



# Recycling of Plastic Waste Material Consumed in Automotive Industry: Short Review

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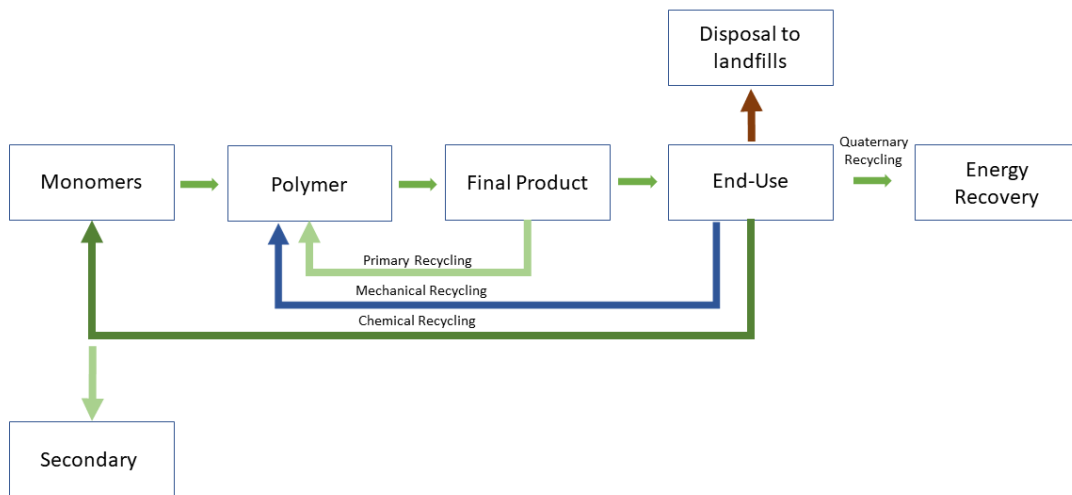
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**Abstract:** Plastic waste material are major cause for pollutions, land hazardous that are been causing up from the automobile transport vehicles. Recycling these waste materials could be turning point for reducing the effects of damages causing to mankind and animals along with making the environment sustainable and diversify. In this review paper, different types of recyclable plastics are been discussed up among which few are- Polyethylene Terephthalate, High-density polyethylene, Acrylonitrile-Butadiene-Styrene, Polycarbonate and Polypropylene. Different collection methods along with automotive applications are also been presented.

