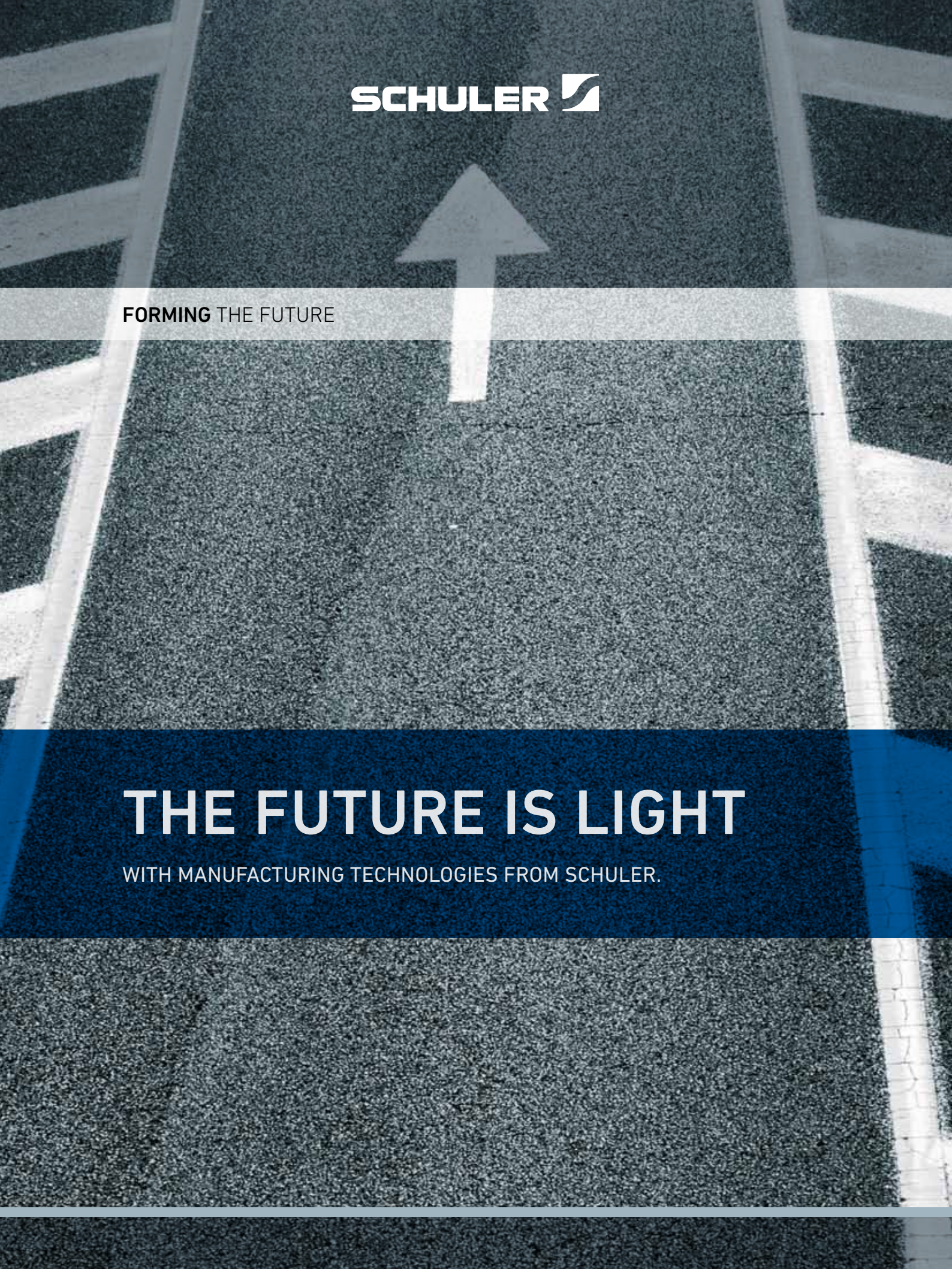

SCHULER
FORMING THE FUTURE
THE FUTURE IS LIGHT
WITH MANUFACTURING TECHNOLOGIES FROM SCHULER.

FORMING THE FUTURE

As a global leader in forming technology, Schuler delivers forming systems, tooling, process expertise and services for the metalworking and plastic processing industries.

Our customers include carmakers and component suppliers, as well as companies in the domestic goods, forging, packaging, energy and electrical industries. In addition, Schuler is a leader in the area of coining technology. The company has a global presence with more than 5,000 employees worldwide with facilities in forty countries.

