A NEW MATERIAL SUPPLY MECHANISM FOR PLUNGER TYPE INJECTION MOLDING

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ABSTRACT

This project was carried out to develop the new material supply mechanism for plunger type injection molding. The objective of this project is to design a new material supply mechanism that can overcome the limitation on the plunger type injection molding at the same the to improve the function of the current material supply that only act as a material storage. The development process consists of the design process and the validation process. The new design consists of the new function to give more functionality to the current material supply. The new function consists of the mixing mechanism and also the heating element and in additional to that, the valve is also being integrated into the mechanism in order to control the molten plastic from flowing out. The process of selecting a new material supply mechanism are made by selecting the best concept from three concept of a new material supply mechanism using a Pugh concept selection method. Due to the constrain in obtaining the component part, validation process was carried out by using CAE software. The validation process is done by using the CAE software analysis in the temperature flow on the mechanism. The value of the temperature was set to the three variable values to see the different flow of the temperature. Based on the analysis of the temperature flow, it shows that the new material supply mechanism are achieving the objective.

ABSTRAK

Projek ini telah dijalankan untuk membangunkan alat mekanisme pembekal bahan baru untuk pelekap jenis acuan suntikan. Objektif projek ini adalah untuk mereka bentuk alat mekanisme bekalan bahan baru yang boleh mengatasi kelemahan pada pengacuan suntikan jenis pelocok pada masa yang sama untuk meningkatkan fungsi bekalan bahan yang sudah ada yang hanya bertindak sebagai alat penyimpanan bahan. Proses pembangunan terdiri daripada proses reka bentuk dan proses pengesahan.Reka bentuk baru ini terdiri daripada fungsi baru untuk memberi lebih fungsi kepada bekalan bahan semasa.Fungsi baru terdiri daripada mekanisme pencampuran dan juga elemen pemanas dan tambahan kepada itu, injap juga disertakan sekali ke dalam mekanisme untuk mengawal plastik lebur daripada mengalir keluar. Dalam memilih mekanisma terbaru, konsep yang terbaik telah dipilh daripada tiga konsep mengunakan konsep pemilihan Pugh. Disebabkan kekangan dalam mendapatkan bahagian komponen, proses pengesahan telah dijalankan dengan menggunakan perisian CAE. Proses pengesahan dilakukan dengan menggunakan analisis perisian CAE dalam aliran suhu pada mekanisme. Nilai suhu yang telah ditetapkan pada nilai tiga pembolehubah untuk melihat aliran yang berlainan suhu. Berdasarkan analisis aliran suhu, ia menunjukkan bahawa mekanisme baru mencapai objektif.

TABLE OF CONTENTS

List of tables

List of figures

List of symbols

T	-	Torque per shaft design
Pmotor	-	Motor power
N	-	Rotational speed
F	-	Lateral impeller force
D	-	Impeller diameter
Fn	-	Hydraulic force factor
M	-	Shafft bending moment
Lx	-	Kength of shaft to intermediate support
Li	-	Length of shaft to impeller
Ds	-	Minimum shaft diameter for shaft stress
Σ_t	-	Allowable tensile stress
Dt	-	Minimum shaft diameter for tensile stress
Σ_s	-	Allowable tensile stress
D	-	Minimum shaft diameter
2d	-	Two dimensional view
3d	-	Three dimensional view
Rpm	-	Rotational per speed
Rps	-	Rotational per second
M	-	Viscosity

List of abbreviation

Rpm	-	Rotational per speed
Rps	-	Rotational per second
Cad	-	Computional added design
Cam	-	Computer automated manufacturing
Abs	-	Acrylonitrile butadiene styrene

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Injection molding is a high-rate production process and permits good dimensional control. Although most parts generally weigh from 100 to 600 g, they can be heavier, such as in automotive-body panels and exterior components. Typical cycle times range from 5 to 60 seconds, although they can be several minutes for thermostting materials.