**Keywords:** Automotive, Applications, Methods, Plastics, Recycle

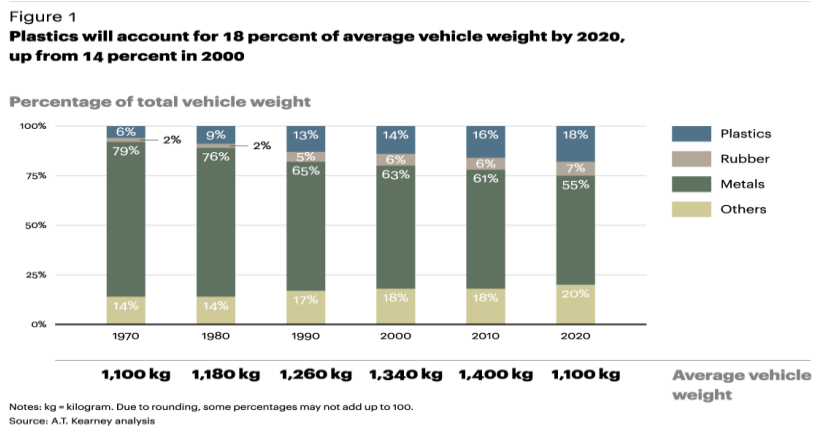
## 1. Introduction

The first plastic waste recycling mill was established in Conshohocken, Pennsylvania in 1972, and it has been the blueprint for all future recycling plants. Government programs and environmental activists have been teaching people about the benefits of recycling for many years now, and this has led to more plastic being made that is easier to recycle. The adoption of HDPE and PETE plastic in the 1980s helped reduce the amount of waste produced from actual plastic use[4]. As recycling programs started to form in large cities throughout America, people were beginning to see the value in recycling. In 1984, an amazing 100 million pounds of plastic was collected nationwide, setting a new record for plastic recycling. As years went by, people gradually became more aware of the benefits of recycling and began to demand that companies produce easier to recycle plastic. The efforts of plastics manufacturers during the 1980s and 1990s came to life with the adoption of PETE and HDPE plastic, which were designed to be recycled. These recyclable plastic products were introduced by the Plastic Bottle Institute of the Society of the Plastics Industry and clearly marked on their containers by the triangle made of arrows [4]. In recent years, the increase in population worldwide has led to an increase in the demand for polymers. The annual demand for polymer applications has exploded in the past few decades, reaching over 100 million tones. The most common way to deal with waste streams from businesses is to incinerate them or to use them for land fill. We are seeing growing pressure to reduce the amount of waste we produce, as well as rising costs and the poor biodegradability of many common plastics. Hence, recycling may be the best solution [1]. There are large areas of plastic on the ground. We see and use plastic on a daily basis, from soda bottles to our ID cards. There are a lot of plastics made from materials like oil and gas. There is some plastic around us that can have advantages, while there is also some plastic that can have disadvantages. Plastic recycling is a way of getting rid of waste plastic and turning it into new plastic products. The world produces and uses more than a trillion pounds of plastic products. This means that the plastic is recycled and does not go to waste. Instead of purchasing the product, you can reprocess the materials to get other products [2]. There are many ways to recycle plastics. There are four main ways to recycle plastic. Primary recycling is the most common recycling technique, involving recycling of scrap generated while manufacturing plastics. Secondary recycling or Mechanical recycling involves separating the contaminants and reprocessing the waste into granules by using traditional plastic processing machines such as extrusion. Chemical recycling is used when plastic wastes cannot be recycled mechanically, typically through depolymerization of polymers to monomers and then polymerizing new polymers. The plastic waste can be incinerated by using paralysis or gasification. The waste that cannot fit into the conventional waste management process is sent to landfills [3].



**FIGURE 1.** Plastic recycling

The use of lighter, more fuel-efficient materials in cars is increasing because people want cars that are lighter and easier to move around. The use of these materials can help reduce the average weight of a car by 200 kilograms [1]. Composite materials are better quality than traditional materials, and they can last longer. Higher strength means that things can carry more weight, and less maintenance means that things don't need to be looked after as much. This has led to many engineering applications, such as reducing energy consumption and environmental impact [4]. Composite materials are special types of materials that can be used to replace materials like metal or plastic. Polymer composites have many applications in different industries, such as electrical engineering, electronics, building and civil engineering, rail, road and marine, aerospace technology and aeronautical, automotive manufacturing [2]. The automotive industry is interested in things like electric motors and ways to make cars lighter and more energy-efficient. Even though the car's inside is beautiful, it cannot be ignored. The inside of a car is where you will be most likely to see it, so it has to be practical, beautiful, and lightweight. Using natural fibers in the interior of a car is important because it helps to reduce the amount of waste that is created. Environmental policies encourage using materials that are environmentally friendly and reduce waste [3]. Governments work together with environmental organizations to help people make good choices about how to use materials. There are four areas where there is high-priority research and development for plastics: interior, body, powertrain, and chassis. Bioplastics and composites can be used to replace metal and metal alloys in car parts. This review points out the benefits of using lightweight plastics in products, as well as the need for companies to use sustainable plastics when making cars [6]. The way we use plastics affects the environment in different ways. When we use plastics in the early stages of an automobile, we are reducing emissions. But when we use them in the end-of-life stage, we have to worry about what to do with all the plastic waste. We don't know for sure if light-weighting our products will have a big impact on the environment, but some people think it might. Previous studies have shown that lighter weight vehicles perform better when it comes to environmental performance even if all the plastic parts are landfilled. According to some studies, lightening the weight of vehicles would have a positive environmental impact, but other studies say the environmental cost of doing this would be more than the benefit [1].



**FIGURE 2.** Change of vehicle composition

## 2. Overview on Recyclable Plastics

There are several different types of recyclable plastics which are been stated below:

