

Future of Automotive Design & Materials

Trends and Developments in Design and Materials



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provincie limburg 



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1 INTRODUCTION

Design and Materials are two different worlds and still strongly related. Each very different in their being and both equally important in shaping the physical world around us. Design creates products and products are made of materials. Design gives functions to products and materials are chosen and formed to best incorporate those functions. Design can also relate to graphics and the virtual world observed on displays or advanced visualization techniques. This trend study however focuses on Design of the physical world, shaped in 3D. And since this trend study originates from the Automotive Technology Centre the subject of this focus is on automotive products

The Automotive Technology Centre is the cluster organization of the Dutch Automotive sector. The goal of the ATC is to stimulate innovation and cooperation in order to strengthen and grow the automotive industry in The Netherlands. The ATC has five fields of action of which Design & Materials is one; the others being 'Vehicle Efficiency', 'Electric Mobility', 'Smart Mobility' and 'Manufacturing & Logistics'.

These fields of action represent the strengths of the Dutch automotive sector and the areas that are vital for future automotive development. To shine a light on the future the ATC has taken the initiative to produce trend studies on each of these five subjects. This report concludes the range. The other reports are available at the ATC.

Design has become a stronghold of the Dutch economy. The creative industry in The Netherlands has acquired an international profile in different markets as furniture, fashion, TV programs and gaming. 'Dutch Design' has a meaning of a new way of looking at things, down to earth, out of the box and often with a touch of humor. The Netherlands have many design education institutes and Dutch design graduates have found their way to make a career at international automotive Design studio's. Others put their design creativity to work in product planning, engineering or product management. New is the design of the virtual world. The Netherlands is strong in game design and design of Human Machine Interface (HMI) displays. Design is more than shape. Design is product creation.

Materials are an important part of the Dutch automotive industry. The Netherlands is home to a number of large raw material suppliers like Corus, DSM, Sabic, Styron, Dow or Akzo Nobel and an industry for advanced semi manufactured materials and components.

There is a synergy to be explored between these two fields of expertise. Both show strong developments. There are trends that relate to both and are important for future automotive innovations. However the two subjects are different enough to also have their own specific trends. Therefore this study, in its different



Figure 1: BMW Vision Efficient Dynamics

chapters, first describes the current situation and future trends for Design and Materials separately and subsequently in combination.

2 CURRENT SITUATION

The automotive industry is always on the move. It is a world of constant change and improvement. In this light a description of the current situation is a snapshot of where the current trends have led to. There are short lived trends and trends of today that will continue long into the future. Sustainability is such a long term megatrend. It determines most automotive developments including those on Design and Materials. Sustainability has been a major driver of innovation for decades and will continue to be for the foreseeable future. It reflects on almost every chapter of this report, but to structure this report aspects of sustainability are (mainly) handled in the chapter 'Future trends'.

2.1 Design

This chapter describes the form this study most relevant aspects of the current situation in automotive Design, first from an international perspective and secondly focused on the situation in The Netherlands.

2.1.1 International

- **Technology as driver**

Designers are looking for new possibilities and technology can provide what they are looking for. New technology can be an option, it can also be a mandatory road to follow. LED technology is an example of the first, aerodynamics of the latter. Technology is a driver for Design.

- LED technology

Lights are very important styling elements on the exterior of a car. They started as true add-ons, mounted on a bracket, were than fluently integrated in the body shape and today stand out as true eye catchers dominating the front end. Chromed lighting technology is dressed to its best behind full transparent glass. The design in no longer the shape of the body, but in the interior of the light; the bulb, the lenses. LED lighting adds an enormous design freedom in arranging multiple small light units into strings or clusters. The looks in the dark, when lighted, become more important than during daytime. Some brands started to use lights this way to make their cars very recognizable. LEDs are very energy efficient and add to fuel economy but the benefits in styling and image seem to have gained more importance then the functional benefits and outweigh the on cost.



Figure 2: Valeo headlight (Volvo S60 Concept)

- **Aerodynamics**

Aerodynamics have been very important in car design since the fifties. First as a gimmick, later as a serious means for fuel efficiency. The ideal aerodynamic shape is still that of droplet, but technology has found ways of making aerodynamic shapes of much more diverse nature. Aerodynamics no



Figure 3: Vanes in grill of Ford Focus 2011

longer makes all cars look alike. It is now clear that much can be gained by attention to detail (gaps), underbody. Huge wings or spoilers have been replaced by a subtle radius in tailgate design to free the airflow. Higher seating position have decreased aerodynamics as have done the larger grille openings to accommodate the higher need of air of modern high performing engines. Active vanes in the grille are used to reduce the opening when possible to improve aerodynamics (Ford Focus 2011).

- **Legislation**

The recent legislation on pedestrian protection dictates a softer front-end that is less harmful in impact. This requires more space between the hard steel powertrain parts and the outer skin. It is one of the reasons for the large front overhangs that we see on many of today's cars. The same goes for the higher hoods that not only change the car silhouette but also have inspired the use of vertical headlights often seen in current car design.