From a locksmith's workshop to a global company. The Schuler Group traces its roots back to a locksmith's shop founded by Louis Schuler in 1839. The company has manufactured sheet metal processing equipment since 1852. Today, Schuler is a global flagship for the press building industry. Major brands such as UMFORMTECHNIK ERFURT and MÜLLER WEINGARTEN have recently joined the Schuler Group.

Put more in motion. Our technologies are used to manufacture lightweight components and subassemblies, providing the industry with solutions that ultimately benefit the environment. Our production systems support a variety of processes to manufacture components for automobiles, from drive shafts and aluminum rims to high strength structural components and light weight body panels – for OEMs and tier suppliers.

CONTENTS

THE FUTURE IS LIGHT

WITH MANUFACTURING TECHNOLOGIES FROM SCHULER

Dear readers,

It is a question of weight. Governments, markets and customers are demanding fuel efficiency and a cleaner environment – and Schuler is focused on the manufacturing processes to help the auto industry provide the answers.

Every gram and ounce saved makes a difference. It adds up to fuel savings and lower CO_2 emissions. Extrapolated to the millions of automobiles in the global fleet, even small progress can deliver major improvements to the environment and reduce our use of natural resources.

For some time now, the automotive industry has faced a demand for vehicle weight reductions while meeting increasingly stringent safety requirements. And great strides have already been made. In the future, however, each increment of progress will entail greater efforts than the last. The bar is set very high.

However, nothing is more exciting than a new challenge. Therefore, our intention in this publication is to provide information and shine light on the topic of lightweight construction for automobiles of the future.

I hope you gain many interesting insights as you read it.

Best regards,

Stefan Klebert
Chief Executive Officer

New opportunities for the future

Our cars are too heavy. It is possible to reach this conclusion by considering car design developments over the past few decades. For example, the most popular model in the compact class has doubled its weight from its first launch to the current model. As a result, the enormous progress made in lower consumption engines has almost entirely disappeared. Lightweight construction can reverse this weight spiral.

THE FUTURE IS LIGHT

A weight-loss regimen for automobiles. Perhaps in the next few years, car dealers will start to experience something quite new. Customers might ask about standard equipment and consumption rather than cubic capacity and engine power. For the first time, they might hear this question in their showrooms: "How much does the car actually weigh?"

In times of rising fuel prices and greater concern about the CO_2 debate, this is a justifiable question. To give an approximate reference point, a weight saving of 100 kilograms (220 pounds) means 0.3 liters of fuel saved and 7.5 grams of CO_2 emmision reduced over 100 kilometers*. Therefore, it is natural that greater attention is paid to this point.

Equipment for comfort and safety can be heavy. An average-sized passenger car weighs about 1.4 tonnes today. Small cars weigh somewhat less, sedans somewhat more, while some off-road models easily break the 2 tonne barrier.

What accounts for such high vehicle weights? For one thing, cars have actually gotten bigger. Each model change generally means an increase in length and, sometimes, width of the vehicle by a few centimeters. There are also convenient servo and adjustment motors which automate manual adjustments. Many manual operations have been replaced by a simple push of a button. Today, air conditioning is a standard feature for most passenger cars. This is an additional weight of up to 50 kilograms (110 pounds). And so it goes.

Achievements in vehicle safety also relate to additional weight on board. These days, nobody wants to drive without ABS and ESP. Head, side, window and knee airbags are regarded as essential. And a reinforced body structure is desired; after all, it is a question of crash safety.

More powerful engines are needed to accelerate these loads and keep them moving, and so the engines are heavier as well. Only recently has there been a trend toward downsizing to smaller engines. Last but not least, it must not be forgotten that having heavier vehicle equipment also demands tougher suspension and more substantial brakes. These features also add their share of extra weight.

*„Automobil Industrie Special" 2010

Escaping the weight spiral. Although it may appear that there is no escape from the list of factors that increase vehicle weight, it is possible to reverse the trend in the future. It won't even take visionary powers to do this. After all, cars with ingenious lightweight designs have been on our roads for some years now. Admittedly, in most cases they have been on racing tracks and segregated sections of roads.

Motorsport has always focused on weight savings, and continues to do so. The more power per kilogram of vehicle weight, the better. Even minor differences are enough to separate the victor from the loser. And indeed, the car bodies used in Formula 1 are very light while rigid and safe, made from carbon-fiber reinforced plastic and lightweight metal components.

