Decoration of Plastics

1. Introduction

Commercial techniques for decorating plastics are almost as varied as plastics themselves. Depending on end-use applications or market demands, virtually any desired effect or combination of effects, shading of tone, and degree of brightness can be imparted to flexible or rigid plastics products.

The primary decorating technique is raw-materials coloring achieved at the compounding stage. Although most thermoplastics are produced in natural white or colorless transparent form, color is usually added by directly blending colorants into the base resin prior to the processing stage. These colorants (or color concentrates) are available in a wide range of stock shades with precise tinctorial values.

Colors can also be matched to exact customer specifications and these specifications kept in computer memory to ensure batch-to-batch or order-to-order consistency. Color blending can also be utilitarian, as in color-coded wire- and cable-sheathing.

Besides basic raw-materials coloring, mentioned above, designers have a large palette of decorating media at their disposal. Plastics can be decorated in various ways, which include painting processes, direct printing, transfer decoration, in-mold decoration, embossing, vacuum metallizing, sputtering, and electroplating. Most of these processes require bonding other media, such as inks, enamels, and other materials to the plastics to be decorated.

Some plastics, notably polyolefins and acetals, are, however, highly resistant to bonding and need separate treatment to activate the surface. Commonly used treatment processes are flame treatment, electronic treatments such as corona discharge and plasma discharge, and chemical treatment.

In flame treatment, plastic objects such as bottles and film are passed through an oxidizing gas flame. Momentary contact with the film causes oxidation of the surface, which makes it receptive to material used in decorating the product.

In the corona discharge process the plastic film to be treated is allowed to pass over an insulated metal drum beneath conductors charged with a high voltage. When the electron discharge ("corona") between the charged conductors and the drum strikes the intervening film surface, oxidation occurs and makes the surface receptive to coatings. Molded products are also treated in a similar manner, often by fully automatic machinery.

In the plasma process, air at low pressure is passed through an electric discharge, where it is partially dissociated into the plasma state and then expanded into a closed vacuum chamber containing the plastic object to be treated. The plasma reacting with the surfaces of the plastic alters their physicochemical characteristics in a manner that affords excellent adhesion to surface coatings. The process can be used for batch processing of plastics products, including films which may be unreeled in the vacuum chamber for treatment.

Acetal resin products are surface treated by a chemical process consisting of subjecting the product to a short acid dip that results in an etched surface receptive to paint.

2. Painting

Virtually all plastics, both thermoplastic and thermosetting, can be pained, with or without priming or other preliminary preparation procedures. The process, however, requires special consideration of the resin-solvent system to achieve adhesion, adequate covering, and chemical resistance. Painting operationshave the advantage of being as simple or as sophisticated as the application may dictate.

Plastics parts or materials can be coated manually by brushing, dipping, hand-spray painting, flow coating or roller coating; they can be automatically spray-painted with rotating or reciprocating spray guns, and electro-statically painted using a conductive precoating procedure.

Painting operations have the advantage of offering almost unlimited color options as well as great variety of surface finishes and final surface properties to meet such needs as gloss, UV resistance, abrasion resistance, and chemical resistance.

3. Machining of Plastics

One of the main attributes of plastics materials is their ability to be moulded into a finished component with no need for subsequent work to be carried out. Complicated shapes, holes and undercut features can be moulded into the component using tooling and moulding techniques. However all this comes at a cost of tooling expense.

Why Machine Plastics?

Moulding tools and forming equipment used in the various plastic moulding processes are invariably hand made one off creations. They can often take weeks and months to manufacture with a resultantly high cost. Where a plastics component is specified and the numbers to be used are not large, then machining the component becomes more economical. Not all plastics materials can be machined. The more rigid a plastic then the easier it is to be machined. The more flexible and the softer plastics are not suitable for machining.

What are the main points to note when machining plastics?

- The cutting tools used in the machining of all materials rely on the rigidity of the component being cut.
- In the case of cutting metals, the materials' natural rigidity is good. Therefore the component resists distortion when the cutter (saw, drill or machine bit) cuts the metal.
- In the case of plastics, machining tends to lend itself better to rigid materials, such as fibre reinforced thermosetting plastics materials, glass reinforced nylons, acrylic or PEEK have good relative stiffness. Less rigid plastic tends to deform and bend away when the cutter attempts to cut the component, making the achievement of fine dimensional tolerances difficult.

Aavantages of Machining Plastics

- No mould costs are needed
- Ability to manufacture plastic components with short lead times
- Ability to manufacture low volumes economically
- Can trial a design before committing to tooling
- Thicker wall sections can be accommodated
- Components too large to be moulded can be machined from fabricated plastic
- The forces required to machine plastics are low
- Plastics normally machine dry
- Swarf can be recycled back into the compounding process

Disadvantages of Machining Plastics Materials

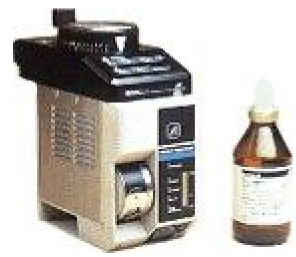
- Machining ability limited to the more rigid plastics materials
- Relative high cost of block plastic material
- High scrap (relative to other plastics forming processes) can result
- High volume of swarf to be removed can present difficulties
- High costs of CNC machine time
- Volume production by machining will require robust jigs and fixtures
- Plastics materials do not conduct away any heat generated in the machining process
- Dust producing composite plastics require an effective dust collection system

Methods of Machining Plastics Materials:

CNC Machining
If the component to be cut has a complex shape, its profile can be programmed into a computer. A CNC machining centre can be used to manufacture duplicate numbers of components. Multiple interchangeable cutters typically used on CNC machines enable complex and varied components to be machined.

