AUTOMOTIVE MATERIALS
PLASTICS IN AUTOMOTIVE MARKETS TODAY

Katarína SZETEIOVÁ

Author:	***Ing. Katarína Szeteiová***
Workplace:	***Institute of Production Technologies, Machine Technologies and Materials, Faculty of Material Science and Technology in Trnava, Slovak University of Technology Bratislava***
Address:	***Paulínska 16, 917 24 Trnava, Slovak Republic***
Phone:	***+421 908 549 646***
E-mail:	***katalin.szetei@gmail.com***

Abstract

The aim of this article is to give an overview about the plastic materials currently used in automotive industry. The first part of the article gives a short history of automotive industry from plastics point of view. The next part lists the exact types of raw materials which replaced the metal components in our cars already with their advantages, also with answering the question, why it happened. The conclusion of this article is providing a summary of development and research the world is working on and the way we‘re following.

Key words

automotive industry, plastics, development, production, four key areas, enhance safety, cost reduction, future

Introduction

The automotive industry is on the brink of a revolution, and the plastics industry poised to play a major role. The real plastics revolution in automotive industry began in 1950 when thermoplastics made their debut, starting with ABS and going on to polyamide, polyacetal and polycarbonate together with introduction of alloys and blends of various polymers. The ongoing development of advanced, high-performance polymers has dramatically increased their usage. Originally plastics were specified because they offered good mechanical properties combined with excellent appearance, including the possibility of self-coloring. The application of plastic components in the automotive industry has been increasing over the last decades. Nowadays, the plastics are used mainly to make cars more energy efficient by reducing weight, together with providing durability, corrosion resistance, toughness, design flexibility, resiliency and high performance at low cost.

Plastics in automotive

The average vehicle uses about 150 kg of plastics and plastic composites versus 1163 kg of iron and steel – currently it is moving around 10-15 % of total weight of the car (Fig. 1).

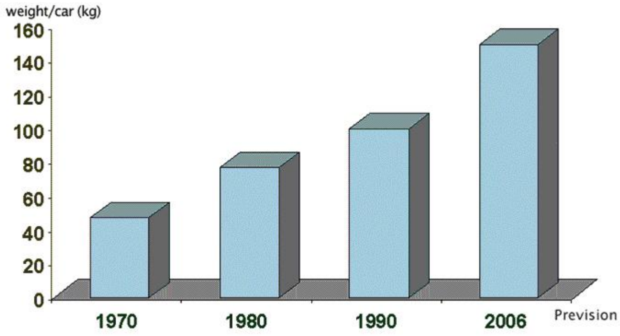

Fig. 1 *Increasing use of plastics in automobiles* [8]

The automotive industry uses engineered polymer composites and plastics in a wide range of applications, as the second most common class of automotive materials after ferrous metals and alloys (cast iron, steel, nickel) which represent 68% by weight; other non-ferrous metals used include copper, zinc, aluminum, magnesium, titanium and their alloys (Fig. 2). The plastics contents of commercial vehicles comprise about 50 % of all interior components, including safety subsystems, door and seat assemblies.

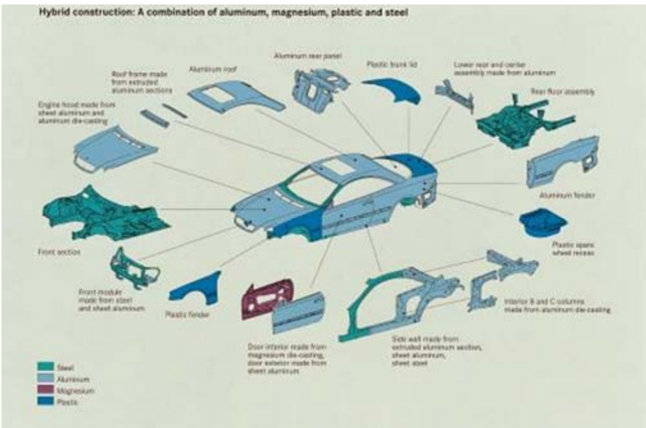

Fig.2 *Hybrid construction of a vehicle, combination of aluminum (light blue colour), magnesium (red colour), plastics (dark blue colour) and steel (green colour)*