Injection molding is a verstile proces capable of producing complex shapes with good dimensional accurancy and at high production rates. As in other forming processes, mold design and the control of material flow in the die cavities are important factors in the quality of the thus to avoid defects. Because of the basic similarities to metal casting regarding material flow and heat transfer, defects observed in injection molding are somewhat of the same nature, as outlined next. Methods of avoiding defects consists of consist of the proper control of temperature, pressures and mold modifications using software.

Much progress has been made in the analysis and design of molds and material flow in injection molding is shown in Figure 1.1. Modeling techniques and simulation software have been developed for studying optimum geting systems, mold filling, mold cooling and part distortion. Software programs now are to expedite the dsign process for molding parts with good dimensions and characteristic. The programs take into account such factors injection pressure, temperature, heat transfer and the condition of the resin.

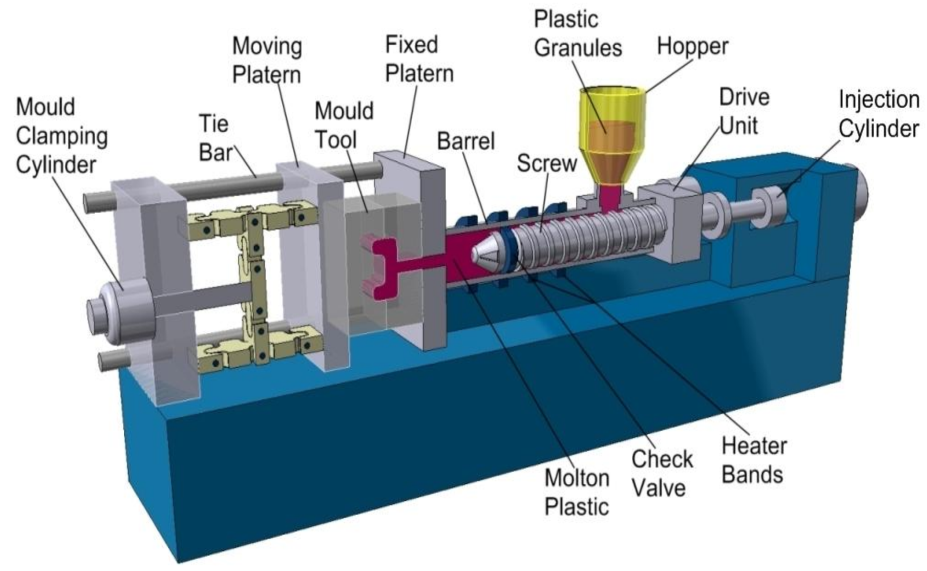

Figure 1.1: Cross-section of typical plunger injection molding machine

(Source : http://www.crown-cm.com/plastic-injection-molding)

Injection molding is used extensively for the precision forming of ceramics in high-technology applications, such as for, key holder to large automobile components through to intricate electronic parts into a big amount. The raw materials is mixed with a binder, such as a thermoplastic polymer (poly propylene, low density polyethylene or ethylene vinyl acetate) or wax. The binder usually is removed by pyrolysis (including chemical changes by heat) the part then is sintered by firing.

The injection molding process can produce thin sections (typically less than 10 to 15 mm thick) from most engineering ceramics, such as alumina, zirconia, silicon nitride, silicon carbide and sialon. Thicker section require careful control of the materials used and of the processing parameters in order to avoid defects, such as internal voids and cracks especially those due to shrinkage. Injection molding can produce a lot of material from almost all thermoplastic and some thermosets materials as shown in the Figure 1.2. Injection molding is widely use in polymer processing, cause of many advantages.

Figure 1.2: Plastic Injection Moulding Manufacturer of Bins, Boxes and Tubs
(Source : http://www.packaging-int.com/suppliers/plasgad)

The advantage of the injection molding is, to allow for the high production output rates. The product can be made in close tolerances on small intricate part. It is also can be used more than one material at the same time when utilizing co-injection molding There is typically very little post production work required because the part usually have a very finished look upon ejection and the scrap may be reground to be used. Therefore there is very little waste can be used in full automation with injection molding.