However, this race car scenario does have a downside for mass automotive production. Motorsport is not faced with the practicalities of industrial scale production, as cost plays a less significant role. In addition, exotic materials are not always available in sufficient quantity for large volume production. Meanwhile, the global automotive industry deals with a high level of cost-driven competition.

Getting to the core of the issue: Cost and production technology. Carmakers and their suppliers have a wealth of experience and continue to work on progress for lightweight designs. Even if it is not always clear from the vehicle registration papers, many new cars today already have lighter bodies than their previous models. In some cases, the differences amount to more than 100 kilograms (200 pounds).

High-strength steels save material volume which results in weight reduction. Lighter plastics replace heavier steel panels. These advances are offset by increased weight from features such as new driver assistance systems, so these successes are almost unnoticed by the consumer. Further creativity and rethinking is needed to eliminate the accumulated additional weight that our cars currently carry.

There will be no return to the lower levels of comfort and safety of the past, even while the environmental consciousness of customers slowly changes. Therefore, any attempt to achieve lighter vehicles will require an approach of new materials, new designs and new production techniques.

A balanced mix of materials delivers success

It is technically feasible to build a light and safe car. However, some particularly light and low-consumption car models have been too expensive to attract enough customers. Manufacturing costs are an influential factor for commercial success. There cannot be one basic approach to achieve greater efficiency. Instead, a variety of approaches are required to meet specific customer requirements for different vehicle platforms.

THE FUTURE IS LIGHT

Aluminum, carbon-fiber reinforced plastics and new steels. There is a wide range of ingredients for lightweight construction in automobile design. A marketable product cannot just consist of technically acceptable solutions. Such a car would be too expensive for most people.

We have also acquired certain expectations for comfort in our cars. When was the last time you rolled a side window down? Indeed, many people regard it as inconvenient to adjust their driver's seat by hand. The various electric motors and air conditioning add to the vehicle's weight.

And then there is the topic of safety. Airbags, ABS, ESP and new driver assistance systems certainly weigh heavily in the equation, but are rightfully regarded as essential. At least the old perception that a high vehicle weight automatically means greater occupant protection has changed. Light no longer means unstable and fragile.

Lighter and more efficient – in different ways. A large business sedan, a small urban compact, a high-volume MPV, SUV or MUV, a powerful sports car – each vehicle category has a different price framework and completely different priorities. Various components made from lightweight materials are already installed in higher-priced vehicles, whereas the majority of cars in the small category still use conventional solutions. However, the underlying concept for the vehicle body is the same.

The answer to the requirements of today and the future is a multi-material solution, with different configurations for each platform. The recipe for success: the right material in the right place at the right price. A flexible system that can respond to changes in auto market segments, raw material prices and technical developments.

Rethink designs with strategic material selection. To put it simply, the car of the future does not have to be lighter everywhere. To achieve a balanced distribution of weight within the vehicle, it is often desirable keep weight in the rear or front end. Here, conventional and less expensive materials will continue to be used. In areas of the vehicle that are weight sensitive, a targeted approach is possible using very light and possibly more expensive components. In addition to improved efficiency, there is potential to improve driving dynamics, but the overall result must compensate for the additional expenditure.

Of course, measures with considerably higher costs cannot be applied to a small car. But here too, new types of processing, conventional materials and new high-strength steel grades can deliver significant weight savings.

Rethinking options for an optimal solution

The multi-material concept changes the way that the automobile industry works. The former approach to think only in terms of material or process technology is declining. The first decision is to select which material is best suited for which component. Steel is competing with plastic. Aluminum is competing with composite materials. The different materials used in production must result in a harmonious and capable whole, so cooperation between these fields is key.

Combination is the solution for the future. This does not just relate to a superior mix of materials. It also refers to thinking and working together. Interdisciplinary cooperation must start at an earlier phase, from the question, "Plastic or steel?" The answer is possibly, "Both." For example, steel components supplied with integrated plastic-based foams are superior to the traditional steel-only or plastic-only solutions, especially when it comes to crash behavior and weight. To achieve this, however, we need to think much more in terms of integrated systems, and not restrict ourselves to individual technologies. If we continue to work in parallel, developmental progress will be too slow. At the moment, it takes an average of ten to twelve years for an idea to make it from the laboratory onto the road. That is definitely too long.

