Short notes on Plastic and Manufacturing of Plastic Components

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Abstract— **In this paper, the basics of plastic material, types and various applications of plastic material was discussed in simple points. Plastic have important position in engineering materials. In addition, various factors influencing the Selection of Plastics material was explained in simple manner. This paper also covers the Moulding of Thermoplastics and Moulding of Thermosetting was explained neatly. Plastic components plays important role for making electrical appliances, pulleys, water tubes, tanks, packing etc. This paper would be helpful for the Mechanical Engineer to understand the basic concepts in Manufacturing of Plastic Components.**

Index Terms— **Thermosetting, Thermoplastic, Moulding.**

INTRODUCTION

I. PLASTIC - INTRODUCTION

A plastic can be broadly defined as any non-metallic material that can be moulded to desired shape. The most common definition for plastics is that they natural or synthetic resins or their compounds, which can be moulded, extruded, cast or used as films or coatings. The basic raw materials used in the manufacture of plastics are generally obtained from the following natural substances Coal, Petroleum, Limestone, Salt, Sulphur, Air, Water, Cellulose from cotton and wood.

II. PROPERTIES OF PLASTICS

1. Lightness in weight
2. Good thermal and electrical insulation
3. Corrosion resistance
4. Easy workability
5. Adhesiveness
6. Low fabrication cost
7. Decorative surface effects
8. Easy moulding
9. Insect-resistance
10. Low thermal expansion coefficient
11. Chemical inertness
12. Transparency
13. Low maintenance cost
14. Low softening points
15. High refractive index
16. Ability to take variety of colours shades
17. Good shock- absorption capacity
18. High resistance to abrasion
19. Dimensional stability
20. Impermeable to water
21. Good strength
22. Toughness
23. Absorbent or vibrations and sound
24. Excellent in finish

III. TYPES AND APPLICATIONS OF PLASTICS

3.1 Thermoplastic resins

Thermoplastic resins have separate long and large size molecules arranged side by side. It does not have any cross linking in their molecular structure.

3.2 Thermosetting resins

The plastics which are hardened by heat effecting a non reversible chemical change are called thermosetting.

3.3 Application of Thermoplastic Materials

S. No.	Type of Thermo plastic material	Applications
1	Polyethylene or Polythene	Used in High voltage applications, coaxial cables, packaging, fan and flower castings, insulation in submarine cables, pipes and tanks, moisture proofing
2	Polyvinylchloride (PVC)	Used in Cable jackets, lead wire insulation, rain water goods, corrugated roofing, flooring and ceiling panels, gramophone recorders
3	Polypropylene (PP)	Used in Vacuum flasks, hair dryers, filament and fibers, refrigerator parts, flash light casings, pipes, tanks, spray nozzles, washing machine parts
4	Teflon or Polytetrafluoroethylene (PTFE)	Used in Non stick coatings, bearing bushes, anti-corrosive seals, mouldings in aircrafts, laboratory equipments, chemical pipes, gaskets
5	Polystyrene	Used in Lenses, radar components, instrument panel, light fittings, house wares, sheets, refrigerator cabinet, electrical insulation, food containers
6	Acrylics	Used in Sanitary ware, sinks, lenses, roof lights, light weight garments, display signs, hospital equipments

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7	Acrylonitric butadiene styrene	Used in extruded sheets, extruded pipes, safety helmets, electrical parts
8	Silicones	Used as high heat resistant insulation
9	Polyvinylidene chloride	Used in seat covers, belt, women fabrics
10	Polyamides	Used in the manufacture of fibre and yarn. Nylon are used for moulding gears, valves and containers
11	Bitumen	Used for battery cell plugs, stoppers

3.4 Applications of Thermosetting materials

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3.5 Comparison of Thermoplastics and Thermosetting

S.No	Thermoplastics resins	Thermosetting resins
1.	They are found by addition polymerization only	Formed by condensation polymerization
2.	They consists of long chain linear polymers with negligible cross links	They have three dimensional network structure
3.	They soften on heating radialy	They cross-links and bonds retain their strength on heating
4.	By reheating to a suitable temperature, they can be softened, reshaped and thus reused	They retain their shape and structure even on heating. Hence, they cannot be reshaped and reused
5.	They are usually soft, weak and less brittle	They are usually hard, strong and more brittle
6.	They can be reclaimed from wastes	They cannot be reclimed from wastes
7.	They are usually soluble in some organic solvents	Due to strong bonds and cross links, they are insoluble in almost a organic solvent