1.2 PROBLEM STATEMENT

Injection molding have been widely use in polymer processing in high volume because of its characteristic that economic when produce large quantity of the product. To ensure that the entire product that produces is in good condition, there are a few parameters that need to be look when running the machine, the purpose is to obtain good condition of the product when produce a large quantity is impossible without the proper supervises. The important to overcome the problem in injection molding is because of every defect considered a loss for the company. The less defect that produce, the higher profit for the company. This is into specific molding problems, below are some possible solutions may be used as an aid in producing quality molded parts. 65 percent of product rejections are directly related to Injection Molding profiles, and that up to 20 percent can be from the Mold. Because of this project are about to develop the new mechanism for the material supply, so the problem are more emphasize to the material supply problem for the plunger type injection molding. Table 1.1 shows the comparison of the disadvantages of the plunger type and reciprocating screw.

TABLE 1.1: The comparison between disadvantage of plunger and reciprocating type

PLUNGER TYPE INJECTION MOLDING	**RECIPROCATING TYPE INJECTION MOLDING**
1. Do not provide uniform melt homogeneity.	1. Significant amount of screw rotation during injection indicates a worn barrel and check valve. This allows a backflow of melt over the ring, causing the screw fights to counter rotate.
2. Plastic melted unevenly.	2. Defective, streaked, splayed, or non-uniform parts due to poor melt quality resulting from worn components.
3. Plastic closer to the heated walls simply had a higher temperature than the plastic further away.	3. Inconsistent shot size.
4. Difficult to meter accurately the shot size. Since metering is on a volume basic, any variation in the density of the material will alter the shot weight.	

1.3 OBJECTIVES

For this project, the main objectives are:

i. To develop the mechanism for material supply mechnism for plunger type injection molding.
ii. To test and analysis the new mini plunger type injection molding using the material supply concept experimentally.

1.4 SCOPE OF STUDY

For this project, the scope of the study are:

i. Write the literature review and summary fo this project.
ii. Elaborate how to making new design of material supply mechanism for plunger type injection molding.
iii. Fabricate to improve the function of the hopper for plunger type of injection molding machine.
iv. Test the type injection molding for plunger type of injection molding machine.

1.5 THE SUMMARY OF THE PROJECT

This project can make new sector of the new mechanism that can produces the limitation of the plunger type in problem statement. It can give advantages in the plunger type injection molding because the new mechanism can produce the part and able to reduce the component in the machine. This project also can provide improvementto the type injection molded. The flow of the process is shown in the chapter 3 and the Gantt chart can be refer in Appendix A1 and A2.

CHAPTER 2

LITERATUTE REVIEW

2.1 INTRODUCTION

This chapter 2 will continues about the information about the research about the material supply and also the other information that can be added for this project after discussion about the type of the injection and the problem in the plunger type injection molding, from that problem, the objective have been define in order to seek the solution that can overcome the limitation in chapter 1.

This research is more toward to make the material supply machine that needs to attach to the current machine that already finish. In conventional injection molding tools, surface engineering is used to improve the molding block performance to obtain parts with superior mechanical quality. Current machine that ready to use is a small injection molding that use a plunger to push the molten plastic into the small mold, so based on the small size of the injection molding, the material supply machine that need to attach are more proper to make in small size s as well as it suitable for the injection machine. This research is about to develop and make the material supply mechanism for the plunger type of the injection molding. Material selection is also important before produce because, different type of material have different melting point and also their behavior, this will affect the final part. It will produce a defect to the part when wrong selection of material and the error in parameter in machine. So it important to know the selection of the material before produces a part (W. Michaeli 2002).

