

Building Plastic

This chapter mainly concentrates on the technological properties of plastic and the applications of building plastic products.

Plastic, a kind of organic synthetic material, are mainly made from the synthetic resin which can be molded into various shapes under certain temperature and pressure and then keeps unchanged in the normal conditions.

Building plastic has the properties of lightweight, high tenacity and multifunction. It follows the trend in development of modern materials and becomes an ideal new material to replace the traditional construction materials, such as steel and wood. Most of the countries in the world are paying much attention to the uses of plastic in construction. With the further development of plastic resources and improvement of technology, the performance of plastic will become better and the cost will decline. Therefore, plastic has broad prospects.

11.1 Components and Classifications of Plastic

11.1.1 The Components of Plastic

Plastic takes synthetic resin as the main raw material which is added by a certain amount of various additives according to needs. There are also several types of plastics without additives, such as organic glass and polyethylene, etc..

1. Synthetic Resin

Synthetic resin, short for resin, is artificial synthesized high molecular polymer. Therefore, different types of plastic can be called after the name of the synthetic resin it is made from.

Synthetic resin, the basic raw material of plastic, takes up 30%~60% or more of its composition. It has the function of agglutination, not only binding

itself together, but also the other materials firmly together. As the type, property, and amount of synthetic resin change, the physical and mechanical properties of plastic also change. Therefore, the main properties of plastic depend on the synthetic resin it is made from.

Synthetic resin is organic compound made by combining carbon atom, hydrogen atom, and a small quantity of oxygen atom, sulphur atom through certain chemical bond. According to the different combining forms of carbon atoms in a molecule, the molecular structure of synthetic resin is classified into three geometric shapes: line type, branched chain type, and somatotype (also called reticular type).

According to the different synthetic method during the production, synthetic resin can be classified into polyaddition resin and polycondensate resin.

Polyaddition resin, also called polymerized resin, is made by breaking the unsaturated double bond of monomeric compound through initiator, and combining it again in covalent bond, thus forming a huge polymer molecule. The common polyaddition resins are polyethylene (PE), polyvinyl chloride (PVC), polystyrene (PS), polyvinyl acetate (PVAC), polypropylene (PP), polymethacrylic acid (PMMA), and acrylonitrile butadiene styrene (ABS), etc..

Polycondensate resin, also called condensation resin, is made by combining two or three types of monomeric compounds in functional groups, which is rid of the small molecules after being heated or catalyzed. The common polycondensate resins are phenolic resin (PF), urea formaldehyde resin (UF), epoxy resin (EP), unsaturated polyester (UP), polyurethane resin (PU), and silicone resin (SI).

According to the changes synthetic resin has when being heated, it can be classified into thermoplastic resin and thermosetting resin.

Thermoplastic resin softens when it is heated and then hardens when it cools down. This process can be repeated for several times without changing the property and appearance of the material. The molecular structure of thermoplastic resin is line type and branched chain type. This material contains all the types of polymerized resin and part of the condensation resin. Thermoplastic resin has the advantage of being easily processed and molded. Moreover, it has better mechanical property. The disadvantage is its weak heat

resistance and stiffness. Polyvinyl chloride (PVC) and polyethylene (PE) are the representative thermoplastic resin.

Thermosetting resin softens when being heated and in this chemical change the adjacent molecules are closely connected. After it hardens and becomes molded, it won't change the shape or softens even when being heated again. Thermosetting resin can only be molded for one time. The molecular structure of thermosetting resin is somatotype. The majority of the condensation resin belongs to thermosetting resin. It has the advantage of better heat resistance, and the disadvantage of poor mechanical property.

2. Additives

In addition to the synthetic resin, all the other kinds of materials in plastic such as filling material, plasticizer, stabilizer, lubricant, and colorant, are collectively called additives. By adding a certain amount of additives, the properties of plastic can be changed; the processing technique can be improved; and the uses of plastic can also be enhanced.