IV. FACTORS INFLUENCING THE SELECTION OF PLASTICS

The following figure 1 shows the factor influencing the Selection of Plastics

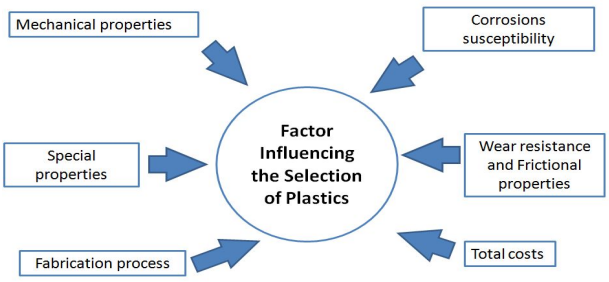

Figure 1 factor influencing the Selection of Plastics

4.1 Mechanical properties

Strength and Stiffness
Creep and recovery behavior
Stress relaxation
Creep rupture
Static fatigue
Toughness

4.2 Corrosions susceptibility

The degradation of the plastic occurs due to a breakdown of its chemical structure. It can occur due to apparently innocuous medium such as water or oxygen.

4.3 Wear resistance and Frictional properties

There is steady rate of increase in the use of plastics in bearing applications and in situation where there is sliding contact. Example: gears, piston rings, seals, cams

4.4 Special properties

The special properties regarding plastics are
Thermal prosperities electrical properties
Optical properties
Flame ability
Permeability

4.5 Processing

The designer must have a thorough knowledge of processing methods because range of methods available for plastics.

4.6 Costs

Plastics are cheap materials. Cost of the components is the sum of raw material costs, fabrication costs, and performance costs.

V. USES OF PLASTICS

1. For making electrical components
2. Used in aeronautical engineering
3. For making furniture
4. For making handles for tools and covers of machines

5. For making special type of paints
6. For making floor and wall linings
7. For making table tops, wind screens
8. For making electrical appliances such as plugs, switches, holders, radio and TV cabinet
9. For making bearing for propeller shafts used in paper industries and rolling mills
10. For heat and sound insulation in cold storage, refrigeration and for packing works
11. For making hoses, water tubes, electrical cables, pulleys, machine parts, safety glass, tank linings for chemical processing storage
12. For preparing decorative laminates and moulding
13. For making films for water proofing, damp proofing and curing of concrete
14. For making overhead water tanks and pipes to convey water, oil, gases, chemicals
15. For making house hold articles like combs, toys, trays, toilet goods, lenses, syringes
16. As water softening agents
17. For making adhesives

VI. MOULDING OF THERMOPLASTICS

Types of thermoplastic moulding

1. Injection moulding
2. Vacuum forming
3. Blow moulding
4. Film Blowing
5. Extrusion process
6. Rotational moulding
7. Sheet forming process
8. The working principle of above process are given below

6.1 Plunger Type Injection Moulding

The following figure 2 shows Plunger Type Injection Moulding.

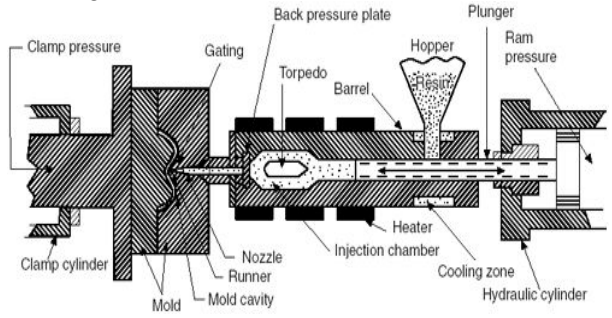

Figure 2 Plunger Type Injection Moulding

A predetermined quantity of moulding material drops from the feed hopper into the barrel.
Plunger conveys the material along conduction from the external heaters.
The material was plasticized under pressure so that it may be forced through the nozzle into the mould cavity.
Function of Torpedo are used to split up the mass of material in the barrel and used to improve the heat transfer.

6.1.1 Disadvantages of Plunger type Injection Moulding

The pressure at the nozzle can vary quite considerably from cycle to cycle.
Presence of torpedo causes a significant pressure loss.
Difficult to meter accurately the shot size.
Pressure amplifies the variability in mould filling.

6.2 Reciprocating Screw Injection Moulding

The following figure 3 shows Reciprocating screw injection moulding.