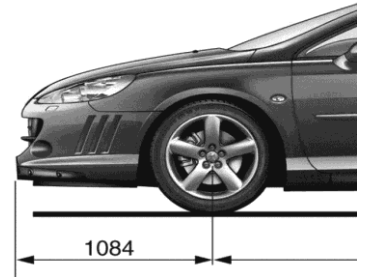


Figure 4: Front overhang Peugeot 407cc

- **Roominess**

The higher comfort requirements of customers today have a.o. been translated into more roominess. This has considerably influenced car design. Cars have become much wider (+10 cm) and higher (+10 cm) to create interior space (and accommodate safety and technology). Compare the new and the original Mini. The feeling of roominess can also be achieved by light. Glass surfaces have grown. Sunroofs today are more a means to let light in than air out. The Citroen Picasso introduced the front screen that runs into the roof.

2.1.2 Design in The Netherlands

- **Education**

Over the past twenty years The Netherlands have developed a strong educational infrastructure for Design on all levels. All three Dutch technical universities run studies on Industrial Design. The Design Academy Eindhoven has acquired world fame in conceptual design. Many other schools run bachelor programs on Industrial Design and the University of Technology in Delft has a master track on automotive Design.

Design studies enjoy a warm interest of high school graduates. They flourish to the extent that one of them, the Industrial Design department of the TU Delft has called upon a numerus fixus in order to handle the flux of new students; exceptional for a Technical University.

- **The role of Dutch Design**

Dutch Design is famous in furniture and fashion. It is a movement on the Salone del Mobile in Milan with well known labels as Droog Design and MOOOI and designs from a.o. Marcel Wanders and Maarten Baas and Piet Boon and Piet Hein Eek. In fashion Victor & Rolf have made it in Paris haute couture and Marlies Dekkers in a different market segment.

Dutch designers have also made name in the international automotive world. Two of the world's most prestigious design jobs are currently held by Dutchmen: Adrian van Hooydonk is Design director at BMW and Laurens van den Acker holds this position at Renault. Many more Dutch designers work in automotive design studio's around Europe and elsewhere. They work in design of cars, trucks, motorcycles and also in the automotive supply industry like Johnson Controls and Inalfa. The role of an automotive designer is to translate the brand image, heritage and culture into a design language that fits its time rather than creating his own personal style.

Automotive Design has a strong relation with national culture. There is French design, Scandinavian design, German design. With the lack of big a national car OEM there is no Dutch Design in automotive. However the role of the designer can have an enormous influence on how the design of the brand evolves. Harm Lagaay at Porsche nurtured the design of 911 to create the icon it is today. Fedde Talsma revolutionized the design of Volvo and Laurens van den Acker revived the design image of Mazda with concept cars with a new nature inspired design and just started to do so at Renault, but then in a very different way. A quote from well known UK Design critic Stephen Bailey: 'One of the most remarkable trends in recent automotive design is that it is being taken over by the Dutch'. The apparent fine touch of English irony leaves the core observation intact.



Figure 5: Marcel Wanders - 'Crochet' chair

2.2 Materials

This chapter describes for this study relevant aspects of the current situation in automotive materials, first from an international perspective and subsequently focusing on the situation in The Netherlands.

2.2.1 International

When it comes to R&D for automotive materials most effort goes into developing and using materials to make cars lighter. In spite of this, cars have considerably grown in weight over the last three decades because of increased safety requirements and comfort specifications (a.o. airco). It is an enormous challenge to bend this curve and effectively reduce weight in order to meet future emission regulation. Powertrains are the most effective way to do so, but weight reduction can help considerably. Studies indicate that 10%

mass reduction relates to a 3% to 7% benefit in fuel consumption depending on the type of car and the drive cycle used. The effect is stronger with more fuel efficient and down sized engines. On average a weight reduction of 100kg delivers -10gr CO2/km. Weight reduction often comes with a penalty on cost. As a rule of thumb the industry uses a target of max €5 per kg gained. For high volume cars in very price sensitive segments this target goes down to €2,5/kg.

• **High Strength Steel (HSS)**

The increased requirements on body strength and rigidity for safety and handling on one hand and the urge for weight reduction on the other have led to an increased use of HSS in car bodies. Since 2001 best practice on steel car body design shows a reduction of 21% of body weight (source: worldautosteel 2010). The use of HSS doubled since 2005 and is expected to triple in the period to 2020 as automakers strive hard to meet the future fuel economy legislation by 2016. Steel is not out. It is still very much alive as a cost effective material for car bodies. A further advantage of steel is that it takes a favorable position in well-to-wheel analysis. Compared to its alternatives steel takes little energy to produce and has good recycling capabilities.