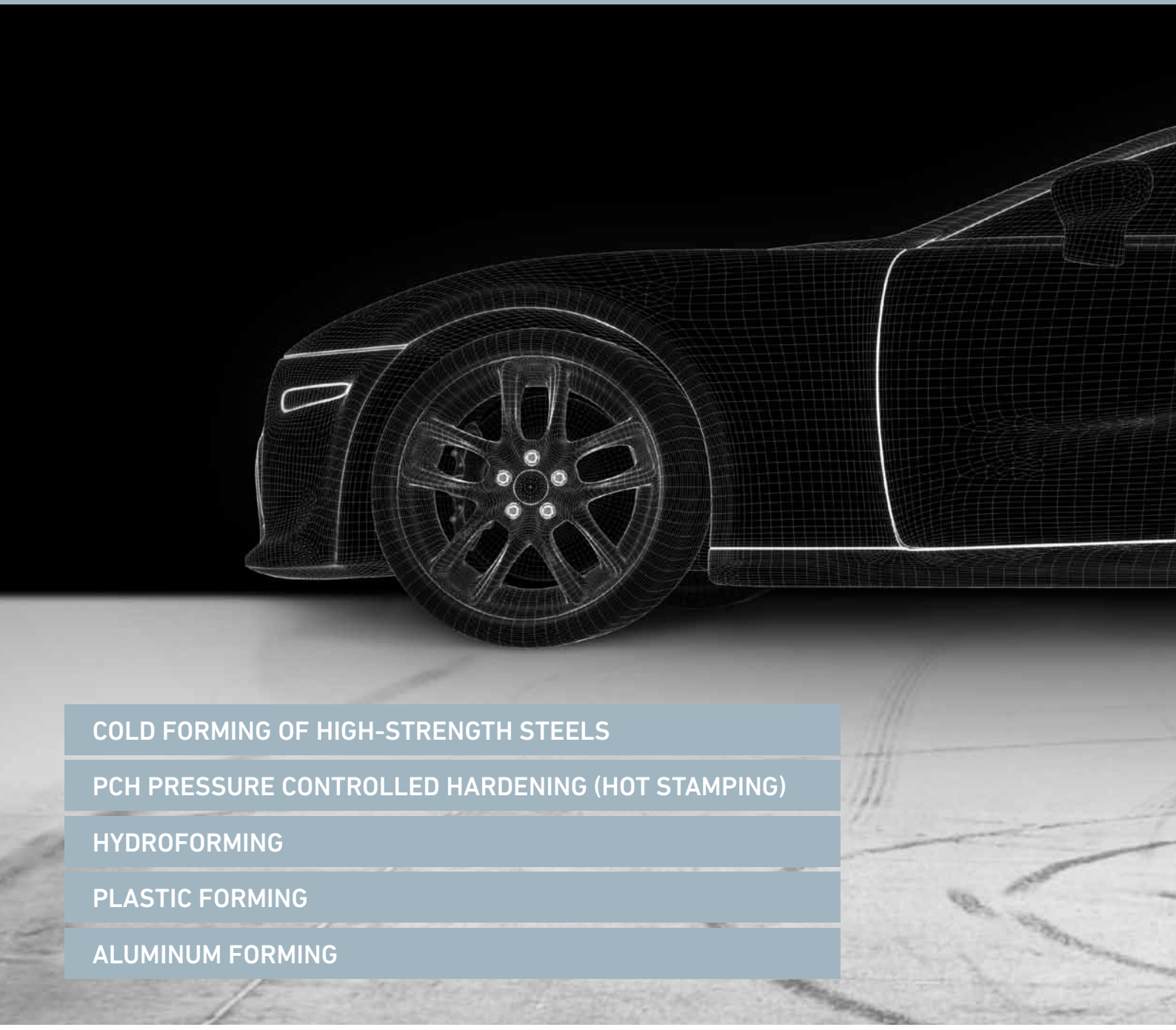
Hybrid – a keyword with materials as well. A lot has already been achieved: the first prototype of a car with 1 l / 100 km (235 mpg) consumption, the Formula 1 racing car with a fantastic power-to-weight ratio and the impressive electric-powered sports cars produced in small batches. However, none of these examples of lightweight auto production can be scaled directly to mass production. The necessary materials and components cannot be sourced in the required amounts; price and cost need to be more than a secondary consideration. Lightweight construction for the mass market will demand hybrid solutions that are an intelligent mix of materials. In this arena, joining and connection technology will also take on a new importance.