Injection Molding (IM) consists in the injection, under high pressure conditions, of heat-induced softened materials into a mold cavity where they are shaped. The advantages the technique may offer in the development of drug products concern both production costs (no need for water or other solvents, continuous manufacturing, scalability, patentability) and technological/biopharmaceutical characteristics of the molded items (versatility of the design and composition, possibility of obtaining solid molecular dispersions/solutions of the active ingredient). In this article, process steps and formulation aspects relevant to IM are discussed, with emphasis on the issues and advantages connected with the transfer of this technique from the plastics industry to the production of conventional and controlled-release dosage forms. Moreover, its pharmaceutical applications thus far proposed in the primary literature, intended as either alternative manufacturing strategies for existing products or innovative systems with improved design and performance characteristics, are critically reviewed. (Martinez, 2010)

2.2 INJECTION MOLDING MACHINES

There are a variety of motives why the conventional injection molding machines fail to satisfy the requirements of the microinjection molding. So far, as typical macroinjection molding machines are concerned, the most important issue becomes its minimum metering size, which apparently is too big in comparison to the tiny quantity of material required to produce a microcomponent. The latter turns precise metering very complicated along with a considerable increase of the time of melt residence in the barrel and eventually may lead to material degradation. In addition, clamping force also has to be reduced in order to guaranty free damage release of the micropart (Giboz et al., 2007; Attia et al., 2009). To accomplish precise, free defect molding of the micro components, every functional system of the macro molding machine has to undergo a series of profound modifications (Giboz et al., 2007). So far, several commercially available and home-made machines are utilized for production of the micromolded components and may be divided in two main groups. In the first one, modifications are accomplished by simple rescale/miniaturization of the metering and injection units addressed to precise dosage of polymer melt in every shot (Giboz et al., 2007). Another approach consists of separation of the plasticization from injection unit, where the plasticization is being performed in the extrusion screw or hot cylinder, mounted at angle to the inject axis. Next, polymer melt enters into the injection unit, where the mini plunger pushes the prepared shot to fill the mould cavity. The above mentioned classification includes both hydraulically and electrically driven microinjection molding machines. However, for the sake of accuracy and repeatability of the process, higherprecision of plastic metering and clamping may be achieved by the servo mechanisms of theelectrically driven machine allowing for more accurate process control along with low noiselevel and energy efficiency. (Whiteside et al., 2003; Chang et al., 2007)

2.3 CLASSIFICATION OF INJECTION MOULDING MACHINE

Injection Moulding machines are broadly classified into two types:-

2.3.1 Plunger type injection moulding machine

The earliest moulding machines were of plunger type as illustrated in fig and still many of these types of machines are used. In this type of injection moulding machine the resin is fed from hopper into the barrel and heated through the input of thermal energy from heaters around the barrel. The molten resin collects in a pool in the barrel called the injection chamber.The molten resin is then pushed forward by action of a plunger driven by a hydraulic system at the head of the machine. To facilitate the melting of any residual solid material and to give better mixing of the melt, the molten resin is pushed past a torpedo or spreader that, along with a back pressure plate, imparts shear to the melt. Then the resin flows through a nozzle into the mould.

2.3.2 Screw type injection moulding machine

Figure 2.1 shows a schematic drawing of the injection end of a reciprocating screw machine. The extruder screw, which is contained in the barrel, is turned most often by a hydraulic motor (as contrasted to an electric motor attached to a gear system) point, at which time the screw stops. The rotary shutoff valve is rotated so that when the injection plunger advances, the material is injected into the mold. The main advantages of a two-stage screw are that the material passes over the whole as the screw turns, it picks up material from the hopper. As it progresses down the screw, the resin is compacted, de-gassed, melted, and pumped past the nonreturn flow valve assembly at the injection side of the screw. This, in essence, is a check valve, which allows material to flow only from the back of the screw forward.