- a) **Polyethylene Terephthalate (PET)**-There are no known particles that can consume PET's comparatively larger molecules; thus, PET is non-degradable plastic in normal conditions. For PET to degrade biologically, complicated and expensive techniques need to be carried on. Recycling is the best method of reducing PET waste [7]. These are the easiest and most common plastics to recycle and are assigned as number "1", examples of which include soda and water bottles, medicine containers, and many other common consumer product containers [8]. As the price of virgin PET remains stable, new and cheaper technologies for recycling PET give an added value to the PET recycling industry by providing the industry with relatively cheaper PET.
- b) **High-density polyethylene (HDPE)**-HDPE is a type of plastic made from oil. It is very strong and can be used for a lot of things. It takes a lot of energy and raw materials to make plastic. It takes 1.75 kilograms of petroleum to make 1 kilogram of plastic. HDPE is a type of plastic that is often recycled. It has a number that is '2'. This number means that something is recyclable. Recycling helps us save energy, protect the environment, and reduce our waste. HDPE is resistant to many different solvents and has a wide variety of applications, including Telecom Ducts, Containers, Laundry Detergent bottles, Milk jugs, Fuel tanks for vehicles, Plastic ladders, Folding- tables, Folding -chairs, Storage sheds, Portable basketball system bases, Plastic bags, Containment of certain chemicals, Chemical-resistant piping systems, Heat-resistant fireworks display mortars [9].
- c) **Acrylonitrile-Butadiene-Styrene (ABS)**-ABS is a type of engineering plastic that is made up of a very stable and durable polymer that has good mechanical properties. The properties of ABS are determined by the composition, thermoplastic and rubbery phases, and how they interact with each other. The properties of SAN (Polystyrene-co-acrylonitrile) depend on its content, molecular weight, and composition. ABS is used in many different industries, including in the automotive industry, telecommunications, business machines, and electric/electronic casing. The wide range of ABS applications is due to its intermediate price between lower-priced commodity thermoplastics and more expensive high-performance engineering plastics. ABS (acrylonitrile butadiene styrene) is a type of plastic that can be recycled. ABS is also an interesting plastic material for recycling [10]. It has outstanding high and low-temperature performance, great insulation properties, and is easy to paint and glue. Its applications can be found in dashboards, wheel covers, and automotive body parts [11].
- d) **Polycarbonate (PC)**-Polycarbonate is a type of plastic that has many different uses because of its great mechanical properties, strong impact strength, heat resistance, and high elasticity. It is also very tough, clear, and resistant to heat, making it a great choice for many applications. Some people are recycling this plastic material after it has had its first life cycle. This is because it is attracting attention recently [12]. PC is a type of engineering polymer that has many different uses in technology, including in optical devices and systems. Demand for this type of polymer is growing every year. The production of this material in 2008 was estimated to be around 3.3 million metric tons, and it is projected to grow by 7% each year [13]. Due to its incredible impact strength, it is one of the top choices for headlamp lenses, bumpers, helmets, and bullet-proof glass [14].
- e) **Polypropylene (PP)**-Polypropylene (PP) is one of the polymers called 'commodities polymers' and it is commonly used in a wide variety of short-term applications such as food packaging and agricultural products. Polypropylene is a common polymer that is processed well and has many uses, such as commodities, medical applications, and automotive parts. It's known that polypropylene is often used to make packaging products, like food or beverage containers. These products often have a short lifespan and end up creating a lot of plastic waste. A lot of plastic packaging ends up being thrown away after it has served its purpose. Fortunately, a large part of plastic residues (more than 30%) is recycled using industrial recycling, completing the loop of the circular economy. Reusing plastic can have a variety of applications, including new packaging products, films, or matrixes of wood composites. Moreover, recycled plastic can be considered a safe material because the producers do not usually use hazardous materials in their process [15]. One of the many benefits of polypropylene is that it is resistant to acids, bases, and chemical solvents. This compound can be found in a variety of materials, including gas cans, carpet fibers, bumpers, cable insulation, and chemical tanks [16].

## 3. Need for plastic recycling

The consequences for our wildlife, water, and land are frightful. If you throw away plastic bottles, you're helping to create a problem by most of the plastic ending up in landfills or the oceans. The problem with plastic is that it takes a long time to decompose, so it's important to address it as soon as possible.

Recycling of plastics has a significant impact due to the following reasons:

- a) Recycling takes 88% less energy than making plastic from raw materials while helping to reduce fossil fuel consumption;
- b) Diverting discarded plastics from the refuse stream and turning them into new goods keeps these persistent materials out of landfills and the natural environment.

