

# Advances in Automotive Polymer Applications and Recycling

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**Abstract:** The cost and comfort pressure make the automotive giants to strive for more and this requires continual innovation. The polymers are finding their way deep inside most of the applications primarily because of low weight and relatively better application properties. The average global plastic penetration is 120kg/vehicle and average Indian plastic penetration is 60 kg/ vehicle. A wide variety of polymers are used in vehicles. Polyurethane and polypropylene dominate for automotive components, with over 1 billion pounds used for this purpose in 2000. The upward turn in the plastic penetration is because of development of new polymers for automotive applications while the tighter regulations and environmental concerns have brought recycling in to focus. Approximately 82 per cent of an average vehicle's weight gets recycled. The materials obtained from recycling give birth to the new parts, jobs to million and environment friendly surrounding to live in. The focus of present study is to give comprehensive review of polymeric foams and their applications in the area of automotive comfort and safety.

**Keywords:** Polymer, Recycling, Automotive and Foam

## I. INTRODUCTION

Automotive industry is one of the oldest and multidisciplinary industries. This industry gives jobs to millions and contributes considerable in the economy of nation. In fact it is sometimes seen as indicator of economic growth. USA witness increase of 143 per cent in the automobiles registered per hundred residents between 1950 and 1996 [1]. Similar growing trends are visible in Asia and China. China polymer foam has obtained the growth rate of 18.1% from 2001 to 2010 [2]. Automotive market is growing with tremendous speed and automotive are changing with the same pace. We have better automotive in terms of clean and green technologies and better energy efficiencies. Changing customer requirements, stringent government regulations and cost pressures are forcing the OEMs to look forward for better design alternatives and hence is the need of alternative materials. This is leading to more automobiles on the road. Full use of resources available, government regulations and customer awareness to clean and green technologies, reduction in landfill spaces is compelling the automakers to design recyclability. As per the Arizona Automobile Recyclers Association, automotive recycling is the 16th largest industry in the United States, with more than \$5 billion in annual sales. Designed replacement of materials has taken the place of random material replacement due to environmental concerns. All the technical, functional, economic and environmental factors are carefully weighed before arriving at any conclusion. Performance, cost and carbon foot print are now become equally important. The substitution of materials in products is driven by technological, economic and environmental factors [3].

## II. ADVANCES IN AUTOMOTIVE POLYMER APPLICATION

Polymer and allied materials are rapidly capturing the share of metal usage in automotive. This is in turn getting rid of traditional approach of product design and development. Material selection is one of the decisive factors in arriving on the product strategy. This is a global trend in the cycle of innovation and also results in better recycling efficiency. Focus on clean and green technologies and increasing strict legislations are creating conducive environment for the growth of alternative materials. Earlier, most of the products were made of metals or metal alloys and now polymers or plastics in general are applied in majority of the applications and trend is rapidly increasing. For example, nine per cent decrease was observed in the use of iron and steel in gross average weight of automotive vehicle from 1990. In 1990 we had 70% of average vehicle weight as iron and steel. This participation reduced to 65% in year 2000 and reduced to 61% in year 2011 [4].

Major polymers used in light vehicles include 90 pounds of Polypropylene (PP), 58 pounds of Polyurethanes, 46 pounds of Nylon, 30 pounds of Polyvinyl Chloride (PVC), 24 pounds of Acrylonitrile-Butadiene-Styrene (ABS), 20

pounds of Polycarbonate resins and 18 pounds of Polyethylene resins. The total global consumption of lightweight materials used in transportation equipment was 42.8 million tons/\$80.5 billion in 2006 and will increase to 68.5 million tons/\$106.4 billion by 2011, at a compound annual growth rate (CAGR) of 9.9% in tonnage terms and 5.7% in value terms between 2006 and 2011[4]. Recycling industry has witnessed tremendous growth though academic work on recycling of polymer is limited [5]. As per trade literature there are following types of polymer mostly used in an automotive:

#### A. High Density Polyethylene (HDPE)

HDPE is used in foam core seating systems and bumper systems in an automobile. Other than automotive HDPE is widely used in the production of plastic milk jugs, butter tubs, soap, detergent and bleach bottles, orange juice containers, heavy duty trash bags, wire insulation, clothing and grocery bags. HDPE is widely recycled compared to other plastic materials. Many recycled products are made like plastic lumber, highway signs, flowerpots, toys, trash cans, kitchen drain boards, detergent bottles and many other things.

#### B. Low Density Polyethylene (LDPE)

LDPE is a clear flexible plastic that is used to wrap produce and bread, and it is used to make dry cleaner bags. LDPE is not recycled on any large scale, mainly due its softness.

