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Introduction

Plastics have become an integral part of our lives. Plastics are an excellent and very useful material and they are functional, hygienic, light, and economical. Using a key polymer processing system, plastics produce diverse products used in packaging, automotive and industrial applications, and also extensively used in medical delivery systems, artificial implants and other healthcare applications, water desalination, and removal of bacteria, etc.

Until the 1930s and in early 1940s, thermoplastics were not common material. Ever since the first industrial scale production of plastics (synthetic polymers) took place in the 1940s, the production and consumption has increased considerably. Although plastic materials are relatively new, they have become basic and indispensable in our life with different shapes, sizes, and applications that can be seen daily at home, office, and even on the street.

The growth in the manufacture of thermoplastic products for various applications has been considerably increased.

It includes many light engineering applications. The plastics materials usage for food packaging has obvious advantages associated with the non-toxic nature of these materials and their resistance to chemical and biological degradation [1].

1.1. Market Trends

Today, the requirements are constantly changing and rising to higher levels [2]. The world's annual consumption of polymer materials has increased from around 5 million metric tons in the 1950s to nearly 100 million metric tons today [3, 4]. The worldwide demand for plastic pipes is forecast to increase 4.6% annually through 2012 to 8.2 billion meters or 18.2 million tons. Demand for HDPE (polyethylene) pipes will benefit from use as small-diameter pipes in natural gas transmission, as conduit for electrical and telecommunications applications, and as corrugated pipes for drains and sewers [5].

The US market for plastic healthcare packaging is expected to reach 3.8 billion pounds of products in 2010. This amount is forecast to increase to nearly 5 billion pounds in 2015. PP (polypropylene) packaging, the largest segment of the market, will reach 1.3 billion pounds in 2015, after increasing by 6.3% per annum from the estimated 2010 total of nearly 1 billion pounds [6].

Global demand for PE, the largest-volume basic polymer, is expected to grow about 4.2% per year to reach about 81 million metric tons by 2013. Demand for engineering plastics will rise by 3.1% per year to reach 5.4 billion lbs by 2012. Polycarbonate, nylon, and ABS will continue to be the largest-volume engineering plastics, accounting for more than 75% of total demand by 2012 [7].

Polymer demand has been driven by high levels of investment particularly in packaging, appliances, consumer electronics, and automotive [8]. However, in the modern global market, quality is a key issue to remain competitive in business. Quality can no longer be simply the result of an inspection process, but very much part of the strategic planning process of successful companies [9].

1.2 Importance of Plastics

Plastics are increasingly important in the manufacture of materials due to their significant higher strength to weight ratio and stiffness, as well as impact strength. The main drivers for the rapid increase in their use are low cost and the possibility of achieving total recyclability. But the large scale and widespread use of plastics is due to its low density and ease of processing.

Plastics are macromolecules derived from monomers, also called polymer. The word "poly" meaning many and "mer" designating the nature of the repeat unit [10, 11]. Polymers are from synthetic or naturally occurring material which can be used with modification to suit with respect to processing. The term "polymer" is these days known as "plastics" when referring to macromolecules like polypropylene, polystyrene, etc.

Plastics are constructed by the covalent linking of simple molecular repeated units [12]. Plastics are composed of carbon, nitrogen, oxygen, sulfur, chlorine, fluorine, and silicon. Moreover, plastics are made from petrochemical products which are a rich source of methane, ethylene, aliphatic, and aromatics. Variations in the elements make the plastic into stiff or flexible, linear or branched, and hard or soft.

Plastics are classified based on recyclability into thermoplastics and thermosets. Polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), etc., are some of the thermoplastics and phenol formaldehyde, urea formaldehyde, etc., are examples of the thermosets. Both thermoplastics and thermosetting materials may be molded and then cooled to obtain the end product. Thermoset once molded cannot be either softened or reprocessed.

Thermosets lead to products which are not recyclable. Moreover, it will form a network and it can neither be melted nor reprocessed. Once shaped, it can be altered by post forming operations if required. Pre-polymers are to be made before processing in thermoset processing. However, thermoplastics soften while heating and solidify during the cooling process. Thermoplastics can be recycled by either direct heating or after grinding into granules of scrap products [13].

Processing technology that shapes material and technology of plastics allows the manufacture of parts with lightweight, precision and strength, and low cost. It is cheaper than metal or ceramic processing. However, to use plastic effectively and to have the best advantage of its application, specific characteristics or physical properties must be considered.

In plastics processing, with technology and application advances, conventional product replacement and unlimited innovation can take place. Plastic raw materials are also widening its range of products. Achieving higher performance with increased quality is the major challenge in manufacturing today. Plastics processing, therefore, requires constant and sometimes fundamental change.

Moreover, as plastics have replaced many conventional materials, such as metal and wood, in many applications throughout the world, the growth will be accelerated by the tendency to substitute plastics for metal [14].