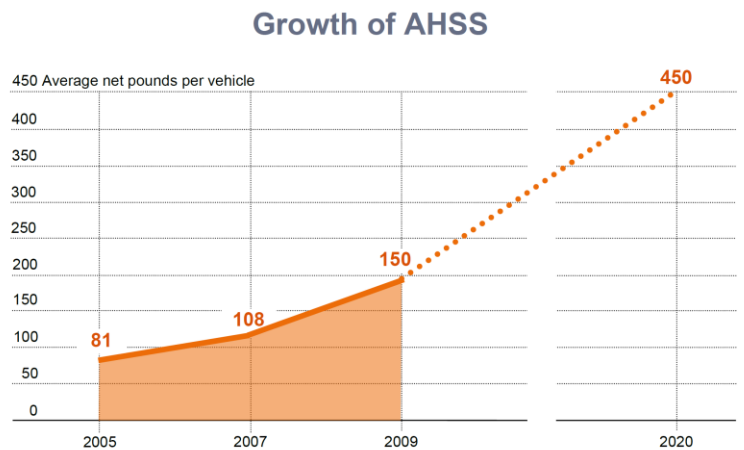


Figure 6: World Auto Steel: Impact of AHSS

• **Non ferro**

Audi set the pace for the introduction of the full aluminum body for its high end models. Jaguar also chose for the full Alu way with the recent XJ series, claiming a 40% weight saving on the body and reporting the use of 50% recycled aluminum. Other car manufacturers met the challenge with using aluminum for parts of the body like the hood or tailgate. The clever material mix seems to be the way forward. The state of the art in this area is indicated by the European Superlightcar study project on the basis of a VW Golf. The aim of 30% body weight reduction (85kg) was achieved with a clever mix of metals headed by aluminum. Aluminum was used for most of the bodywork. The material mix of this project is indicated in Graph 2.

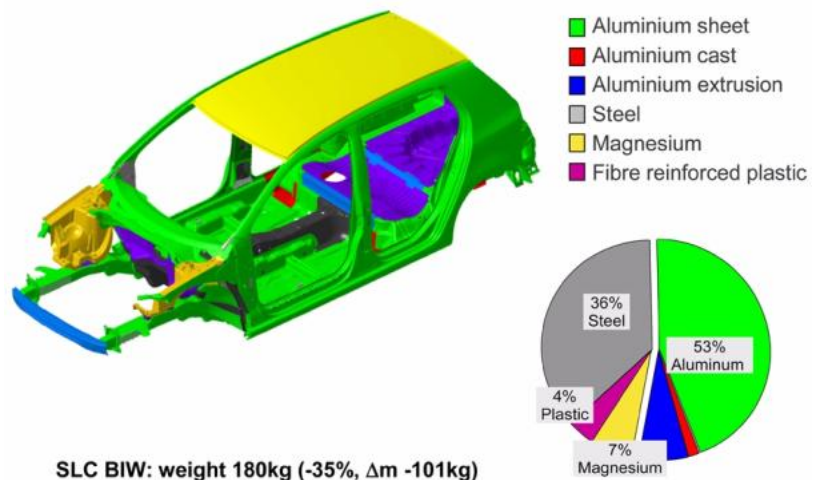


Figure 7: VW Super Light Car

When introduced in 1936 the VW beetle carried 20kg of magnesium components. A considerable share of its modest weight. Magnesium largely disappeared from the automotive scene but makes a hesitant return. It is more than 20% lighter than aluminum and available in abundance, but has a drawback in cost, energy consumption and deformation capabilities. Machining magnesium castings requires extra precautions to prevent possible flaming of chips. Superlightcar uses Magnesium for inner fenders and the roof. Porsche uses Mg for window frames and in front end modules. BMW has its own magnesium foundry.

- **Composites**

Just like non ferro materials also composites are not new to the automotive world. The Citroen DS was introduced in 1955 with a glass fiber reinforced plastic roof as one of its breakthrough technologies.

Composites have been used ever since but mainly restricted to small volume specials. The initial problems with quality control in production have largely been solved.

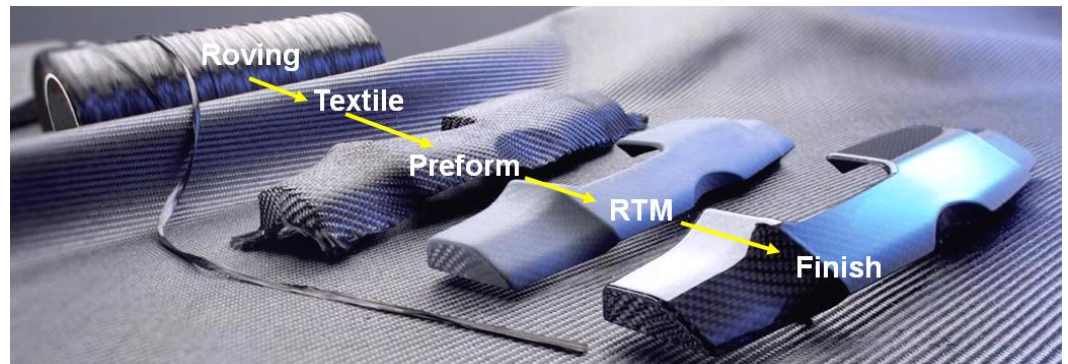


Figure 8: Benteler SGL composites process

The major remaining drawback for wide

spread use is the cost of the part due to handling and high cycle times for thermoset resins. Examples of present day use of composites are Volvo and Renault for tailgates, BMW, Peugeot and Maybach for trunk lids and Bentley for the spare wheel well.

DSM is a large manufacturer of automotive composite resins supplying automotive companies all over the world.

The Dutch company Proven Concepts in Valkenswaard is very experienced in engineering composite body panels to be best standards for surface quality and fit & finish.

Glass fiber remains the common reinforcement so far and most processes rely on the RTM technology. Due to cost carbon fiber today is only found in exotic high end sport cars.

The high cycle times related to the use of thermoset resins can be avoided by using thermoplasts to embed the fiber reinforcement. voestalpine in Roostendaal, The Netherlands, produces large series of composite parts for underhood and underbody applications using GMT (Glass Mat reinforced Thermoplastics) and SMC (sheet Molding Compound) technology.