Putting development into motion. Schuler is a contributing player to progress for developing lightweight automotive designs. We are ready for the production challenges of the future that the industry works to solve today. Schuler has been closely aligned with automotive, steel and aluminum manufacturers for years. We have also entered the arena of industrial-scale production processes for fiber-reinforced plastics. We are not devoted to one material, rather we gather expertise from a wide range of material technologies. Therefore, we are a suitable partner to help advance multi-material solutions, bringing them to scale for series production and transferring them into production smoothly.

Lightweight technologies from Schuler

Success can be achieved in lightweight design with the integration of a strategic mix of materials and processes. Each material has specific strengths suited to different installation areas of the car. We are the only manufacturer in the world to offer press systems for all manufacturing processes in the area of these demanding applications: Cold forming high-strength steels, PCH pressure-controlled hardening (hot stamping), hydroforming, plastic forming and aluminum forming. In close cooperation with our partners, we achieve economic and reliable production solutions for high-volume manufacturing.

THE FUTURE IS LIGHT



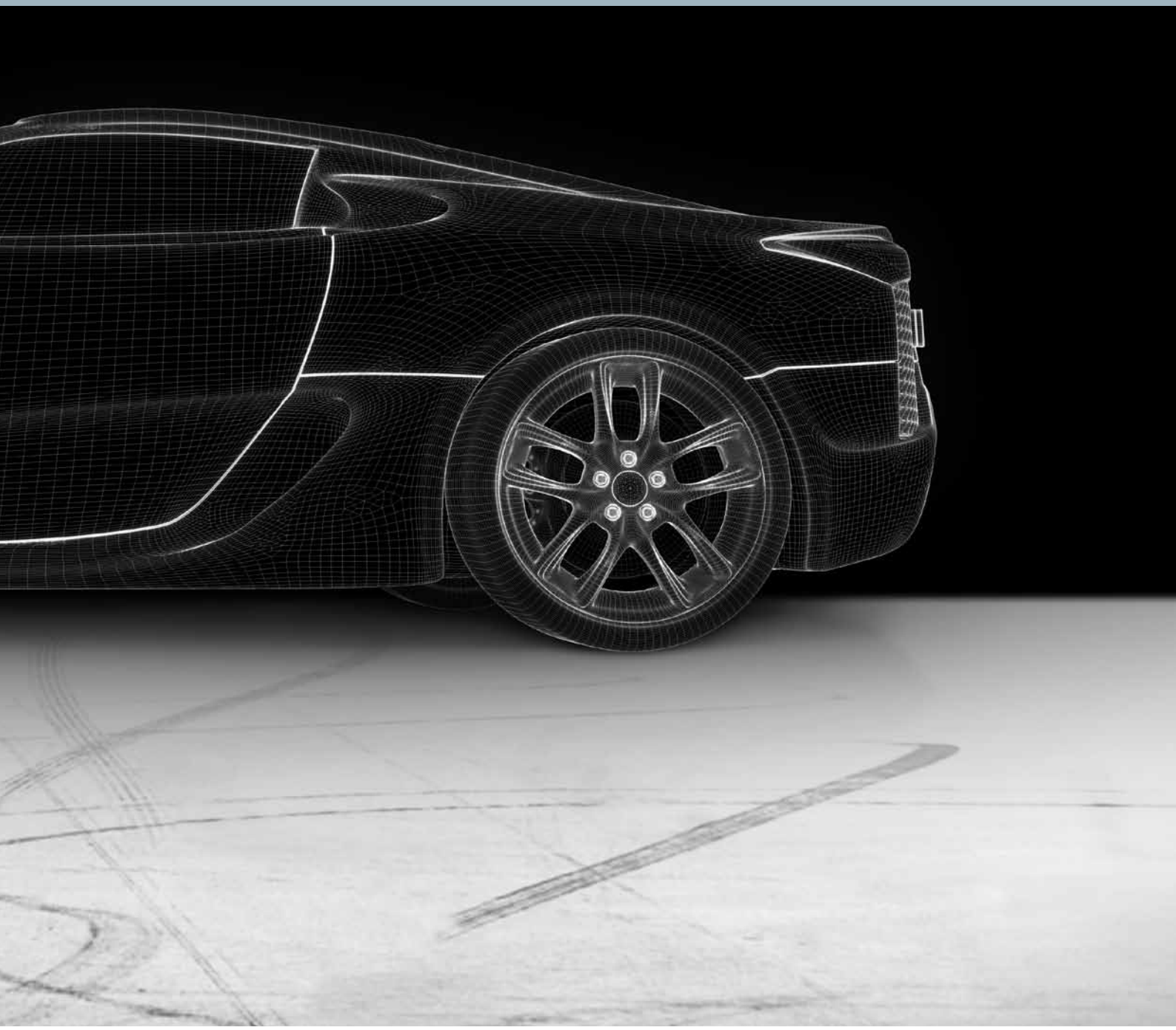
COLD FORMING OF HIGH-STRENGTH STEELS

PCH PRESSURE CONTROLLED HARDENING (HOT STAMPING)