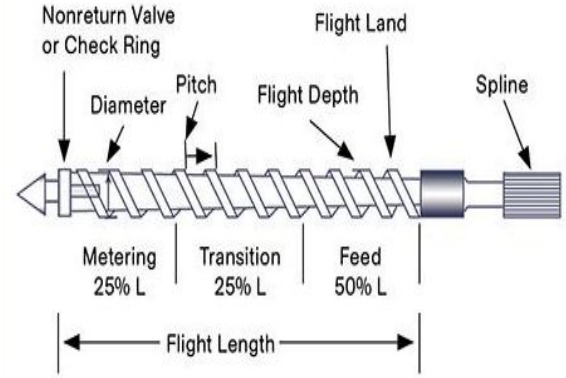

Figure 3 Reciprocating screw injection moulding

In this moulding the plastic powder was fed into a heated cylinder
Screw arrangement or a piston plunger is used to inject the plastic powder at a controlled rate which becomes tightly locked mould.
The mould was kept cold to allow the hot plastic to cure and become rigid

6.2.1 Advantages of Reciprocating Screw Injection Moulding

Mostly used for moulding of thermoplastics
Provides high speed production
Low mould cost
Low finishing cost

6.2.2 Limitation of Reciprocating Screw Injection Moulding

A large number of cavities cannot be filled simultaneously, so there was limitation of design of articles to be moulded

6.3 Vacuum forming process

This process was also called as thermoforming
In this a heated plastic sheet is changed to a desired shape by causing it to flow against the mould surface by reducing the air pressure between one side of the sheet and the mould surface

6.4 Blow moulding

A hot extruded tube of plastic called parison was placed between two parts of open moulds
The two valves of the mould move towards each other so that the mould closes over the tube
The bottom end of parison is sealed
The compressed air was used to blow the molten plastic into the mould and the tube gets pinched off
The air pressure will force the tube against the wall of the mould
The component was finally cooled and the mould opens to release the components

6.4.1 Application of Blow moulding

It is used making plastic bottles and toys
Hollow cylinders are produced by this process

6.5 Film Blowing

The following figure 4 shows the Film Blowing process.

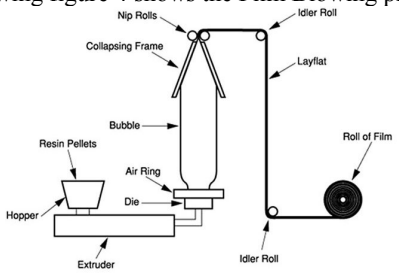

Figure 4 Film Blowing Process

Nylon (or) PET is suitable for the film productions by melt casting techniques

The heated plastic powder was extruded by using extrude machines

In extruding process, the thin film was produced

It is stretched by pulling rollers through the chilled drum in the reeling wheel

The reeling wheel is used to make the film roll

6.6 Extrusion moulding

The following figure 5 shows the Screw type extrusion machine.

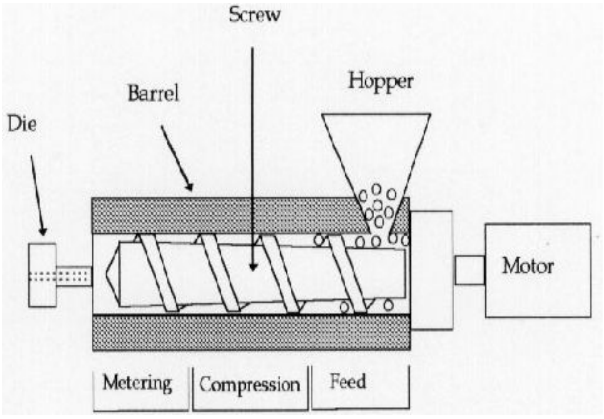

Figure 5 Screw type extrusion machine

Is used for continuously moulding of the thermoplastic materials into articles of uniform cross section

The thermoplastic ingredients are heated to plastic condition and then pushed by means of a screw conveyor into a die, having the required

Here the plastic mass gets cooled due to the atmosphere exposure

A long conveyor carries continuous cooled product

6.6.1 Applications Extrusion moulding

Used to make tubes, sheets, films, ropes

Can get complete shapes with constant cross sections

6.7 Rotational Moulding

Is used make thin walled hollow parts

In this method, a measured quantity of polymer powder was placed in a thus walled metal mould

The metal is closed and it is rotated about two mutually perpendicular axis

This rotation will cause the powder to sinter against the mould walls

After heating and sintering, the mould was cooled by using water and air

Then the rotational is stopped when the moulded compound is removed

6.8 Calendering

The following figure 6 shows the typical arrangement of rolls in calendaring process.