Unique for voestalpine is the EASI technology where glass fiber mats are replaced by weavings of very thin metal threads that are formed in the die to produce high tensile strength parts for use in crash structures.

More on composites can be found in the chapter on Future Technologies.

- **Plastics**

Although half of the volume of an average European Car is built out of plastics because of their low weight, plastics constitute not more than approximately 10% of the vehicle weight. Plastics-made bumpers are up to 10.4 kilograms lighter, engine covers 4.2 kilograms lighter and plastics fuel tanks five

kilograms lighter than those made of conventional materials. Plastics account for a major weight reduction in cars and will continue to do so. This broad field of technology cannot be dealt with in the context of this report. Two specific developments are;

- High performance: New applications of plastics can be found in areas with high performance requirements like engine bay components. Special heat conductive plastics have been developed by a.o. DSM. Metal particles added to the plastic transfer the heat and, if needed, can also serve as EMI shield. Engineering plastics like DSMs PA grade Stanyl keep their high level of stiffness up to temperatures of near to 300 °C. A joint study of BMW and Mitsubishi Turbochargers proved the feasibility of using plastic for the 'cold' side of a turbocharger.
- Interior: In the car interior the seat structure is almost the only part not made out of plastic, but also that is going to change. The Audi TT already features thermoplastic rear seat backs that are made through a low cost blow molding technology developed by Styron (formerly DOW Chemical) in Terneuzen. This development proves that high performance does not always imply high end materials



Figure 9: Styron blow molded seat back

2.2.2 Materials in The Netherlands

Material technology and production are important to The Netherlands.

The Dutch Automotive Landscape shows a large number of raw materials suppliers, suppliers of semi manufactured materials. AKZO Nobel is a leader in automotive surface coating, DOW, DSM, SABIQ and Styron are large plastic suppliers and TATA steel, the former Corus, has a strong position in supplying sheet metal coils to the automotive industry. Their research programs for new materials are supported by research on the Technical universities of Delft and Eindhoven and the materials innovation program M2I.

Applied research and engineering is provided by innovative companies like Light Weight Structures and ALE. New semi manufactured materials come from Ten Cate composites, AFPT, Eurocarbon, Novameer and FITS. Special promising newcomers in the area of biomaterials are Hempflax, for natural fiber reinforced composites and Greengran that produces PP reinforced with 50% hemp fibers.

2.3 Design & Materials

The relation between design and materials has already become clear from many of the examples used above. A remarkable example from history is the introduction of curved glass in 1947 on the Studebaker Starlight Coupe.

Of comparable importance and relevance in the framework of this study is the introduction of fully integrated bumpers in the way as first shown on the Porsche 928 designed under the responsibility of Harm Lagaay. As from then on body shapes can flow fluently and seamlessly flow from steel to plastic without showing gaps or bulges in outside temperatures from -40°C to +100 °C.

New body materials like plastics or composites give the



Figure 8: Porsche 928 (Production: 1977-1995)

designer new freedom in detailing shapes. For instance the sharp cut-of of the tailgate that Volvo uses as a family identity item is enabled by plastic panels that allow for a sharper radius than pressed steel panels would do in a complicated component like a tailgate or trunk lid.

The most eye-catching example of the synergy of new materials and new design in current automotive industry is probably LED lighting as discussed above. It is only the beginning of light design in automotive.

3 FUTURE PERSPECTIVE

Describing the future is describing the unknown. It is necessarily indicative based on developments we see today, combined with logic derived from history and professional views. This way the trends below have been selected.

3.1 Design by Tiers

Like R&D Design is all about product creation. In the automotive world R&D has traditionally been done by OEM but has over the last three decades moved largely from OEMs to Tiers. Applied research for component and system development is almost in all cases the terrain of Tiers. The early research phase and the last stage of vehicle integration are a joint field of action. OEMs expect their Tier-1s to come up with ideas on how their product and systems should evolve over time and make proposals on how this would fit the OEM product line-up. As a result a likewise development is taking place between Tier-1s and Tier-2s and further down the line.

In the slipstream of this development Design will follow. First in line to take on the challenge are the Tier-1s



Figure 10: Vredestein – Giugiaro design

that supply large visible parts of the car. An example is car interiors. Today the Tier-1s in this area supply complete interiors and have integrated the very diverse value chains of all parts necessary to build them. These large companies like Johnson Controls and Faurecia provide the complete engineering and supply of a complete interior. They have their own styling studio's that come up with advanced design studies on how a future car interior should look and how it should be engineered. They even tailored to the brands they supply.

Other examples are suppliers of sunroofs like Inalfa and Webasto that propose new solutions to OEMs to enhance their product offer. A remarkable front runner in this development is Apollo-Vredestein. As tire manufacturer they supply products that are necessarily circular and still they have decided to hire top designer Giugiaro to make Design a prime market profiling tool for their brand. It has brought them name, image and sales.

Since light design has become an issue in automotive also suppliers like Hella and Valeo actively show new design ideas and provide the detailed design of their components to their customers. Design spreads as a field of action for tiers. It is a trend to stay.