HYDROFORMING

PLASTIC FORMING

ALUMINUM FORMING



Cold forming high-strength steels

When approaching modern lightweight designs, high-strength steels improve the relationship between component weight and function. The introduction of Schuler's ServoDirect Technology is improving capabilities to cold form high-strength steels. Whether on a press line, blanking or forming press, transfer or prog-die press – the advantages are proven: maximum flexibility in production, economical production of complex geometries and a high level of productivity with optimum part quality.

THE FUTURE IS LIGHT

High strength steel content continues to increase in innovative lightweight vehicles. It is possible to achieve further reductions in sheet thicknesses by using new, high and extra high-strength steels while maintaining the same component properties. This means a lighter weight and reduced costs.

ServoDirect Technology is steering the way to the future. Press lines, transfer and prog-die presses as well as blanking systems with ServoDirect Technology have significantly changed press shops. They are characterized by maximum flexibility, high output and short die change times. The slide movement of the press can be adapted to each component's forming process, die and automation. This is opening new possibilities to cold form high-strength steels.

New processes – new possibilities. Using the advantages of ServoDirect Technology, Schuler is developing new production concepts to manufacture lighter components. For example, interdisciplinary teams are exploring the integration of downstream processes into the press to adopt new methods to manufacture hybrid components. The objective is to develop new production processes that meet the requirements of large scale automotive production, optimizing the objectives of reduced component weight, high safety requirements and efficient mass production.

Automated press lines with ServoDirect Technology are highly flexible and suitable for processing complex and challenging applications with steel sheet metal, high-strength steels and aluminum.

Servo presses in tie rod construction with a destacker/coil line combination for manufacturing high-strength structural components.

PCH Pressure Controlled Hardening

In the area of hot stamping, our innovative PCH technology stands for new, tailor-made solutions in automation and press technology. Developed in Schuler's Press Hardening Center of Competence and designed to meet the needs of the automotive industry, hot forming production processes are now even more controlled and reliable. At the same time, production efficiency is unparalleled in terms of process speed and throughput.

Pressure controlled hardening (PCH) is a comprehensive system to manufacture die-hardened components. The advantage of this process is the ability to control the forming and cooling procedure during the die-hardening process with pressure-controlled hardening. This new press technology includes a cushion system that makes it possible to achieve unmatched component quality due to the controlled and even contact pressure.

The result in the end product is the ability to achieve even higher rigidity - for example, in the body structure in order to improve crash properties. The ultimate benefit is a design that achieves higher component strength while the overall weight is reduced.

The process is also very economical and energy efficient. The material is less expensive than high-strength steel, and can be processed with lower press forces. This type of production process offers entirely new possibilities for component design.

Of course, economy is an important argument in any process. Here too, Schuler scores points with PCH. The process can achieve faster production. Shorter cooling times, high-speed transfer automation and innovative die solutions make it possible to double previously achieved output. Significantly lower die costs can also be included in the list of economic advantages. We are sure that PCH will open up entirely new perspectives for the automotive industry to rethink design, safety and sustainability.

Fully automated systems from Schuler are setting new standards in international competition for series production of structural and safety components.

We continue to develop and improve the processes at our test facility in Göppingen, Germany.

Hydroforming

There is a large variety of possibilities for hydroforming. It is used in automotive design where light weights, design freedom and structural strength are needed. It also provides opportunities to reduce multiple joined parts into one formed component. The process is used to form exhaust, chassis and structural components. Schuler provides design support, component analyses, feasibility studies, prototyping, dies and full scale part production – all from a single source.

