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Commentary

3D Printing Technology and Additive Manufacturing of Polymers

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DESCRIPTION

The polymer processing technology has huge progress with in the development of synthesis methodologies, materials properties, and their ultimate applications. It involves in the current development of conventional process methods and their controlling parameters. Each type of polymer process is considered according to the most recent developments.

Similar experiences undergo by a polymeric material that may be common to all processing machinery (single and twin screw extruders, batch mixers, roll mills); and they can be described by a set of elementary steps that prepare for shaping. It involves some of the following unit operations:

- Handling of particulate solids (particle packing, agglomeration, gravitational flow, compaction and others).
- Melting or heat softening; this is the rate determining step in polymer processing and depends on the thermal and physical properties of the polymer (Tg, Tm, degradation temperature, viscosity, and others).
- Pressurization and pumping; moving and transporting the melt to the shaping operation largely depends on the polymer rheological characteristics.
- Mixing for melt homogenization or dispersion of additives.
- De-volatilization and stripping of residual monomers, solvents, contaminants.

The product development has found various routes for manufacturing in previous decades. Additive Manufacturing (AM) represents the adopted techniques for polymer processing. Thermoplastic matrix of polymer has been widely used in FDM platform for different range applications but has not found such wide adoptability in 3D printing due to its chemical nature (complex carbon chain linkage) etc. Several routes for recycling the thermoplastic and thermoset matrix of polymer has been used such as primary (without any modification in material matrix), secondary (adding some reinforcement in material matrix), tertiary (changing the chemical nature of polymer by chemical treatment) and quaternary (incineration) is recycling processes.

There are various methods of Additive Manufacturing (AM) such as Stereo Lithography (SLA), FDM, Digital Light Processing (DLP), direct wire printing, laser jet printing etc., which have been explored for product and functional prototype development of different range of material varying from metallic, non-metallic to thermoplastic matrix.

The most common manufacturing processes used for short fibers are extrusion, injection and compression molding. Forming has been used with short dis-continuous fibers but with only limited success. The precursor materials that are usually used in extrusion and injection molding are pellets containing short fibers that are compounded or pultruded with the polymer. For the compression molding, the precursor material is known as the charge that is used in sheet or bulk form. The sheet material usually consists of discontinuous or continuous fiber that is embedded with thermoplastic matrix or sheets of thermoplastic films in between them. However, the bulk charge is the preferred material for high volume low cost requirements such as automotive applications due to its ease of processing. Bulk charge is usually unsaturated polyester paste containing random fiber strands or short fibers and is known as Sheet Molding Compound (SMC) or Bulk Molding Compound (BMC).

The static 3D printed objects can shift their shapes to various stimuli, which have been coined as 4D Printing. The resulting new polymers have potential applications in 4D printing based on shape of memory effect, which has been widely used to achieve the stimuli-response of shape-changing function. The printed polymers could be thermo mechanically programmed to a temporary shape was firstly deformed into a designed shape at 120°C; subsequently, the fixation of the temporary shape could be achieved by cooling under stress below Tg. By re-heating the structure to 120°C, the deformed polymer chains could recoil, thus leading to the recovery of the original shape. So, it can function as a load-bearing actuator at high-temperature environments.

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CONCLUSION

The physical properties of polymers are tensile strength, melting point, boiling point, hardness, heat conductivity, electrical conductivity, refractive index, elasticity, crystallinity, permeability, etc. In bearing and wear applications, the polymers provide extensive advantages over the metals by allowing them to low power motors of moving parts due to lower frictional properties of polymer when compared to wear components of metals.