Turning
If the shape to be achieved is round, then a simple turning operation can be used. Specialist supplementary equipment attached to the lathe can extend the capabilities of the lathe's operation.

Milling
This method of machining can vary from simple milling to profile and CNC milling.
Again as with lathe work, either additions to the milling machine, or the use of a more complex milling machine can extend the milling machine's capability to make more complex shapes.



Sawing
Invariably this method of machining is solely for parting off sections of plastic material from bar stock for subsequent working by other machining operations.

Die Cutting
In certain cases the use of die cutting of plastics material can produce a simple component. The process is limited to sheet material. A male and female die are used to punch out a predetermined shape. The process can be either a manual process or automated using a special machine.

Hot Knife Cutting
The softer less rigid types of plastic can be cut using a hot knife to slice through the plastic. An electrically heated wire or blade melts the plastic locally. This type of process is commonly used to cut blocks of foam and Expanded Polystyrene (eps).

Punching
Certain shapes can be cut on metal type punching presses. Like a CNC machine, they are invariably computer controlled and are multi tool bit equipped. This process is limited to the thinner thermoplastic and thermoset sheet.

Water Jet Cutting
This process is used to edge trim fibre reinforced thermosetting components, which would otherwise prove difficult to trim by other processes. The tough reinforcing layers in the material defy trimming by conventional knives and cutting equipment. The narrow cutting path and fast progess without dust or chippings are an advantage.

Separating
Acrylic and laminated sheet can be separated by means of scoring using a sharp knife and breaking about the scored line.

Laser Cutting
This process can be used for cutting and profile boring of certain types of acrylic and other plastics although not thermosetting. The process uses an industrial laser to melt the plastic often

with computer controlled profile following.

Ultra-sonic Cutting
Some of the softer thinner plastics can be cut using ultra-sonic equipment. The high frequency generated by ultra-sonics in the tool, have the effect of locally melting the plastic being cut. Again, integrated with computer profile control the process lends itself to high speed automated production lines.

4. Electroplating

Electroplating is a chemical process for depositing heavy metals on plastics to achieve decorative effects and/or upgraded functionality. Since plastics are nonconductors of electricity, electroplating requires that the surface be properly conditioned and sensitized to receive metallic coatings. The principle of electroplating is to electrically conduct metal atoms such as copper, nickel and chrome off anodes placed within the plating baths through the plating solutions and onto the plastic production part. The target, i.e., the production part, acts as a cathode via connection to conductive plating racks, the part being attached to the plating rack with metal holding devices, spring-loaded contacts or prongs. The point of contact between the plating rack and the plastic part forms the continuity of the current flow from anode through the solution onto the plastic part.

The process of electroplating begins with the plastic part attached to the plating rack being subjected to preplate procedure, which is designed to create a surface on the plastic parts that will develop a bond between the plastic and the first nickel or copper deposit. These initial deposits are extremely thin, in the micron (10−6 mm) range. This first deposit is designed to increase conductivity uniformly over the plastic surface.

When preplating is completed (and the plastic articles have a conductive coating), it is possible to proceed to the electroplating operation, which is very similar to conventional electroplating on metal. Electroplating of plastic products provides the high-quality appearance and wear resistance of metal combined with the light weight and corrosion resistance of plastics. Plating is done on many plastics, including phenolic, urea, ABS, acetal, and polycarbonate. Many automotive, appliance, and hardware uses of plated plastics include knobs, instrument cluster panels, bezel, speaker grilles, and nameplates. In marine searchlights zinc has been replaced by chrome-plated ABS plastics to gain lighter weight, greater corrosion resistance, and lower cost. An advantage of plastics plating is that, unlike metal die castings, which require buffing in most cases after plating, plastics do not ordinarily require this extra expensive operation. The use of plated plastics also affords the possibility of obtaining attractive texture contrasts.

5. Vacuum Metallizing

Vacuum metallizing is a process whereby a bright thin film of metal is deposited on the surface of a molded product or film under high vacuum. The metal may be gold, solver, or most generally, aluminum. The process produces a somewhat delicate surface compared to electroplating. The metallizing process can be used on virtually all properly (surface) prepared thermoplastic and thermosetting materials.

Small clips of the metal to be deposited are attached to a filament. When the filament is heated electrically, the clips melt and, through capillary action, coat the filament. An increased supply of electrical energy then causes vaporization of this metal coating, and plating of the plastic product takes place.

To minimize surface defects and enhance the adhesion of the metal coating, manufacturers initially give the plastics parts a lacquer base coat and dry in an oven. The lacquered parts are secured to a rack fitted with filaments, to which are fastened clips of metal to be vaporized. The vaporization and deposition are accomplished at high vacuum (about 1/2 micron). The axles supporting the part holding the fixtures are moved so as to rotate the parts during the plating cycle to promote uniform deposition. The thickness of the coating produced is about $5 \times 10{-}6$ in. (127 nm).

After the deposition is completed, the parts are removed and dipped or sprayed with a top-coat lacquer to protect the metal from abrasion. Color tones, such as gold, copper, and brass may be added to this coating if desired.