3.2 Design trends

Design is a sign of the times. It is in a constant change, influenced by trends with often a much wider base than the world of products. They can reflect social developments and feelings around emancipation,

sustainability or economics. There is a relation with fashion on the one hand and with technology on the other (see chapter 2.1.1). A summary of relevant trends in automotive design is given below.

3.2.1 *Inspired by nature*

Sustainability is by far the most important megatrend in automotive product creation in the western world. It is mainly a technical issue but also an inspiration to designers like Laurens van den Acker who translated patterns of deserts and sea life into automotive design. Adrian van Hooydonk takes the air patterns of wind tunnels as an inspiration for the Vision concept car. In a more subdued form this trend can be recognized in the natural curves of interior handgrips and instrument panels.



Figure 11: Mazda Concept Car Nagare

3.2.2 *Floating elements*

Designers translate functions into shapes that seem to float in their surroundings, like islands. This can be seen in centre consoles or instrument clusters or in the way light clusters appear in body shapes. A very good example is the Renault Zoe. The seats are shaped as pebbles (nature) that seem to float in the air, like the IP. On the exterior lights and even door handles appear as leaves floating in the water. It is the translation of a Japanese garden incorporating 'inspired by nature' and 'floating elements'.



Figure 12: Renault ZOE interior

3.2.3 *Sculpted surfaces*

Surfaces are no longer nicely curved and integrated to make a nice overall form. German design was traditionally characterized as 'aus eimem Guss' until Chris Bangle set BMW design upside down by creating complex surfaces with sharp lines and a mix of convex and concave shapes. SEAT, Mazda, and Opel have since followed with sculpted side panels.



Figure 13: BMW Z4 Coupe

3.2.4 Individuality

People not only want 'a' car, they want 'their' car. Individually styled to their taste as a means of personal expression. Individual, low volume, body shapes are enabled by modern production technology and platform based architectures. Further individualization can be done by extensive option packages and individualized color and trim.

Prime examples are the new Citroen DS derivatives of volume models and the extensive range of accessories the Fiat 500 with.



Figure 14: Citroën DS3

was introduced

3.2.5 Femininity

Emancipation is a social issue that translates to marketing that clearly addresses the female buyer and show women in role models traditionally held by men (and vice versa). We recognize this trend in automotive design by the use of soft and very outspoken, accentuated design in, mostly, small cars. Feminine shapes, strong colours, glossy chromed elements. Like make-up, sometimes deliberately over the top. The Mini brand very successfully uses this theme. Another example is the Citroën Révolte concept car with sofa-like rear seating and lip-stick colored elements.



Figure 15: Interior Citroën Révolte

3.3.6 Electric drive

Electric drive offers new options to package a car with fewer and/or smaller powertrain components with flexibly routed wired connections. This will lead to other vehicle layouts and new styling. We will see even more emphasis on the interior and another treatment of the front. Designers will have to create family identity that does not need a grille. Pininfarina explores these possibilities with the BlueCar concept.



Figure 16: Pininfarina BlueCar

3.3.7 Light design

LED technology has already been mentioned as a technology driver for the design of front and rear light clusters. LED lighting will also be used in new applications for instance to light elements and surfaces to add to the atmosphere and comfort of the car. OLEDs (organic LEDs) will make it possible to create light emitting surfaces. The complete surface becomes a source of light. The same technology will enable flexible displays to be used on so far unfamiliar places. Light can be everywhere, new IP architectures will be possible. OLEDs have no problem with direct sunlight. They have a great potential for use in cars. The technology is already on the market in smartphones (a.o. Samsung). Automotive applications await further development for automotive specifications, larger components and lower prices.



Figure 17: EDAG Light Car - Open Source

3.3 Materials

3.3.1 Intelligent materials

Materials in future are not just dead construction elements. They become alive to perform new functions. A fascinating new technology trend also referred to as 'functional materials'.

- **Self healing materials**

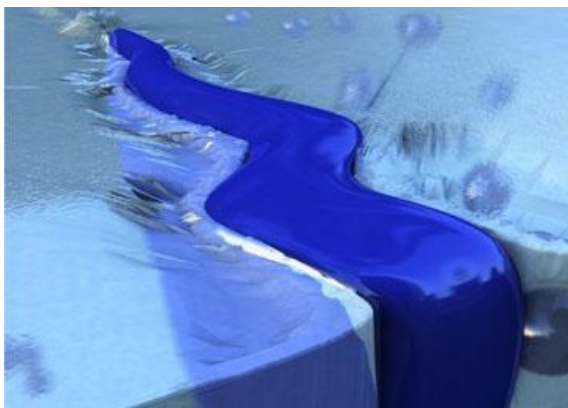


Figure 18: Conference on Self Healing Materials 2009

Like human beings this category of materials has the ability to autonomously restore damages. The technology is being developed for coatings, thermoplasts, metals, composites and civil engineering materials. There is an enormous potential of further development in the number of times self repair is possible and in now close the original material properties can be met. Microcapsules with special agents are embedded in the base material. They are opened by the damage done to free the agent and start the self healing chemical reaction.

In automotive first applications can be expected in the area of coatings. In future scratches on paint will disappear in a few hours.