(1) Filling Material

It is filler for short. By adding filling material to the synthetic resin, the flow between the chains of macromolecular compound can be slowed down; the strength, stiffness, and heat resistance of the synthetic resin can be improved; and the cost of plastic can be lowered. The common inorganic filling materials are talcum powder, diatomite, mica, limestone powder, and glass fiber, etc. The common organic filling materials are wood flour and wastepaper, etc..

(2) Plasticizer

The purpose of adding plasticizer is to improve the plasticity and flexibility of plastic as well as to lessen the brittleness. Plasticizer is either liquid with high boiling point and poor volatilization or solid with low melting point. Plasticizer has the disadvantage of reducing the mechanical properties and heat resistance of plastics. The common plasticizers are dibutyl phthalate (DBP), dioctyl phthalate (DOP), and camphor, etc. .

(3) Stabilizer

When plastic is being molded and used, it may undergone degradation, oxidative scission and cross bonding under the influence of heat, light, or oxygen. Then the color of plastic will fade and the properties will become weak. However, by adding stabilizer, the quality of plastic can be improved

and its useful life can also be extended. The common stabilizers are stearic acid, white lead, and epoxide, etc..

(4) Lubricant

When producing plastic, lubricant is added in order to knock it out easily and also to smooth its surface.

In addition to the additives listed above, others can also be added according to need, such as colorant, hardener or curing agent, foaming agent, antistatic agent, and fire retarding agent, etc..

11.1.2 Classifications of Plastic

There are many varieties of plastic and also various classification methods. According to the synthetic method of resin, plastic is classified into polymer plastic and condensate plastic; according to the changes of resin when being heated, plastic is classified into thermoplastic plastic and thermosetting plastic. When the thermoplastic resin, the substrate material, is added by auxiliary materials or additives, thermoplastic plastic can be made. In the same way, when the thermosetting resin is added by auxiliary materials, filling materials, or other additives, thermosetting plastic can be made.

11.2 Properties and Common Varieties of Plastic

11.2.1 The Main Properties of Plastic

1. Light Weight

The density of plastic is usually between $0.8\sim 2.2\text{g/cm}^2$ approximately $1/5$ of the density of steel, $1/2$ of that of aluminum, $1/3$ of that of concrete, and similar to the density of wood. This not only allows it to lessen the labor intensity, but also to reduce the dead weight of the building.

2. High Specific Strength

The strength of plastic per unit mass approaches or even exceeds that of steel. It is a kind of splendid material with lightweight and better strength.

3. Good Heat Insulation

The thermal conductivity of plastic [about $0.020\sim 0.046\text{W}/(\text{m}\cdot\text{K})$] is low. And that of foam plastic is even lower. Therefore, it is an ideal heat insulating material.

4. Good Processability

Plastic can be made into products with various shapes through simple processes. Thus make it easy to carry out mechanical mass production.

5. Good Ornamentality

Plastic products can be colored and keep fresh for a long period of time. Through photogravure printing, plastic can copy the texture of natural materials, making it difficult to differentiate the genuine from the fake.

In spite of the merits listed above, plastic has many weak points, such as aging easily, flammability, poor heat resistance, and weak stiffness. These weak points can be improved in some way. The aging process can be slowed down by adding a certain amount of stabilizer and high quality pigment; the flammable property can be lessened by adding a little more inorganic mineral filling material; the strength and stiffness can be enhanced greatly by adding fiber reinforced polymer.

11.2.2 The Common Varieties of Building Plastic

1. Polyethylene Plastic (PE)

Polyethylene plastic is made from the polymerized vinyl monomers. Monomer is a kind of simple compound, which can be polymerized to become macromolecular compound. Three ways are used to polymerize the monomer: high-pressure process, middle-pressure process, and low-pressure process. Different ways make different degrees of crystallinity and density. High pressure polyethylene has low crystallinity and density while low-pressure polyethylene has high crystallinity and density. As the crystallinity and density increases, on one hand, the hardness, softening point, and strength increase accordingly; On the other hand, the impact toughness and elongation decrease.

Polyethylene plastic has better chemical stability and water resistance. Even though its strength is not high, it is quite flexible in low temperature. A certain amount of carbon black can strengthen the aging resistance of polyethylene.