During the enormous growth of plastics components in automotives, the advantages of using plastics have changed. Mounting costs are being met by the ability of plastics to be molded into components of complex geometries, often replacing several parts in other materials, and offering integral fitments that all add up to easier assembly. Many types of polymers are used in more than thousand different parts of all shapes and sizes. A quick look inside any model of the car shows that plastics are now used in exterior and interior components such as bumpers, doors, safety and windows, headlight and side view mirror housing, trunk lids, hoods, grilles and wheel covers.

Although up to 13 different polymers may be used in a single car model (Fig. 3), just three types of plastics make up some 66 % of the total plastics used in a car: polypropylene (32 %), polyurethane (17 %) and PVC (16 %) [5].

Component	Main types of plastics	Weight in av. car (kg)
Bumpers	PS, ABS, PC/PBT	10,0
Seating	PUR, PP, PVC, ABS, PA	13,0
Dashboard	PP, ABS, SMA, PPE, PC	7,0
Fuel systems	HDPE, POM, PA, PP, PBT	6,0
Body (incl. panels)	PP, PPE, UP	6,0
Under-bonnet components	PA, PP, PBT	9,0
Interior trim	PP, ABS, PET, POM, PVC	20,0
Electrical components	PP, PE, PBT, PA, PVC	7,0
Exterior trim	ABS, PA, PBT, POM, ASA, PP	4,0
Lighting	PC, PBT, ABS, PMMA, UP	5,0
Upholstery	PVC, PUR, PP, PE	8,0
Liquid reservoirs	PP, PE, PA	1,0
Total		**105,0**

Fig. 3 *Plastics used in a typical car* [5]

PP – polypropylene is extremely chemically resistant and almost completely impervious to water. Black has the best UV resistance and is increasingly used in the construction industry. Application: automotive bumpers, chemical tanks, cable insulation, battery boxes, bottles, petrol cans, indoor and outdoor carpets, carpet fibers,

PUR – polyurethane materials are widely used in high resiliency flexible foam seating, rigid foam insulation panels, microcellular foam seals and gaskets, durable elastomeric wheels and tires, automotive suspension bushings, electrical potting compounds, hard plastic parts (such as for electronic instruments), cushions,

PVC – poly-vinyl-chloride has good resistance to chemical and solvent attack. Its vinyl content gives it good tensile strength and some grades are flexible. Colored or clear material is available. Application: automobile instruments panels, sheathing of electrical cables, pipes, doors, waterproof clothing, chemical tanks,

ABS – acrylonitrile-butadiene-styrene is a durable thermoplastic, resistant to weather and some chemicals, popular for vacuum formed components. It is a rigid plastic with rubber like characteristics, which gives it good impact resistance. Application: car dashboards, covers,

PA – polyamide is known as nylon 6.6 or nylon 6. Both these nylons have high resistance to abrasion, low friction characteristics and good chemical resistance. They also absorb water easily and components in wet or humid conditions will expand, precluding their use in applications where dimensional stability is required. Application: gears, bushes, cams, bearings, weather proof coatings,

PS – polystyrene is very popular, ease to manufacture, but has poor resistance to UV light. Application: equipments housings, buttons, car fittings, display bases,

PE – polyethylene has good chemical resistance. Two types are used, low density polyethylene (LDPE) and high density polyethylene (HDPE) can be manufactured in a range of densities. Application: glass reinforced for car bodies, electrical insulation, packaging, where strength and aesthetics are important,

POM – polyoxymethylene (also know as polyacetal or polyformaldehyde) has big stiffness, rigidity and excellent yield, which are stable in low temperatures as well. Very good chemical and fuel resistance. Application: interior and exterior trims, fuel systems, small gears,