THE FUTURE IS LIGHT

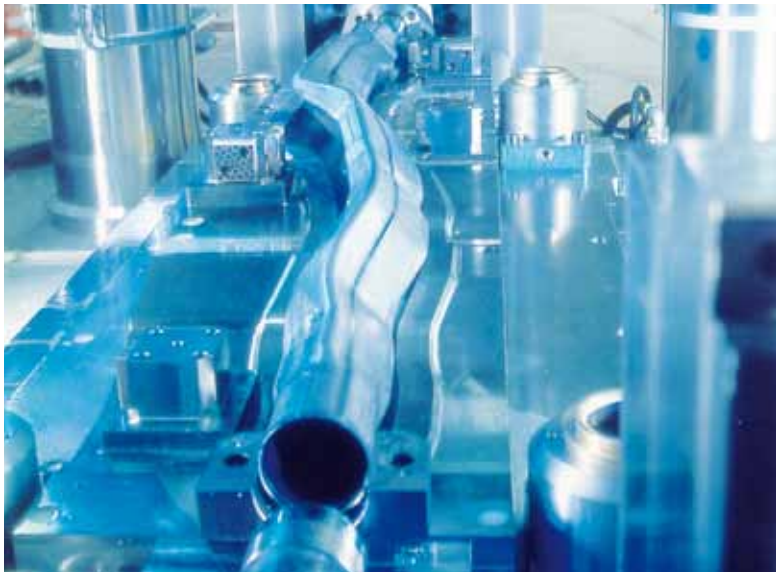
Schuler is setting new standards in mass production of vehicle components with its hydroforming systems. The process provides a new perspective, especially when it comes to forming parts for lightweight automobile production. Feasibility studies are best developed together with customers in the beginning of the design process, in order to meet specific design and performance requirements.

Hydroformed structural components provide high strength and stiffness. This is achieved by strain-hardening in the forming process as well as the use of high-strength steels. These components meet requirements for lower weights with reduced material. Furthermore, it is possible to integrate additional functions into the component and also optimize space in the vehicle. High material utilization is achieved by minimizing blanking and trimming waste with end compression to achieve the final dimensions. Hydroformed parts provide long service life thanks to reduction or elimination of welds, as well as optimized functional geometries. Hydroforming also delivers high quality and production accuracy. The process of hydroforming under supporting pressure also allows the use of higher-strength steels.

In close cooperation with its customers, Schuler also develops complex turnkey hydroforming systems. Engineers and planners can maximize the benefits of this technology by incorporating it into the early stages of planning. In practice, several steps need to take place consecutively. First, a collaborative feasibility study is prepared. This is followed by component and process design, and then die production. After prototyping, pilot and pre-series production takes place. The final step in the process is design of the production equipment – depending on the "make or buy" decision.

Hydroforming opens many possibilities for component design in lightweight bodies.

Hydroformed longitudinal member.



Plastic forming

The plastic processing industry is on the lookout for economic and flexible systems to mass produce components for lightweight automotive designs. The best quality and highest production reliability need to be guaranteed throughout the process. Our hydraulic press systems deliver innovative solutions for series production of fiber-reinforced plastics, and meet the most demanding requirements for component production.

Up to 50 percent lighter than comparable steel parts – as a result, fiber-reinforced plastics are now essential aspects of automobile design. The challenge with regard to these "lightweights" remains to reduce the costs of the manufacturing process and the parts themselves. Nowadays, about 15 percent of a new car is made from plastics. From structural components such as front ends, underbody trims, instrument panels through to functional elements such as head restraints and door handles.

Recently, we have supplied a variety of production systems to process fiber-reinforced plastics with hydraulic press technology. Different systems are used depending on the component requirements and production process. Our hydraulic press systems are suitable for series production of SMC (sheet molding compound) components, GMT (glass mat thermoplastics) components, LFT (long fiber-reinforced thermoplastics) components and RMT (resin transfer molding) components. The requirements on modern production systems are very high: accuracy, precise reproducibility, simple operation and faster cycle times are at the top of the list. We have developed open and closed-loop control systems which ensure continuous operation as well as smooth-running production processes for the long term.

We are a reliable partner when it comes to standardized modular solutions for rapid start-up and maintenance, for standardized and user-friendly machine visualization systems as well as sequence charts for operator guidance to enable production to start without difficulties. We place great emphasis on process data analysis in order to support process optimization as well as remote maintenance.

Fiber-reinforced plastics offer design freedom and high functionality combined with minimum component weight.

Hydraulic press systems permit fiber-reinforced plastic components to be manufactured in series production.

Aluminum forming

Aluminum has become a standard material for exterior body panels in many types of vehicles. The material significantly reduces the weight of a body-in-white, although it is rarely a complete aluminum design. Nowadays, the body accounts for about 40 percent of overall car weight. Aluminum is a part of the trend toward an increasing variety of materials and its use continues to increase in automotive designs.