2. Polyvinyl Chloride Plastic (PVC)

Polyvinyl chloride plastic is a kind of common building plastic made from the polymerized vinyl chloride monomer. Polyvinyl chloride plastic has better

chemical stability and aging resistance, but poor heat resistance. It may decompose and metamorphose if the temperature exceeds 100°C. Usually, it should be used at temperature of below 60~80°C. By adding different amounts of plasticizer, hard and soft polyvinyl chloride plastic can be made.

3. Polystyrene Plastic (PS)

Polystyrene plastic is made from the polymerized styrene monomer. It has the merits of good light transmittance, easy pigmentation, better chemical stability, water resistance, light resistance, easy processing, and low price. However, polystyrene plastic has the disadvantages of weak stiffness, poor impact toughness, weak heat resistance and easy flammability. These weak points set restrictions to its uses.

4. Polypropylene Plastic (PP)

Polypropylene plastic is made from the polymerized acrylic monomer. It has the properties of light weight (density 0.90g/cm²), strong heat resistance (100~120°C), regular ductility and water resistance. The weak points are that it has poor stiffness in low temperature; and poor air resistance. Therefore, polypropylene plastic is fit to be used indoors. Recent years have seen the rapid development of polypropylene. Polypropylene, together with polyethylene and polyvinyl chloride, has become the main varieties of building plastic.

5. Polymethyl Methacrylate (PMMA)

Thermoplastic resin, also called organic glass, can be made from the polymerized polymethyl methacrylate. It has the advantages of good light transmittance, high strength at low temperature, low water absorption, better heat resistance, better aging resistance, and easy to be processed. However, it has the disadvantages of poor abrasive resistance and high price.

6. Polyester Resin (PR)

Polyester resin is made by condensing diatomic or polybasic alcohol and diatomic or polybasic acid. Polyester resin has the properties of good bonding capacity, elasticity, better colorability, flexibility, heat resistance and water resistance.

7. Phenolic Resin (PF)

Phenolic resin is made by polymerizing phenol and aldehyde under the influence of acid catalyst or alkaline catalyst. Phenolic resin has better cohesive strength, light resistance, water resistance, heat resistance, corrosion resistance, and electrical insulation. However, it has poor stiffness. Phenolic resin, added by filling material and curing agent, can be made into phenolic plastic. Phenolic plastic is smooth, strong, durable, and cheap. It has become a type of commonly used plastic.

8. Organic Silicon Resin (SI)

Organic silicon resin is made by hydrolyzing of one or more types of organic silicon monomer. Organic silicon resin has the properties of heat resistance, cold resistance, water resistance, and corrosion resistance. However, it is poor in mechanical performance and cohesive force. These two weak points can be improved by adding synthetic resin (phenolic aldehyde, epoxy, and polyester), glass fiber, and asbestos, etc..

Table 11.1 is a list of the properties and main uses of building plastic.

continued

Type	Density (g/cm ³)	Linear Expansivity (10 ⁻⁵ /°C)	Water Absorption (24h) (%)	Heat Resistance Temperature (°C)	Tensile Strength (MPa)	Extensibil- ity (%)	Compressi on Strength (MPa)	Bending Strength (MPa)	Modulus of Elasticity (MPa)	Properties	Main Uses
Polyvinyl Chloride (hard)	1.35-1.45	5-18.5	0.07-0.4	50-70	35-63	20-40	55-90	70-110	2500-4200	Corrosion resistance, electrical insulation, better strength in normal temperature, poor strength in high and low temperature	decorative sheet, accessory parts in construction, pipeline
Polyvinyl Chloride (soft)	1.3-1.7	-	0.5-1	65-80	7-25	200-400	7-12.5	-	-	Corrosion resistance, electrical insulation, flexible texture, low strength	thin plate, thin film, pipeline, wallpaper, wall cloth, carpet
Ther- mopl- astic Resin	0.92	16-18	<0.015	100	11-13	200-550	-	-	130-250	Corrosion resistance, electrical insulation, water insulation, low strength	Thin plate, thin film, pipeline, cold water tank, electricity-insulating material, various accessory parts
Polystyre ne	1.04-1.07	6-8	0.03-0.05	65-95	35-63	1-1.3	80-110	55-110	2800-4200	Corrosion resistance, electrical insulation, light transmittance, water resistance	Water tank, foamed plastic, various accessory parts
Polyprop ylene	0.90-0.91	10.8-11.2	0.03-0.04	100-120	30-63	>200	39-56	42-56	-	Light weight, stiff, ductility, heat resistance, corrosion resistance, poor abrasive resistance, flammability	Pipeline, container, accessory parts, corrosion-resisting lining board etc.