#### 4. Types of collection methods

Thermoplastic and thermosets should be sorted from each other so that they can be properly understood because thermosets cannot be remolded to reprocess them. However, individual thermoplastics families are not always compatible. The PVC and PP should be separated before they can be reprocessed. Collection of Waste Plastic. The first step to recycling plastic is finding and collecting waste plastic products. The plastic waste from various sources is collected and then it is disposed to various recyclers. There are places where people can discard their plastics, and some of these sites are better than others. Sorting of Plastics into Categories. After collecting the plastic, recyclers send it to facilities where they separate it into different types of plastics. There are many plastics, each with its unique properties. The recycling machines in this process sorted plastics based on their characteristics. The recycler sorts plastics by their colors and resin content. Recyclers use these symbols to know which materials are being recycled and how they are recycled. Different collective methods are been described below:

- a) **Washing to Remove Impurities** - After sorting the plastics, the impurities are washed by recyclers. The plastic in this product includes paper labels, dirt, and particles. Washing plastic removes additional chemicals that can be harmful to the environment. Washing your product is important because if the impurities are not removed, they may cause the product to fail. There are some harmful chemicals and products made of plastic that are not plastic and may not be recycled.
- b) **Shredding and Resizing** -This process involves breaking down plastic into smaller pieces to make it more easily recyclable. Shredding plastic helps to recycle other materials besides plastic products. If a recycler missed finding metal during the wash, it can be easier to identify it in the future by resizing the image.
- c) **Identification and Separation of Plastics** -The plastic particles in this process are subjected to tests to see if they are safe. Separation is necessary for good properties, and single polymer mixtures can also command a higher price in the marketplace.

#### 5. Methods for recycling

There are different types of plastics because they are made from different types of materials. Hence, it is impossible to recycle all types of plastics in the same way. There are two ways to recycle plastic - either by using the plastic to make something else or by using it to create a new product.

- a) **Traditional Recycling** -This recycling method is the most common. Traditional recycling is also known as mechanical recycling. Thermoplastic materials are recycled by using this method. The traditional recycling method is to melt plastic and process it into new plastic products. After recyclers melt the plastic, they make it into new products by using different types of plastic processing techniques.
- b) **Advanced Recycling**-Chemical recycling is the process of recovering plastic by changing the polymer structure to form a raw material that can be used to produce new products. Chemical recycling can deal with plastics that are not suitable for mechanical recycling. There are different types of chemical recycling technique
- c) **Purification** -Solvent-based purification is a process that can remove unwanted substances from plastic by dissolving it in a suitable solvent. Following this, a series of purification steps are undertaken to separate the polymer from additives and contaminants. Once the polymer(s) are dissolved in the solvent(s), they can be selectively crystallized by selectively reducing the solvent's concentration. When a solvent can dissolve only the polymer of interest, it might be used for selective dissolution. The key requirement for this is to have a specific solvent. The polymer formed is the result of the polymerization process, which is unaffected by the user's choice of ingredients and can be used to create new plastics.
- d) **Depolymerization** -Depolymerization is the process of breaking down a polymer into individual monomer molecules or shorter polymer fragments. Glycolysis and hydrolysis are currently the most commonly used chemolysis methods to reverse the polyurethane polymerization reaction. The recycling of feedstock into simpler molecules can be used in several ways to produce products, including petrochemical-type processing. The two important processes here are pyrolysis and gasification. The basic chemicals (e.g., hydrocarbons or singes) that are recycled need to be processed further to yield a polymer. This allows petrochemical plants to reuse components and technologies to create more efficient and cost-effective products.

#### 6. Application of Recyclable Plastics used in Automobiles

Carbon fiber-reinforced composites present a special type of construction that offers many advantages over other materials. They are especially good at replacing a variety of materials, such as plastic and metal. Since the early 2000s, their production of waste materials has increased significantly, and their waste production has become increasingly bulky. There are many alternative ways to handle composite waste, but many problems still need to be solved [17]. There are several ways to recycle carbon fibre composites rCF, and some of them provide a good surface and low weight. There are some disadvantages to rCF composites, including the need for a lot of processing time and cost [18]. After the widespread use of CFRP in mass

applications in automotive engineering, development is increasingly moving towards hybrid construction methods. Compared with metallic materials, CFRPs have anisotropic material properties and fibre orientation is different among different types of materials [19-20]. The shredding produces short fibres. These can then be re-used for the production of non-woven materials and mats, and they are the most widespread semi-finished products, which are used especially for sheet molding compound (SMC) semi-finished products. For the production of reinforcement of the C-pillar with sheet molding compound, BMW Group is using recycled carbon fibres. Mitsubishi Rayon's (MRC) sheet molding compound is used by Toyota for the production of hatch door frame. Furthermore, to increase surface quality, especially for exterior parts, non-woven are used as cover layers in component production [22-25].

## 7. Conclusion

In this paper, we have discussed a short history of plastics along with the significance of recycling. Followed by different types of plastics which can efficiently be recycled into desired automobile applications and predominant methods used to systematically recycle plastics and convert those into their applicable form were also discussed. Moreover, the application of recycled plastic components is used in the automobile industry.

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