As the material is pumped in front of the screw, it forces back the screw, hydraulic motor, and screw drive system. In so doing, it also moves the piston and rod of the hydraulic cylinder(s) used for injection. Oil from behind the piston(s) goes into a tank through a variable resistance valve, called the back pressure valve. Increasing this resistance requires higher pressures from the pumping section of the screw, and results in better mixing, a slower cycle, and greater energy consumption. The screw will continue to turn, forcing the carriage back until a predetermined location is reached. Then the rotation is stopped, and an exact amount of melted material is in front of the screw and will be injected into the mold at the appropriate time in the cycle. This is accomplished by using the hydraulic injection cylinder(s).

2.4 INFORMATION ON THE MATERIAL STORAGE OR HOPPER

The hopper, also used on extrusion and blow molding equipment, funnels unmelted plastic pellet, by gravity, to the feed section of the barrel. Some hopper will have a transparent window to view the material level. Material van added manually or with an attached vacuums system for high throughput applications. Hopper are covered to prevent possible contamination and also feature a magnetic screen above the entrance to the throat of the barrel to catch any metal fines, chips, blot or other small object that may be accidently dropped into the hopper. Metal contaminants can seriously damage the screw (Eric, 2009).

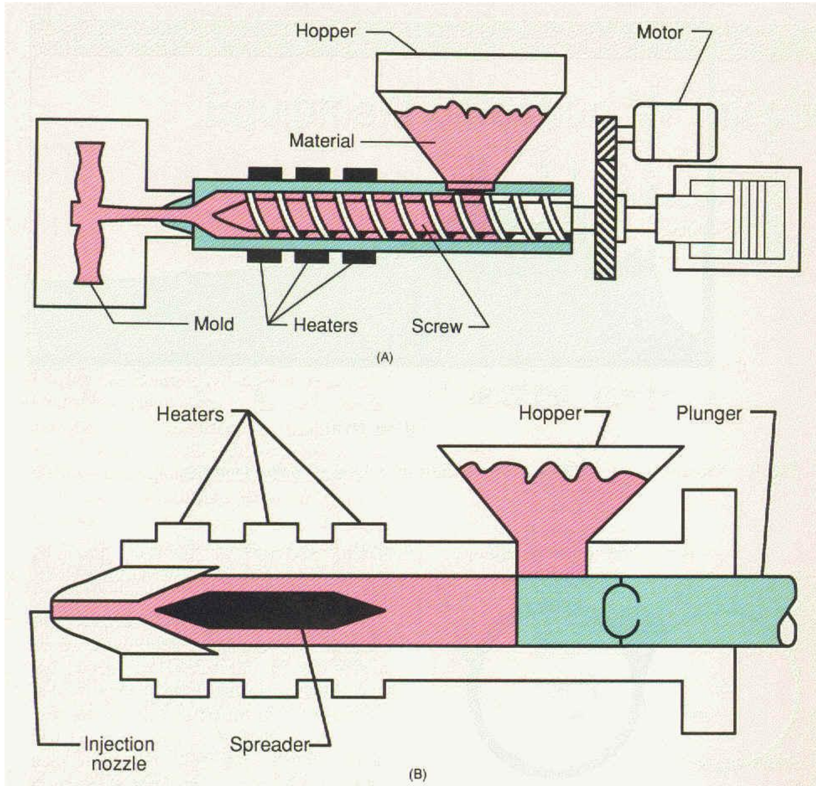

Figure 2.1: Drawing of (a) screw and (b) plunger type injection molding machine (Source: mechanicalhome.blogspot.com)

Plastic usage for a given process should be measured so as to determine how much plastic should be loaded into the hopper. The hopper should hold enough plastic for possibly one-half to one hour's production. This prevents storage in the hopper for any length of time. A combination feeding and drying device is used to force hot air upward through the hopper containing the plastics to be processed. Care should be taken to ensure that hygroscopic plastics are in an unheated hopper for no more than a one-half to one hour, or as determined from experience and/or specified by the material supplier.