Table 11.1 Properties and Main Uses of Common Building Plastic

Type	Density (g/cm ³)	Linear Expansivity (10 ⁻⁵ /C)	Water Absorption (24h) (%)	Heat Resistance Temperature (°C)	Tensile Strength (MPa)	Extensibil- ity (%)	Compress- ion Strength (MPa)	Bending Strength (MPa)	Modulus of Elasticity (MPa)	Properties	Main Uses
Thermosetting Resin	Phenolic Resin	2.5-6.0	0.1-0.2	120	49-56	1.0-1.5	70-210	85-105	5300-7000	good electrical insulation, water resistance, light resistance, heat resistance, corrosion resistance, better strength	Electrical material, bonder, coating
	Organic Silicon Resin	5-5.8	0.2-0.5	<250	18-30	-	110-170	48-54	-	Heat resistance, cold resistance, corrosion resistance, electrical insulation, water resistance	Heat-resisting and electricity-insulating material, electrical material, water-resistin material, coating
Polyester Resin (hard)	1.10-1.45	5.5-10	0.15-0.6	120	42-70	<5	90-225	60-130	2100-4500	Corrosion resistance, electrical insulation, heat insulation, light transmission	glass fiber reinforced plastics, various accessory parts

11.3 Applications of Building Plastic

11.3.1 Plastic Doors and Windows

Plastic doors and windows are mainly made from polyvinyl chloride resin (PVC). By blending the polyvinyl chloride resin with a certain amount of additives, various profiles can be made through the pressing process. Then the doors and windows of buildings are made by processing these profiles.

Plastic doors and windows can be classified into wholly plastic, composite, and polyurethane door and window, with the wholly plastic being in the majority. The plastic door and window is made of the assembled PVC hollow profiles. The color can be white, dark brown, two-color, and wood-like.

Compared with the other kinds of doors and windows, plastic doors and windows have the advantages of water resistance, corrosion resistance, air impermeability, water tightness, heat insulation, sound insulation, burning resistance, dimensional stability, and decorativeness, etc. Furthermore, it needs no painting, is easy to maintain, and can save a lot of energy. It is widely used abroad at the present time. Considering the condition of China and basing on the overseas experience, replacing wooden and metal doors and windows gradually with the plastic is an important way to save wood, steel, aluminum, and energy.

11.3.2 Plastic Pipes

Compared with the metal pipes, plastic pipes have the advantages of light weight, rustproof, unfit for moss to grow, not begriming easily, smoothness in tube wall, small resistance to fluid, easiness of processing, and energy saving, etc. Recent years have seen rapid development in the production and application of plastic pipes. They are in the majority of building plastic products.

Plastic pipes can be classified into rigid tubes and flexible tubes. According to the raw materials, they can be classified into polyvinyl chloride pipe, polyethylene pipe, polypropylene pipe, ABS pipe, polybutylene pipe, and glass reinforced plastic pipe. Most of plastic pipes are made by using polyvinyl chloride resin which is blended with a proper amount of additives, and then molded through injection machine and extruding machine. Plastic pipe thus made is usually called PVC plastic pipes, which is plastic pipe for

short. There are various plastic pipes, such as drain pipe, rainwater pipe, water supply pipe, corrugated pipe, wire pipe, gas pipe, etc..