PC – polycarbonate has good weather and UV resistance, with transparency levels almost good as acrylic. Applications: security screens, aircraft panels, bumpers, spectacle lenses, headlamp lenses,

PMMA – acrylic is more transparent than glass, has reasonable tensile strength (shatter proof grades are available) and good UV and weather resistance, high optical quality and surface finish with a huge colour range. Application: windows, displays, screens,

PBT – polybutylene terephthalate has good chemical resistance and electrical properties, hard and tough material with water absorption, very good resistance to dynamic stress, thermal and dimension stability. Easy to manufacture - fast crystallization, fast cooling. Application: foglamp housings and bezels, sun-roof front parts, locking system housings, door handles, bumpers, carburetor components,
PET – polyethylene terephthalate has similar conditions as PBT, good thermal stability, good electrical properties, very low water absorption, excellent surface properties. Application: wiper arm and their gear housings, headlamp retainer, engine cover, connector housings,

ASA – acrylonitrile styrene acrylate material has great toughness and rigidity, good chemical resistance and thermal stability, outstanding resistance to weather, aging and yellowing, and high gloss. Application: housings, profiles, interior parts and outdoor applications.

In automotive design, plastics have contributed to a multitude of innovations in safety, performance and fuel efficiency, but it requires never-ending research and improvement. Leading experts say that the easiest and least expensive way to reduce the energy consumption and emissions of a vehicle is to reduce the weight of the vehicle. It is estimated that every 10% reduction in vehicle weight results in 5% to 7% fuel saving. Thus for every kilogram of vehicle weight reduction, there is the potential to reduce carbon dioxide emissions by 20kg. The incorporation of the lightweight materials in automotives is a necessity and our common need.

Technology activities and priorities

Plastics industry is very important in supporting the automotive industry. Automobile engineers are working together closely to optimize other systems, integrating injection and blow molded parts offering a better product without expensive assembly work. Plastics are also finding their way into the structural design of the cars (the most complicated design problem the tank fuel system has been solved thanks to plastics).

There are four areas requires highest-priority research and development with plastics. These are:
- interior,
- body and exterior,
- powertrain and chassis,

- lightweighting.

Interior (Fig. 4) – priorities for improving safety in the passenger compartment include making safety advances affordable through innovative design and more efficient manufacturing capabilities, designing for increased vehicle compatibility, accommodating an aging driver population, including more safety features in reduced package space, and enhancing safety belt designs [7].

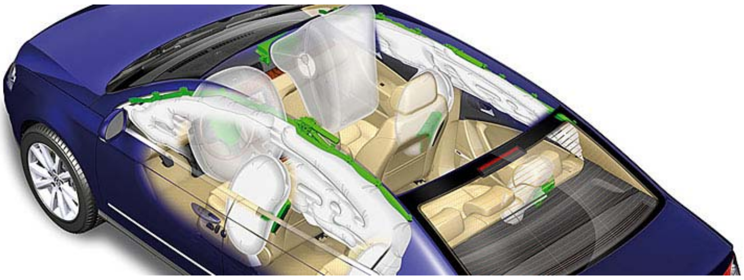

***Fig.4** Interior of a typical vehicle*

Body & Exterior (Fig. 5) – from bumpers to body panels, laminated safety glass to rear parking assists, research activities must include energy management technologies that resist vehicle intrusion, impede roof crush, and reduce body and exterior weight without compromising safety performance [7].

***Fig.5** Body and Exterior of a typical vehicle (bumper, body panels and trims)*

Powertrain & Chassis (Fig.6) – research in this area focuses on components that generate and deliver power and include the frame and its working parts. R&D priorities include pursuing significant advancements in engineering and research capabilities for designing with plastics, exploring new ways to optimize safety and fuel efficiency, expanding predictive modeling capabilities for composite materials, and developing the new safety components that will be required for future alternative vehicles and powertrain options [7].