Different methods are used to feed plastic to the hopper. These range from manual to very sophisticated automatic material handling systems. Vacuum or positive air pressure systems are used. The type used depends on factors such as space available, type plastic (shape, form), blending or mixing requirements, amount to be processed, and delivery rate into the plasticator. Consider, for example, disc feeders. These horizontal, flat, grooved discs installed at the bottom of a hopper feed a plasticator to control the feed rate by varying the discs' speed of rotation and/or varying the clearance between discs. A scraper is used to remove plastic material from the discs. Stuffers are used to handle paste type molding compounds that do not flow through conventional hoppers. They usually include a ram or a screw with the screw also acting as a plunger, which moves material into the plasticator. The stuffer may include a preheater for the material.

Hopper mounted coloring loaders combine virgin plastics, regrinds, one or more colorants, and/or additives (such as slip agents inhibitors, etc.). Materials are mixed by tumbling or gravity, and the loader drops the mixture into the process hopper. Some coloring loaders allow the use of dry, powdered colorants, color concentrates, or liquid colorants through the same unit without major equipment alterations. The component are self-loading and mount directly over processing machines, obviating the need to manually handle component materials and risk contamination and waste. When powdered dry colorants are used, the hopper can be placed in a canister in a separate color room and the filled canister is then mounted on the coloring loader.(Tim A, 2008). Figure 2.2 show the cut view of hopper.

2.5 PLASTIC

Plastics are non-metallic, polymeric engineering materials that can be formed by many methods. They have taken the place of traditional materials like woods and metals. Plastics differ from other materials largely because of the size of their molecules. Most materials have molecules made up of less than 300 atoms, whereas plastics contain thousands of atoms that is Macromolecules. There are some plastics derived from naturally occurring materials like wood, animals and insects (Tony, 1994).Based on molecular structure, thermoplastics can be classified into two groups that are; amorphous materials never really melt during processing. They just soften and are formed under pressure. These materials possess close dimensional tolerances on the part compared to crystalline materials. ABS, are classified under this group. Crystalline materials have a specific melt temperature and remain solid until this temperature is