1.2.1 Plastics vs Metal

When plastics are compared with metals, some of the properties of plastics can be considered either favorable or unfavorable depending upon the application. Plastics are not so strong as metal. However, plastics have certain properties to be considered as advantageous for engineering applications. Plastics have better chemical and moisture resistance. Plastics are more resistant to shock and vibration than metals. Plastics are usually easier to fabricate than metals. Nylon material is self-lubricating and does not require any external lubrication during operation.

Table 1.1 Materials properties comparison.

No.	Property	Plastics	Metals	Paper	Wood
1.	Density	Low	High	Low	Low
2.	Mechanical properties	Better	Good	Poor	Poor
3.	Chemical Properties	Good	Better	Poor	Poor
4.	Water resistance	Good	Corrosive	Absorb	Absorb
5.	Shock and vibration resistance	Good	Better	Poor	Poor
6.	Microbial resistance	Good	Poor	Poor	Poor
7.	Degradation	Difficult	Easy	Easy	Easy

1.2.2 Plastics vs Paper and Paper Board

Paper and paperboard are widely used as food packaging materials and have been used with a number of chemicals such as slimicides, bleaching agents, and inks during the production process. Virgin paper and paperboard products produced by pulping, bleaching, and treatment processes undergo severe chemical treatment and it is impossible to eliminate the chemical residue present [15 –17]. Hence, migration of chemicals from paper packaging to the food is quick resulting in toxicity to humans as being the main concern.

1.3 Plastics Processing

Plastics processing requires the knowledge fundamentals of the raw material, additives, process control, and finally the product properties required to the finished end product. Today, polymer contains a package of ingredients to modify its properties while processing, or at its end product stage to create a new one.

In thermoplastics, processing techniques can be classified into either batch or continuous process. Batch processes include injection molding, thermoforming and rotomolding. Extrusion of plastics is a continuous process. However, blow molding is available both in batch and continuous process. In these days, online continuous thermoforming machines are available along with extrusion process.

As the scientific techniques become available, the plastics processing is quickly incorporating the changes. However, new solutions pose new problems so these continue to be challenges to overcome. Troubleshooting helps to solve the problem at the root and increase the production efficiency during processing.

1.4 Fundamentals

- Based on recyclability, plastics can be divided into thermoplastics and thermosets.
- Knowledge of properties with respect to plastics raw material or its end product is essential to establish the trouble free plastics processing.

References

1. Plastics versus Food Contamination, *Corrosion Technology*, June 1965.
2. Reilly, J.F., Doyle, M., Kazmer, D., An assessment of dynamic feed control in modular tooling, *J. Inject. Mold. Technol.* 5 (1) (2001) 49–59.
3. Takoungsakdakun, T., Pongstabodee, S., 2007. Separation of mixed post-consumer PET–POM–PVC plastic waste using selective flotation. *Separation Purification Technology* 54 (2), 248–252.
4. Burat, F. Güney, A. and Olgaç Kangal, M../ *Waste Management* 29 (2009) 1807–1813.
5. *Macplas International*, March 2009, p. 20.
6. *Plastics and Rubber Weekly*, 28th May 2010, p. 11.
7. *Chemical Week*, 171, No.16, 8th-15th June 2009, p. 22–26.
8. *International Bottler and Packer*, 83, No.5, May 2009, p. 12–13.
9. McKeown, P., (1992), "Implementing quality improvement programmes", Robotics & *Computer Integrated Manufacturing*, Vol. 9 No. 4/5, pp. 311–20.
10. Mark, H. and Whitby, G.S., (eds), *Collected Papers of Wallace Hume Carothers on High Polymeric Substances*, John Wiley & Sons, New York, 1940.

11. P.J. Flory, *Principles of Polymer Chemistry*, Cornell University Press, Ithaca, NY, 1953.
12. H. Staudinger, *From Organic Chemistry to Macromolecules*, John Wiley & Sons, New York, 1970; H. Staudinger, Chem. Ber., 1924, 57, 1203.
13. Throne J.L. *Adv Polym Technol* 1987;7(4):347.
14. Nuñez, A.J., Sturm, P.C., Kenny, J.M., Aranguren, M.I., Marcovich, N.E., Reboredo, M.M. Mechanical characterization of polypropylene-wood flour composites. *J Appl Polym Sci* 2003;88(6):1420–8.
15. Ozaki, A.,Yamaguchi, Y., Fujita, T., Kuroda, K., Endo, G., Chemical analysis and genotoxicological safety assessment of paper and paper-board used for food packaging, *Food and Chemical Toxicology* 42 (2004) 1323–1337.
16. Arvanitoyannis, I.S., Bosnea, L., Migration of substances from food packaging materials to foods, Crit. *Rev. Food Sci. Nutr.* 44 (2004) 63–76.
17. Vitrac, O. Mougharbel, A., Feigenbaum, A., Interfacial mass transport properties which control the migration of packaging constituents into foodstuffs, *J. Food Eng.* 79 (2007) 1048–1064.