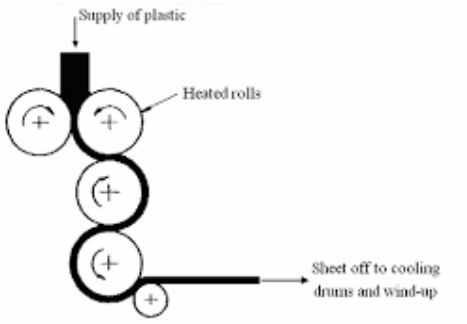

Figure 6 Typical arrangements of rolls

Is a method of producing plastic film and sheet by queezing the plastic through the gap or nip between two counter rotating cylinders

In this method premixing of the polymer, plasticizer, and pigments are used for sheet production.

Strainers and metal detectors are used to remove any foreign matter

The preliminary operation provides material wit h a dough, which is then supplied to the calendar rolls for shaping into sheets

6.8.1 Assumption made in calendaring process

Flow is steady and laminar

Flow is isothermal

Fluid is incompressible

There is no slip between the fluid and the rolls

6.8.2 Advantages of calendaring

Provides more accuracy

VII. PROCESSING OF THERMOSETS

The compression moulding and transfer moulding are the most common methods of processing thermosetting plastics. The working principles of these processes are given below.

7.1 Compression Moulding

The following figure 7 shows the compression moulding process.

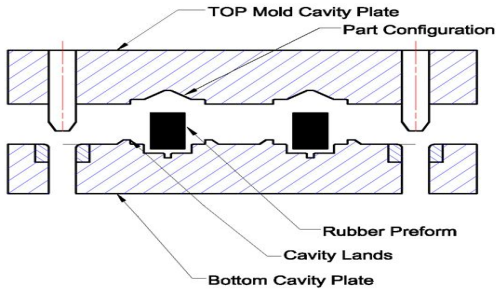

Figure 7 shows the compression moulding process

Widely used for thermosetting polymers and it is also used to thermoplastic polymers
In this process pre measured quantity of plastic was placed in a heated mould and compressed at suitable pressure and temperature.
Both the pressure and heat ensure the flow of resin, filling of all parts and corners of the cavity.

7.1.1 Thermosetting
The pressure is maintained till the linking is obtained to an optimum level. Finally, the mould is opened and ejected from the cavity.

7.1.2 Thermoplastics
The mould is cooled below the transition temperature before the mould is opened.

7.1.3 Types of compression moulding
Flash type compression moulding
Landed positive type compression moulding
Positive type compression moulding
Semi compression moulding

7.2 Transfer moulding
The following figure 8 shows the transfer moulding.

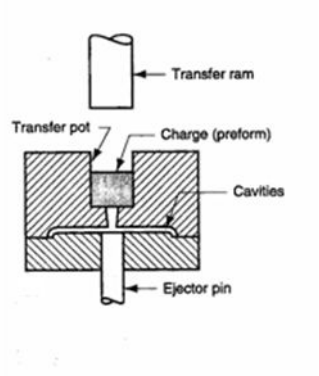

Figure 8 Transfer moulding

Is the modification of compression moulding in which the material is first placed in a separate chamber called transfer pot.
Then the material is pushed in sprue through the orifice and into the mould cavity by the action of a punch

7.2.1 Applications of transfer moulding
Used for batch production
Shape of mould can be readjusted
Short runs of mould metal during moulding

CONCLUSION

The basic of plastic, types and applications of plastic components were discussed in simple. The plastic components processing and applications were explained with diagram. This paper surely helpful for the Mechanical Engineer to enrich their knowledge in the field of manufacturing technology.

REFERENCE

[1] Gowri P. Hariharan, A.Suresh Babu, "Manufacturing Technology I", Pearson Education, 2008
[2] Roy. A. Lindberg, "Processes and Materials of Manufacture", PHI / Pearson education, 2006
[3] Paul Degarma E, Black J.T and Ronald A. Kosher, "Materials and Processes, in Manufacturing" Eight Edition, Prentice – Hall of India, 1997.
[4] Sharma, P.C., "A Text book of production Technology", S.Chand and Co. Ltd., 2004.
[5] Rao, P.N. "Manufacturing Technology Foundry, Forming and Welding", 2ndEdition, TMH-2003;2003
[6] Hajra Chouldhary S.K and Hajra Choudhury. AK., "Elements of workshop Technology",volume I and II, Media promoters and Publishers Private Limited, Mumbai, 1997
[7] Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India Edition, 2006