#### C. Polyvinyl Chloride (PVC)

PVC is used in wiring harnesses and pipings of automotive. PVC is used in some food containers, plastic wraps, shampoo bottles and building materials. Recycled PVC is used to make drainage and sewer pipes, bathtubs, floor tile, and outdoor furniture. At this time there is very little recycled PVC available.

#### D. Polystyrene (PS)

PS is used to seat cushions, cups, plates, fast food containers, egg cartons, packing pellets, and the clear clamshell containers used at salad bars. The recycled PS is used to make office accessories, note pad holders, and waste cans.

#### E. Polypropylene (PP)

PP is used seat back fillings and in blow molding for bottles, other thin wall products, and also for "living hinges", since they have a high resistance to flexing. PP is also used in the packaging of tobacco products, snack foods, and pharmaceuticals (Brady, 1991).

#### F. Polyethylene Terephthalate (PET)

The products made with PET are soft drink bottles, peanut butter containers, mouthwash and mustard jars, and plastic wrapping.

About 20% of PET is recycled (Sombke, 1991) and used in carpet fibers, fiberfill, paint brushes, twine rope, scouring pads, industrial uses, and clear detergent bottles.

#### G. Composites and Multilayer

Ethylene vinyl acetate (EVA), Polyvinyl Acetate, and Ethylene Vinyl Alcohol are examples of composites. Composites are also the major type of plastic in automobiles. Composites contain many different types of resins and other materials in layers and are replacing materials that have been previously recycled, such as glass and paper board. Although these plastics have a longer life than those used in the packaging industry, they are almost impossible to recycle.

#### H. Acrylonitrile-butadiene-styrene (ABS):

ABS plated parts are replacing metal parts in the automotive and appliance industries. The typical products made from ABS are; helmets, refrigerator liners, luggage tote trays, housings, grill for hot air systems, tubing, piping, and pump impellers. ABS can be recycled, but currently is not being recycled widely.

### III. AUTOMOTIVE RECYCLING

Reducing margins and stringent government regulations are forcing automotive majors to go for reuse and recycling. Automobiles are the most recycled consumer product and as per European Union End of Life Vehicle (ELV) Directive the recovery target is 85% (2015) for end of life vehicles [5].

#### A. Cost Benefit

Each year steel industry recycles more than 14 million tons of steel which can produce 13.5 million automobile[6]. This number is equivalent to total number of new automobile produced in the same year. Hence we can say that automotive industry is having recycling rate of 100 per cent. One ton of steel recycling results in saving of 1400 pound coal, 120 pound of limestone and 2500 pounds of Iron ore. Enough material can be recovered from one year's recycling that 48

million utility poles can be produced. Also, recycling helps steel industry save power equivalent to power consumption of 18 million households. Automotive recycling employs more than 40,000 people in the United States, and there are an estimated 7,000 vehicle recycling operations across the country[7].

#### B. Environmental Benefit

This operations produce scrap metal for steel industry. This scrap metal is much cheaper than raw ore and environmentally safer as well. As per EPA estimates low sulfur scrap metal reduces water pollution by 76% and water pollution by 86 % when compared to high sulphur raw ore[8]. Non bio degradable plastics are the major environmental concerns. Recycling plastics apart from other benefits helps prevent environmental deterioration. Plastics from an end-of-life vehicle are growing part of the recycling industry. Ford, Toyota and Mazda are recycling their vehicles plastics and reusing in the new vehicles for example old or damaged bumpers are recycled and reused in bumper reinforcement cores or somewhere else.

#### C. Recycled content of automobiles

By weight, the typical passenger car consists of about 65 percent steel and iron. The steel used in car bodies is made with about 25 percent recycled steel[9]. Many internal steel and iron parts are made using even higher percentages of recycled steel. All steel products contain recycled steel because steel scrap is a necessary ingredient in the production of new steel. Steel scrap is derived not only from automobiles but also from steel cans, appliances and construction material.

### IV. CONCLUSION

Automobiles have found their place from luxury to daily needs and hence should be designed very carefully for performance, efficiency and environmental impacts. The current automotive market is very competitive in terms of cost and quality. This pressure cascade down to materials as well. Materials have significant role in overall vehicle cost, overall vehicle weight and fuel consumption. This participation calls for application of alternative light weight polymeric materials which can help Original Equipment Manufacturers(OEMs) to meet different performance parameters though these materials are not very extensive used due to various challenges like huge cost of raw material and heavy capital investment in establishing forming processes. Thus there is demand for further research for suitable cost effective processes for extensive utilization. Also the recycle and reuse must be placed at top of design matrix in order to reduce the cost and better environmental conditions for living.

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