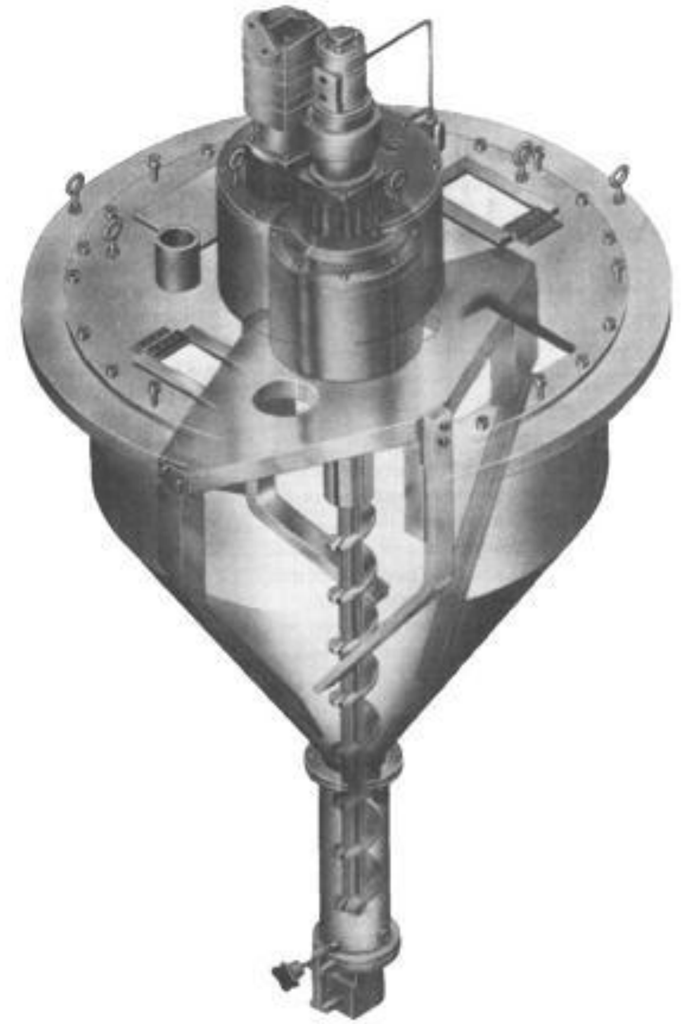

Figure 2.2: The cut view of hopper
Source: Tim A. Osswald, Lih-Sheng Turng, (2008)

reached. After the melt temperature is achieved, the materials flow very easily with very low viscosity. When the material is cooled to a temperature below the melt temperature, the material hardens to a solid form.

Thermosetting materials are those, which set solid on curing after being melted to the liquid state by heating. The thermoset polymeric material can be formed by the application of heat and pressure, but cannot be reformed upon further application of heat and pressure. These materials chemically react to form cross-link polymer chain molecules during processing. These materials possess heavy impact strength with good resistance against heat and chemicals. For instance the material like phenol formaldehyde, melamine formaldehyde, urea formaldehyde.

2.5.1 Classification of plastics

Plastics are usually classified by their chemical structure of the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, polyaddition, and cross-linking.

There are two types of plastics: thermoplastics and thermosetting polymers. Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be molded again and again. Examples include polyethylene, polypropylene, polystyrene, polyvinyl chloride, and polytetrafluoroethylene (PTFE). Common thermoplastics range from 20,000 to 500,000 amu, while thermosets are assumed to have infinite molecular weight. These chains are made up of many repeating molecular units, known as repeat units, derived from monomers; each polymer chain will have several thousand repeating units.

Thermosets can melt and take shape once; after they have solidified, they stay solid. In the thermosetting process, a chemical reaction occurs that is irreversible. The vulcanization of rubber is a thermosetting process. Before heating with sulfur, the polyisoprene is a tacky, slightly runny material, but after vulcanization the product is rigid and non-tacky. Other classifications are based on qualities that are relevant for manufacturing or product design. Examples of such classes are the thermoplastic and thermoset elastomer, structural, biodegradable, and electrically conductive. Plastics can also be classified by various physical properties, such as density, tensile strength, glass transition temperature, and resistance to various chemical products.

2.5.2 Thermoplastic

A Thermoplastic, also known as a thermo softening plastic, is a polymer that becomes pliable or moldable above a specific temperature, and returns to a solid state upon cooling. Most thermoplastics have a high molecular weight, whose chains associate through intermolecular forces; this property allows thermoplastics to be remolded because the intermolecular interactions spontaneously reform upon cooling. In this way, thermoplastics differ from thermosetting polymers, which form irreversible chemical bonds during the curing process; thermoset bonds break down upon melting and do not reform upon cooling.

Above its glass transition temperature, T_g, and below its melting point, T_m, the physical properties of a thermoplastic change drastically without an associated phase change. Within this temperature range, most thermoplastics are rubbery due to alternating rigid crystalline and elastic amorphous regions, approximating random coils.

Some thermoplastics do not fully crystallize below T_g, retaining some, or all of their amorphous characteristics. Amorphous and semi-amorphous plastics are used when high optical is necessary, as a light wave cannot pass through larger crystallites than its wavelength. Amorphous and semi-amorphous plastics are less resistant to chemical attack and environmental stress cracking because they lack a crystalline structure.

Brittleness can be lowered with the addition of plasticizers, which interfere with crystallization to effectively lower T_g. Modification of the polymer through copolymerization or through the addition of non-reactive side chains to monomers before polymerization can also lower T_g. Before these techniques were employed, plastic automobile parts would often crack when exposed to cold temperatures. Recently, thermoplastic elastomers have become available.