- **Coatings**

More can be done with coatings. This is the area where automotive uses nano technology. Coatings can already make glass heat reflecting. Special coatings are being developed to make materials like glass water and dust repellent. Akzo-Nobel announced a paint that through special elastic properties can reduce the air drag of vehicles. It has already been applied to race cars. On the other side of the spectrum very hard

material coatings, like ceramics, will improve wear and friction characteristics of mechanical powertrain components or make plastic front windshields withstand the use of wipers. Nano technology opens an array of possibilities in the area of sensors. Special ceramic coatings can be developed to detect very small concentrations of gas in vehicle interiors.

- **Memory materials**

Shape memory is another way of self repair. Materials are being developed that can refined their original shape under influence of external temperature. Most Shape Memory Polymers (SMP's) can remember one original shape, but there are even materials reported to be able to regain two different shapes. In future such technologies could be applied to repair dents in (plastic) fenders by simply applying heat.

Shape Memory Alloys (SMA's) are special grade alloys that use the change of crystalline structure to remember their shape, also by applying heat. GM showed how this can be used to operate the vanes of a car grille or as a pop up mechanism for rear spoilers.

- **Electro responsive materials**

Materials can also change properties under the influence of electric voltage. The Dutch startup company Ioniqa develops the technology of magnetic substances dispersed in a salt solution. When an electromagnetic field is applied the viscosity of the liquid changes. The technology is being developed for a.o. use in shock absorbers.

New coatings on glass can change color under voltage to darken in case of sunlight. Daimler introduced a sunroof option with electrochromic glass. A small voltage causes the glass to darken. A reverse voltage causes them to lighten again. The electrochromic coating is built of up to seven layers of materials.

- **Solar materials**

Photovoltaic foils will be applied on sunroofs and possibly other sun exposed surfaces to generate energy. In an electric car, where energy is scarce, a solar paneled roof can provide the energy to keep the car ventilation going when parked in the sun. This adds to comfort and reduces the amount of energy needed to cool down the interior after return.



Figure 19: Solar roof of Renault ZOE Z.E.

3.3.2 *New E-conductive materials*

Copper is heavy and increasingly expensive. The price of copper has seen a fourfold increase since 2003. The complete wiring harness of a car weighs approximately 40 to 50 kg. The number of e-connections tend to increase while multiplexing technology aims to bring the weight of the wiring harness down. New materials are sought for conductivity and insulation in wiring. Aluminum instead of copper can save 4-7 kg on wiring per car but has drawbacks on corrosion and needs a bigger cross section (space). New insulation materials can reduce the weight of a wire bundle by up to 40% (source: Delphi). Signal wires can be printed on foil to reduce weight and space.

Conductivity of materials will also be a development in the world of coatings. Transparent conductive layers are developed to create ice-free windshields. New conductive coatings are also the base of the OLED technology described in chapter 3.3.7.

3.3.3 Materials for energy storage

New materials to store energy will be very important for the future. The capacity and weight (and costs) of batteries are still the major competitive disadvantages of electric vehicles compared to the Internal Combustion Engine. The energy content of a liter petrol is hard to beat. A fuel tank of 50kg will get a car 25 times as far as a Li-ion battery of 50kg and refueling takes only a fraction of the time of recharging. Future technology will have to close this gap. Step by step. Many different ways are explored. The University of Maryland reported (January 2011) that they

are able to increase the capacity of a Li-ion battery by a tenfold by using a genetically modified virus that is attached to and coated with special metals. The virus loses life during the production process. In the quest for better batteries also the construction of the battery is bound to change. The Imperial College of London and Volvo have a research project on body panels that serve as a battery. The body panels are made of a sandwich material that is able to store energy. The idea is to fight the 100kg penalty of electric drive by giving the body this double function.



Figure 20: Interior Johnson Controls' re3 concept

3.4 Design & Materials

3.4.1 Sustainability

This is by far the most important automotive megatrend. It has gradually grown in importance since the Club of Rome (1972) and will continue to lead automotive developments in the next decades. It started as a driver for powertrain innovations and has spread to be a base philosophy for all automotive operations, including production and end of life procedures.

Sustainability is a driver for new (light) materials in motorized transport and a challenge for designers to explore the opportunities of new materials for new design. It is also an inspiration for designers to express 'the sign of the times'.



Figure 21: Volkswagen XL1



VW is very active in research and profiling on cars with low CO₂ production. The goal is to achieve a fuel consumption of 1 liter per 100 km with a normal production car. Technically the goal was already met in 2002 with the first L1 prototype. Production seemed very far away at the time, but is rapidly coming closer with the latest XL1 revealed in Qatar in January 2011.

Even more realistic is the VW Up! Lite a four-seater concept car introduced in 2010 that combines very practical specifications with a fuel consumption of only 2.44 L per 100km. (1: 41). The vehicle weight is only 695 kg. It is almost half of the weight of the present Golf. This brings the weight back down to halfway the weight of the VW Beetle and Citroen 2CV of old, but with the specifications on comfort and safety of today. This is the kind of change cars need for long term sustainability.



Figure 22: Volkswagen Up! Lite Concept

- **Further weight reduction**

The future perspective is a widespread use of composites to deliver the substantial weight reduction cars are waiting for. The most promising in this respect is carbon fiber. Today the cost of a CFRP (Carbon Fiber Reinforced Plastic) component is at least ten times that of metal, even though carbon fiber costs have dropped ten-fold in the last decade. New technologies will bring the cost down further. Benteler SGL in Germany is working hard to reduce handling costs by further automation of production lines and has cut cycle times from 20 to 5 minutes to enable large series production. Styron in The Netherlands has meanwhile developed resins that allow a cycle time of 2,5 minutes.