THE FUTURE IS LIGHT

Crash resistance of aluminum supports suitability for efficient weight reduction. From body panels to structural components – aluminum is being used more and more frequently in modern vehicle design as a means to replace heavier materials. Thanks to its unique ability to absorb energy, it can also save lives in the case of a collision. Lower fuel consumption, greater comfort and performance are further arguments for the use of aluminum alongside that of increased safety.

It is possible to make each vehicle up to 40 kilograms (90 pounds) lighter. To do this, however, all outer body panels must be made from the material. Further earth friendly benefits are the facts that recycling aluminum requires much less energy than the production of other metals and it is 100% recyclable.

Schuler develops turn-key mechanical and hydraulic press lines to produce aluminum body panels. Our turnkey systems are designed with components to handle the materials they will process, from automation through to the press and die. We also deliver custom retrofit solutions for existing production systems. We work hand-in-hand with our customers throughout the entire project. From design through turnkey installation and production, we support and ensure the development of an integrated system where all of the individual components will function smoothly.

Hydraulic press line with robot automation for manufacturing aluminum components.

Modern blanking presses make it possible to process a wide range of materials, including aluminum.

A good time for pioneers

Electric drive? Fuel cell? Hybrid technology? It is by no means clear what the future of our automobiles will be. Currently, it appears that the tried-and-tested internal combustion engine will remain with us for longer than had been assumed. It will be more economical and cleaner, of course. For as long as this remains the case, good ideas and intelligent solutions for lighter bodies and chassis components are more than welcome. After all, the experts agree: The future is light.

THE FUTURE IS LIGHT

"Light" is very much in demand. Many automobile manufacturers have definitively aligned their strategy to a lighter future. Those with heavy sedans as their core business have the best incentive to do this, as this is where the greatest potential lies. In this area, there is more financial freedom for innovative solutions. And there are likely to be new laws and provisions applied here in the future.

The recent developments of electric cars have also given lightweight construction a considerable boost. The first large-scale production of electric cars on the market saw designers attempting to compensate for the still-enormous weight of the battery by using new, lighter materials. Based on prototypes, it is only a guess as to what the future of our roads will look like.

In 2011, a version of a vehicle with 1 l / 100 km (235 mpg) fuel consumption in "close to series production" was presented, weighing only 795 kg (1750 pounds). The body weighs 230 kilograms (500 pounds), and consists of a mix of CFRP, lightweight metal, steel, thin glass and plastic materials. In addition, the components include light materials such as magnesium, ceramics and natural fibers. The steel, accounting for 184 kilograms (405 pounds) of the overall weight, plays a surprisingly important role in the construction of the vehicle. It is clear that the advantageous properties of new, high-strength steel grades are paying off here.

Of course, lightweight construction is only one of several measures taken to reduce consumption in a prototype of this kind. Extremely frugal engines, tires with low rolling resistance and a particularly aerodynamic skin make their contribution to low CO_2 emissions. However, according to the designers of the"1 liter car", the decisive factor in reducing energy consumption is the vehicle's weight.

Lighter and lighter – incremental challenges for the future. We have already mentioned it. The path to the car of the future demands ingenious teamwork. Technical experts from all disciplines will have to work closely on the new lightness. In addition, it will be necessary to think outside the box in order to consider solutions from other areas of technology. Impressive successes will only be possible as a sum of many exceptional projects and skilful integration of newly developed ideas.

Is it possible to look any further ahead? Even today, there are signs that people are thinking about the car in a totally new way. There are ideas for a modular vehicle architecture which can be individually tailored to the customer's wishes. A car that matches every situation in life? That sounds enticing. Until then, however, we should assume that there will be relatively little change in the preferences of car drivers. Without a doubt, driving pleasure and great design will continue to thrill us in the years to come as well.

THE FUTURE IS LIGHT

WITH MANUFACTURING TECHNOLOGIES FROM SCHULER

Fax response – Please send this fax to +49 7254 988-339 or 734 207 7222 (US customers)

I am interested in lightweight technologies from Schuler and would like more information:

- ☐ Cold forming for high-strength steels
- ☐ PCH Pressure-controlled hardening (hot stamping)
- ☐ Hydroforming
- ☐ Plastic forming
- ☐ Aluminum forming

☐ Please send me informational material.

☐ Please call me.

Last name, first name

Company

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Tel.

E-Mail

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