11.3.3 Plastic Wallpaper

Wallpaper is the most widely used wall surface decorative material. Plastic wallpaper, in particular, is various and fresh in its patterns. Using the technique of printing and foaming, plastic wallpaper can copy the texture of wood, stone, brocade, textile, ceramic tile, and common brick, etc. If the processes go on well, no one can tell the genuine from the fake. Therefore, plastic wallpaper makes it much easier for interior decoration.

There are many ways to classify the wallpaper. According to the different raw materials, it can be classified into the following types.

1. Wallpaper of Paper Surface and Bottom

This is the earliest kind of wallpaper made by embossing or printing patterns on the paper surface. It has the advantages of better air permeability, easiness to release the moisture stored in the wall, exemption from discoloration and swelling, as well as low price. However, it is hard to clean, easy to crack, and is not water resistant. Right now, this kind of wallpaper is not produced much.

2. Wallpaper of Textile

This kind of wallpaper is made of the fiber materials, such as silk, wool and linen. It may create an amiable, cozy, and comfortable environment, giving people a feeling of elegance. However, it is quite expensive.

3. Wallpaper of Natural Materials

This kind of wallpaper is made of grass, leaves, and wood. It is plain, natural, lifeful and without the artificial decoration. It is popular with the urban dwellers that live in the downtown or far away from the natural environment. However, it is not durable.

4. Plastic Wallpaper

This kind of wallpaper is fast developing and most widely used.

Plastic wallpaper can be classified into three types: common wallpaper, foamed wallpaper, and special wallpaper.

(1) The Common Wallpaper

It is also called wallpaper of plastic surface and paper bottom. It is made of paper coated with a layer of plastic. In order to bring out better decorative effect, patterns are often embossed or printed on the paper surface before a layer plastic is coated. This kind of wallpaper is water resistant, easy to be cleaned, durable and cheap.

(2) Foamed Wallpaper

It is made by coating the paper surface with a layer of foam plastic. This kind of wallpaper gives strong stereoscopic impression. It is sound absorbing, thus having better sound effects.

In order to strengthen its cohesive force and improve its strength, cotton cloth, linen cloth, and chemical fiber cloth can be used to replace the paper bottom. Foamed wallpaper thus made is called foamed wall cloth. By sticking the foamed wall cloth to the wall, it will not come off easily, and won't crack when being hit. Moreover, it is cheap and can be produced easily. Therefore, the foamed wall cloth is much favored.

(3) Special Wallpaper

Special wallpaper is made for specific needs. It is also called functional wallpaper, such as water-resisting wallpaper, fireproofing wallpaper, corrosion-resisting wallpaper, plastic granular wallpaper, and metal matrix wallpaper, etc..

Plastic granular wallpaper is easy to be stuck. It has some heat-resisting and sound-absorbing effect. Moreover, it can be cleaned easily.

Metal matrix wallpaper is energy saving.

Recent years see the production of electrostatic flocking wallpaper which is printed with patterns, decorative, feeling well, but quite expensive.

11.3.4 Plastic Floor

Compared with the traditional floor, plastic floor has the advantages of light weight, beautiful appearance, abrasion resistance, damp proof, fire proof, sound absorption, heat insulation, elasticity. In addition to these, it is also easy to be processed, cleaned and maintained. During recent years, it has already become one of the main ground decoration materials.

There are various types of plastic floor. According to the resin used, plastic floor can be classified into polyvinyl chloride plastic floor, vinyl chloride—vinyl acetate plastic floor, polythene plastic floor, and polypropene plastic floor. At the present, polyvinyl chloride plastic floor is in the majority.