Figure 23: Citroen Carbon fibre study

Another way to reduce cycle times in production of composites is the use of thermoplastics instead of thermoset resins. The company Bond Laminates (DE) uses glass or carbon filled PA6 mats that can be shaped and die casted adding ribs and other engineering details. Costs are in the range of €5/kg.

The application of composites will grow from body parts (SMC, GMT) to construction parts like leaf springs, crash cones and drive shafts. BMW has announced to build the body structure of their new Megacity vehicle completely in carbon composites. This will be a true breakthrough for car industry; a milestone for the future.

A special grade of composites are the new monomaterial composites. These materials contain one base material, like PP, in two forms. When extremely stretched PP fibers become very strong. These fibers can be embedded in normal PP as bonding element. Mats of this combination can be to components by carefully controlling the temperature in order to prevent relaxation of the fibers. The result is a strong monomaterial composite part that can easily be recycled by melting.

Weight reduction can also be achieved with more simple means and optimizing of today's technologies. Styron uses blow molding technology to produce the backrests of Audi rear seats and now works on upgrading to belt in seat constructions as part of the HTAS innovation program. Fontijne Grotnes, also HTAS partner, takes the chance to take 30% of the weight of steel rims by optimizing material thickness. TATA Steel does the same for body work with tailored blanks. ApolloVredestein works on a new tire concept with very innovative use of materials. This HTAS project not only aims to make tires 30% lighter, but also reduces rolling resistance and makes the tire quieter. A threefold approach to sustainability.

A new dimension in vehicle weight reduction will be PolyCarbonate (PC) glazing. It is already extensively used for headlights but like CFRP it is not yet used for large parts because of costs being still considerably higher than the alternative; glass. PC glazing can account for about 18 kg lower weight (source: Sabic). For use on front glazing there is the matter of scratch resistance of wiper use to be solved. Very hard nanotechnology coatings should bring the solution here. Designers tend to use more glass in their designs especially on the roof where weight also brings a penalty on car handling. The sunroof company Webasto meanwhile runs two PC glazing production lines. PC gives designers the opportunity to add more shape to glass. Seat designers showed how to make use of that option when Seat introduced PC side glazing on the Leon model in 2006 with an integrated pocket to reach the door handle.



Figure 24: Roof of Smart ForTwo produced by Webasto

- **Cradle to cradle**

The use of recycled materials in cars has substantially grown over the last few years since car manufacturers use it as a possibility to create a better public perception. Cars are 95% recyclable but OEMs have long time preferred virgin materials for more secure product properties while recycled materials offered little cost

benefit. The scale has tipped the other way, a.o. because well to wheel analysis is taken into account showing a benefit in production energy for reused materials. Ford is reported to use 25% of recycled materials in their cars and VW even 40%. Most recycled materials are metals and plastic. In future battery recycling will be added. Ford USA already adopted the strategy to require the use of recycled plastics from tires, detergent bottles and car battery casings for all fender liners and splash shields and underbody and aerodynamics shields. Thermoset composites have the drawback of having little recycling options the use of recycled materials. This can be improved by the use of biomaterials.

- **Biomaterials**

Biomaterials have a long history in the automotive industry. Leather upholstery has been there from the start. Paneling has long been made of pressed wood fibers and cotton and wool are well known as isolation materials. New is the use of bioplastics. The technology to produce bioplastics started with (non automotive) degradable materials and has advanced to the point that is possible to make parts up to automotive standards. DSM has launched EcoPaXX in 2009 as a bio-based, high performance engineering plastic. Approximately 70% of the polymer consists of building blocks derived from castor oil. DSM proved EcoPaXX™ to be 100 % carbon neutral from cradle to gate. Castor beans are not fit for human consumption and hence the material does not disturb the food production chain.



Figure 24: Castor plant

A relatively new trend in composites is to replace glass or carbon fibers with natural fibers from plants. There are various plants

suited for this purpose. Most used is hemp.

Hemp fibers can be cut to be used as filler in

thermoplast injection molded materials. The PP blend with 50% hemp fibers produced Greengran creates parts that are stiffer, comparably strong, and cheaper than the conventional glass filled alternatives. The composite has fogging and humidity characteristics and odor emission levels within present norms and a further advantage in better sound deadening. Hemp can also be used as base for long fiber reinforced composites. The company Hempflax produced mats and parts this way. As with Greengran physical properties are very comparable to glass filled alternatives while these products are half made from plants. The next step is the resin. In 2010 DSM introduced a biobased resin for automotive composites. Palapreg is 55% biobased and this content of renewable material can be increased in the years to come. Palapreg also offers a solution to the recycling of composites. Since it contains short cycled carbon incineration can be regarded as CO₂ neutral in terms of climate change. When combined with hemp fibers this opens the perspective that composites components can be fully recyclable.

OEMs that promote the use of biobased materials are Toyota, BMW and Daimler.

