scarcity of oil somewhere in the near future and in an increased green and TCO awareness at end consumers. As a result a number of consortia have been formed or are being formed between automotive OEMs, utility/electricity providers and battery suppliers and also new players like Tesla, Think, Duracar, BYD, Better Place do enter the market place.

However, still various roadblocks do exist in the areas of batteries (limited lifetime and high cost levels), infrastructure (availability of a complete network of charging stations and maintenance stations) and discussions around eco footprints (as related to the origin of the electricity). Therefore it is logical, that most predictions regarding the amount of electrical vehicles driving around in the market do still not exceed 5-10% for 2020 and that the combustion technology will remain therefore a dominant factor still for a long time (see picture 7).
The plastic industry can nevertheless not ignore the electrification trend and therefore has to scan now already the array of new opportunities in this field. These can be found as well for thermoplastics as for thermosets in the area of electrical parts:

- **start/stop** components (micro hybrids) to be introduced in big volumes already soon in many car models soon
- **electromotor** components of hybrid and electrical vehicles
- **battery** components of hybrid and electrical vehicles
- **inverter/converter and ECU components**
- **HV cables** for electromotors and batteries
- **E-subsystem** components as E-AC Compressors and E-water pumps
- **Charging station components**

The new start-stop systems must be able to withstand more than 300,000 start/stops, whilst the conventional systems are designed for only 60,000 starts. This makes the use of materials as **PA46** with its extreme good wear and abrasion resistance in combination with its excellent high temperature and fatigue resistance almost mandatory for starter gears, especially for the higher starter motor powers.

In Hybrid Cars and Electrical Vehicles **E-motors, Batteries, Inverters/Converters and HV Cables** are subsystems, where potential applications – mainly in insulation parts - can be found for Engineering Plastics and High Performance Plastics.

Due to the high temperatures in the **E-motors**, the **coil insulation** requires high temperature resistant materials such as PA46, PA4T, PPS or LCP. PA46 offers the lowest potential system costs because of a potential wall thickness reduction of 20-40% and a much easier processability compared to PPS and because of a lower material price than LCP; system costs can also be reduced by integrating the different insulation parts into 1 part.

Possible **battery** components in thermoplastics and thermosets are Cable Insulation (PVC, TPC), Cooling Fans (PET) and Cooling Tubes (PA66), Connector Parts (PA46, PPS, LCP, PBT, PA), Insulation & ECU’s (PA6, PBT, PP), battery trays (PA66, thermosets) and also various covers/boxes (PP, PA, thermoset). Also various components in the **Inverter/Converters** including the ECU can be produced out of plastics as PP, PBT and PA. The **HV cable insulation** can produced by using PVC; however also halogen free flame retardant TPC or high temperature resistant, non-flame retardant TPC can be considered as well.

Next to that it is also here of course crucial to keep the weight of those vehicles as low as possible. This implies for hybrids especially a strong emphasis on downsizing of combustion engines combined with the increased use of turbo systems and on metal-to-plastic conversion as much as possible for parts as air inlet manifolds, oil sumps, air bag containers, turbo parts. For
both hybrids and electrical vehicles other significant weight reduction opportunities do exist for thermosets and thermoplastics in applications as structural parts, battery protections, battery trays, body panels, fenders, floor pans and others.

**Cost Down.**

System cost optimizations remain key especially in automotive. Fortunately DSM has developed various offerings for the automotive industry to deal with this: many of the metal-to-plastic conversions lead to significant system cost reductions, especially when various parts are integrated into one and/or functions are integrated via specific designs.

Also the realization of optimal and more reliable part designs via the use of specific CAE calculation methods as Digimat and/or the use of specific data sets such as high speed tensile and dynamic burst pressure data by DSM lead to significant system costs optimization for various automotive applications.

Last but not least, also the use of high flowability and high productivity materials such as Akulon Ultraflow (PA6) enabled DSM’s customers to reduce the production costs significantly: Akulon Ultraflow (PA6) enables up to 20-25% faster injection moulding cycles, lower energy consumption during moulding of parts, 10% thinner walls for bigger parts and lower tool investment costs as a result of the 80% higher flowability and also great surface appearances for 50-60%GF grades. Akulon Ultraflow (PA6) has been approved already for various automotive applications, even safety parts such as air bag housings.

![Figure 11. High Flowability & High Productivity PA6.](image)

**Conclusions**

In this article various trends in the automotive industry and their possible impact on applications in Engineering Plastics, High Performance Plastics and Thermosets have been described. It can be concluded that there will still be ample opportunities for these high temperature resistant plastics in order to boost SUSTAINABILITY in automotive in the near future.

**References**

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