According to the shape, plastic floor can be classified into floor tiles and floor rolls. Plastic floor tiles can be pieced together to create different colors and patterns. Therefore, it has good decorative effect and is easy to be repaired partially. Plastic floor rolls can be laid quickly and efficiently. According to the texture, plastic floor can be classified into semi-rigid and soft. Semi-rigid plastic floor is the most widely used at the present for its advantages of low cost, dimensional stability, heat resistance, abrasion resistance, good decorative quality, and easiness to be stuck. Soft plastic floor has good elasticity. It is a comfortable experience to walk on it. Moreover, it also has the merits of heat insulation, sound absorption, and moist insulation. According to the structure, plastic floor can be classified into monolayer and multilayer. Plastic floor of monolayer usually belongs to low-foamed floor. The monolayer floor is about 3~4mm in thickness. Its surface can be embossed with ridge design. It has the advantages of abrasion resistance, impact resistance, and skid resistance. However, its defects are poor elasticity, heat insulation, and sound absorption. The multilayer plastic floor usually has three layers: upper, middle, and lower. The upper layer is abrasion resistant and durable; the middle layer is elastic foaming layer; the lower layer is the base layer with many filling materials. The three layers are stuck together through hot-pressing. Multilayer plastic floor has the properties of elasticity, comfortable feeling, heat insulation and sound absorption.

In addition, there is seamless plastic floor, also called plastic coating ground. It has the properties of seamlessness, easiness to be cleaned, corrosion resistance, leakage proof, impermeability, and simple processing. It is suitable to be cast-in-place, used to renew the old one, and used in laboratory and hospital where the floor is easy to be corroded.

By adding a certain amount of asbestos, the asbestos plastic floor has the properties of abrasion resistance, corrosion resistance, poor flammability, self-extinguishing, and good elasticity. It is suitable for the hotels, restaurants, civilian or public buildings.

Rubber floor takes natural rubber, synthetic rubber or regenerated rubber as the principal raw material. This makes rubber floor has the properties of abrasion resistance, sound absorption, elasticity, impact resistance, and electrical insulation. But it has poor heat insulating property. Therefore rubber floor is suitable for the public buildings or industrial factory buildings which set low demand on such a property.

Antistatic plastic floor has the properties of light weight, corrosion resistance, fire proof and antistatic. It is suitable for the computer room, post and telecommunication office, or other buildings which have anti-static requirements and high demand on the air-conditioner.

When laying the plastic floor, the base ground should be dry and smooth. Wastes on the ground must be removed. Furthermore, the plastic floor should be flat and true-to-size. If curling and rake angle occur, it needs to be pressed flat first, and then the damaged corner is dealt with.

The binder used by the plastic floor has two types in China: the solvent and emulsion. Generally, the floor and binder are sold together. Instructions must be followed to carry out the work. Otherwise, the quality will be affected.

11.3.5 Other Plastic Products

1. Plastic Veneer

It can be classified into rigid, semi-rigid and soft plastic veneer. Its surface could be printed with various patterns like wood grain and stone grain. It may also be coated with decorative paper, plastic film, glass cloth and aluminum foil. It can also be embossed with spots, concave-convex patterns, and other various three-dimensional contours. When the raw material is added by fluorescent pigment, fluorescent plastic plate can be made. This type of plastic veneer has the properties of light weight, heat insulation, sound absorption, water resistance, and decorativeness. Moreover, it is suitable for the interior wall and suspended ceiling.

2. Glass Fiber Reinforced Plastics

It has the properties of light weight, water resistance, high strength, corrosion resistance, and decorativeness. It is suitable to be used as lighting and decorative sheet.

3. Plastic Film

It has the properties of water resistance, corrosion resistance, and high extensibility. It can be printed and be bound together with veneer, fiberboard, plasterboard, paper, and glass cloth, etc. Plastic film can be used as interior decoration material. In addition to that, it can also be used as water proofing material and cement-maintaining material.

4. Synthetic fiber reinforced film

It is the main raw material used in building aerated house. It has the properties of light weight, airtight, heat insulation, and easiness to be transported. It is suitable for the exhibition hall, gymnasium, agricultural greenhouse, temporary granary, and other kinds of temporary buildings.

Questions

- 11.1 What are the properties of building plastic?
- 11.2 What is the composition of plastic?
- 11.3 Explain the following terms: polymerized resin, thermoplastic resin, and thermosetting resin, thermoplastic plastic and thermosetting plastic.
- 11.4 Tell briefly the main properties of plastic.
- 11.5 What are the common types of building plastic?

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