3.4.2 Downsizing

Sustainability is a driver for making cars smaller. It is as well rational as an emotional issue. Smaller cars are lighter, smaller engines more efficient and small cars occupy less space where room is scarce. A smaller car is also a way of showing a more modest way of consumption that fits with the philosophy of sustainability. Downsizing calls for optimal vehicle efficiency in all aspects and hence is a challenge for engineers and for designers alike. An inspiring and extreme example of how downsizing can look in the future is the Peugeot BB1 (French: Béb ). It is an out of the box idea for a four seater car that is 20 cm (!) smaller than a Smart ForTwo.



Figure 25: Peugeot BB1

3.4.3 Cost down

Another megatrend of very different nature that affects both Design and Materials is the never wavering pressure on cost reduction in the very competitive automotive arena. In terms of materials this trend is visible in the shift to PP as 'default' plastic material for many automotive parts. Many special grades of PP have been developed to meet the high requirement levels. The relevance of this trend for Design is that a good design does not need to cost more. Design is a way to improve product value without increasing cost. On the other hand designers will have to work with cost limitations in their choice of materials. Cooperation between designers and material engineers has led to new, innovative, developments in for instance interior trim materials.

3.4.4 Rapid manufacturing

Laurens van den Acker, in his time at Mazda, has said that the ultimate future of car design is that everyone has his own individually styled car. New manufacturing techniques should make this possible. He pointed at moldless rapid manufacturing using 3D printing techniques. It is certainly an image of a far ahead future but less science fiction as it may seem. One-off car are being made for wealthy customers and smart material deposition technology makes it possible to build components right from computer files. The Belgian company Materialize runs a 'prototype on your desk in 24 hours' service. This technology may well serve to create special headlights, grilles and other trim components for a unique or small series car design.

4 RELEVANCE FOR THE DUTCH INDUSTRY

The Netherlands have a strong raw material industry and a lot of design creativity. Hundreds of Industrial Design graduated enter the market place each year. It is a chance for the automotive industry to attract them and give them a place to develop their skills. Their creativity can be put to use to generate new ideas for better products.

Design and Materials belong together. Many Dutch automotive companies work with materials, but many more of them can benefit by using the creativity of designers. Design and materials shape the world around us. But designers can do much more. Designers are trained to think from the customer point of view. They

can think about how to improve the functionality of the product, also when it is a technical component. New create thinking on functions can improve the product concept.

Thinking about the customer is thinking the market. Designing products starts with thinking about the future. Both in terms of market and technology. Hence designers can support the product strategy process of the company. And when product development gets technical lateral thinking of designers can spark new ideas for new solutions.

Design is a way to communicate quality. It is a way to express that this product is made with care and attention to detail, that quality thinking in the company reaches beyond ppm. statistics to all expressions of the company. Design expresses care and dedication to the product. Also for hidden components there is always a moment when this is important; when show in a brochure, at a sales meeting when discussing price, at a show or even in the hands of the person who mounts it in the car to inspire him to handle with care.

Design and materials are both a way to create a better product. The Dutch automotive industry can benefit from the results of strong Dutch material suppliers, creative research of knowledge institutes and professional serve suppliers. A non exhaustive number of very promising developments mentioned in this report that Dutch industry members can use to innovate their product range are listed below.

- Monomaterial composites Styron
- Biobased materials DSM / Greengran/ Hempflax
- PC glazing Sabic
- Fast reaction resins Styron
- Solar / oled / smart foils Holst/Solliance
- New steel grades / HSS Tata Steel / M2i

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- WorldAutoSteel – Reinventing Automotive Steel (Greet Designs in Steel – May5, 2010)

ATC Design/Materials Partners & Members:

Addcomp Holland B.V.	NIJVERDAL	www.addcomp.nl
AKG Polymers	VROOMSHOOP	www.akgpolymers.com
Alutech Nederland B.V.	KATWIJK ZH	www.sag-alutech.nl
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Buvo Castings BV	HELMOND	www.buvo.nl
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DSM Engineering Plastics	SITTARD	www.dsm.nl
Duvedec Europe B.V.	HELMOND	www.duvedec.nl
Eurocarbon BV	SITTARD	www.eurocarbon.com
Helvoet Rubber & Plastic Technologies BV	HELLEVOETSLUIS	www.helvoet.nl
HempFlax bv	OUDE PEKELA	www.hempflax.com
Hoogerdijk Technisch Rubber BV	EINDHOVEN	www.hoogerdijk.nl
Inalfa Roof Systems Group B.V.	VENRAY	www.inalfa-roofsystems.nl
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Modesi BV	EINDHOVEN	www.modesi.nl
Motio Development	EINDHOVEN	www.motio.nl
Proven Concepts bv	VALKENSWAARD	www.provenconcepts.nl
SABA Dinxperlo BV	DINXPERLO	www.saba.nl
Sekisui S-Lec BV	ROERMOND	www.sekisui-corp.com
Sika Nederland BV	UTRECHT	www.sika.com
SPG Pre-Series Tooling & Prototyping B.V.	WEERT	www.spg-arrk.nl
SKM Rapid Modelling B.V.	HELMOND	www.skmrapid.nl
Tata Steel IJmuiden B.V.	VELSEN-NOORD	www.tatasteelautomotive.com
Technische Universiteit Eindhoven	EINDHOVEN	www.tue.nl
TEGEMA group	SON	www.tegema.nl
Van Wees UD and Crossply Technology	TILBURG	www.vanwees.nl
VDL Bus & Coach	VALKENSWAARD	www.vdlbuscoach.com

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