***Fig.6** Powertrain and chassis of a typical vehicle*

Lightweighting – for example the marketplace offers new ultra light-weight wheel trims successfully, which provides innovation in products with high rigidity and low weight (these components had to put through high testing due to control of resistance to the weather conditions and long lifetime). Continuous development of new PP types allows the replacement of steel in automotive in the near future as well (for example new type GB 266 WG is hard, light material with perfect heat resistance and mechanical properties; suitable for products used in high stress areas). The transition to lightweight materials from conventional ones requires research activities that will increase the overall value of plastics in automobiles; develop new, high performance components that lower the center of gravity of a vehicle; improve crash avoidance and performance systems; and enhance pedestrian safety [12, 7].

The development and research of new materials and their manufacturing is permanently ongoing. Lighted PP, blended thermoplastic materials, biodegradable plastics are just examples of the continuous growth of innovation. The purpose of the biggest raw material suppliers (GE Plastics, BASF, Borealis AG, Ticona, etc.) is to develop materials easy to produce with best properties as possible from handling and environment point of view either. Injection molding is the most important of all the commercial methods of plastics processing. Many variations have been developed and one of the rapidly expanding fields is multi-material injection molding or over molding technologies, where one material is molded into another one (advantages is in much lower production cost for bigger quantities, no assembly cost, water resistant seal, sound absorption, increase in comfort level…). Wider application of over molded plastics components can meet any of the demands in the automotive industry as the properties of different polymers can be better utilized and many modern design features can be easily implemented [12, 5, 7].

Multi-layer extrusion technology is coming rapidly as well into the production of fuel tubing, to reduce permeability to nearly zero and, where required, to include electrical conductivity. The next stage will be the integration of the total fuel system, to be designed as a complete unit. This will almost certainly change the methods of assembly and connection (as research shows that it is at these points that there is greatest risk of emissions) [5].

Reinforced thermosetting resins also have a key part to play. While there is nearly fifty years of experience of the use of glass fibre-reinforced resins in production of bodywork, this has tended to be restricted by the nature of the material to low-volume production (of sports cars and ‘special’). However great strides have been made in the development of processes for molding fibre-reinforced polyesters and polyurethanes at mass-production levels, there is an increasing number of exterior bodywork panels and bumper systems that are produced in volume in these thermosetting materials.

Focusing on safety of travelers is also a very important area plastics playing part in. As the population of older drivers increases, improved counter measures and crash performance systems will be needed to keep these passengers safe. Many older drivers have lower biomechanical tolerances and require special safety features to avoid injury. With targeted research, highly versatile plastics may enable important advances in safety features that are needed to protect the 65-and-older population.

The greatest challenge to plastics in the automotive sector is in recycling (automotive industry has probably the best record of all industries when it comes to recycling its materials – with an average of around 75%, but the expectations are continuously increasing). Fortunately, automakers continue to devise new uses of recycled materials. Used tires, though still a serious landfill problem, are recyclable. Manufactures can now safely build new tires with 10 percent recycled tire rubber material. Designing vehicles with recycling in mind further reduces the solid waste stream. It also makes it easier and cheaper to dismantle vehicles when they reach end-of-life. Using materials that are cost effective to recycle plus documenting how to remove valuable parts helps promote recovery. The real challenge now for each participant is to work together to develop new assemblies that not only meet cost/performance requirements but also allow easier dismantling and recycling. [10] In the context of a realistic experiment, a nonsignificant result becomes meaningful for unraveling an ecological pattern [13].

Conclusion

The automotive industry today is a very competitive industry. In short, plastics meet the challenges of an industry whose demands are greater than ever. While motorists want high performance cars with greater comfort, safety, fuel efficiency, style and lower prices, society demands lower pollution levels and increased recovery at end of life. Continual innovation is a key feature in the use of plastics in cars. Plastics will continue in the next decade to help designers and engineers to innovate and take car performance further.

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