# THE THERMOSET DIFFERENCE:

## THERMOSET VS. THERMOPLASTIC

**Thermoplastics vs. Thermosets**

A ***thermoplastic*** is a polymeric material or plastic that becomes soft and formable when heated and rigid when cooled. This process may be repeated a number of times without chemically altering the material.

A ***thermoset*** is a polymeric material that undergoes irreversible chemical changes when it is cured through heat, catalysts, or ultraviolet light: cross-linking prevents movement of molecular chains after curing. Once cured, the structure cannot be altered.

| THERMOPLASTICS | THERMOSETS |
|---|---|
| Pros | Pros |
| High Impact Strength | Easy to process and laminate |
| Attractive Surface Finish | May not need pressure or heat to form |
| Recyclable / Scrap is Reusable | Typically inexpensive |
| No Emissions | Typically stronger than thermoplastics |
| Can bond to other thermoplastics | Better suited to higher temperatures |
| Can be molded or shaped by reheating | |
| Cons | Cons |
| Typically will soften with heat | Often release emissions known as volatile organic compounds (VOCs) |
| More difficult to prototype | Non-recyclable and cannot be reclaimed easil |
| Short workable pot life, with some exceptions | |

| Thermoplastic Materials | | |
|---|---|---|
| Name | Properties | Applications and Uses |
| Acetal | Extremely rigid, high melting point, high strength, good frictional properties, resistance to fatigue | Gears, bearings, bushings, cams, housings, conveyors, plumbing fixtures, gas tank caps, automotive door handles, seat belt components, and zippers |
| Acrylics | Exceptional resistance to long-term exposure to sunlight and weathering, outstanding clarity, good light transmission | Swimming pools, skylights, sinks, washbasins, room dividers, and the tail lights on automobiles |
| Acrylonitrile-Butadiene-Styrene (ABS) | Outstanding impact strength and high mechanical strength, great as a substrate for metalizing | Appliances, automotive parts, pipe, business machines, telephone components, shower heads, door handles, faucet handles, and automotive front grilles |
| Nylon | Known for their stability and adaptability | Automotive parts, electrical and electronic applications, and packaging |

| Thermoplastic Materials | | |
|---|---|---|
| Name | Properties | Applications and Uses |
| Polyamide-Imide | Exceptional mechanical, thermal and chemical resistant properties | Aerospace, heavy equipment, and automotive |
| Polyarylates | Known for its strength, toughness, chemical resistance, and high melting points | Automotive, appliances, electrical and electronic applications, ovenware, and outdoor lighting |
| Polybutylene | Known for high flexibility, resistance to creep, resistance to cracking, and chemical resistance | Pipe and packaging film |
| Polycarbonate | Excellent electrical insulating characteristics, strong, and rigid | Appliances, and electrical and electronic applications |
| Polyethylene | Available in a range of flexibilities and properties, rigid, and moisture resistant | Packaging films, house wares, toys, containers, pipes, drums, gasoline tanks, and coatings |
| Polyketones | Resistant to solvents and has great mechanical properties | Appliances, industrial applications, electrical and electronic applications, automotive applications, bearings, gears, hoses, and tubing |
| Polyphenylene Oxide, Modified | Low moisture absorption levels, good electrical properties over a wide range of humidity and temperature ranges, resistant to most chemicals | Electrical and electronic applications, appliances, automotive parts, business machine parts |
| Polyphenylene Sulfide | Excellent heat resistance, as well as outstanding chemical resistance, high stiffness and good retention of mechanical properties at elevated temperatures | Electrical and electronic applications, and automotive parts |
| Polypropylene | Light-weight material, about 95% air and has very good insulation properties | Packaging and foodservice products, automotive parts, toys, house wares, appliance parts, wall tiles, radio and TV housings, furniture, floats, and luggage |
| Styrene Acrylonitrile | Good chemical resistance, high heat resistance, great clarity, good dimensional stability, and high rigidity | Automobile instrument panels and interior trim and house wares |
| Sulfone Polymers | heat-resistant, can be molded to tight tolerances, exhibit low creep, excellent oxidation resistance, and compressive strength | Electrical and electronic applications and automotive parts |
| Thermoplastic Polyester (Saturated) | Highly crystalline, hard, strong and extremely tough | X-ray film, magnetic tape (audio, video and computer); packaging; metalized film, strapping and labels |

| Thermoset Materials | | |
|---|---|---|
| Name | Properties | Applications and Uses |
| Alkyds | Excellent heat resistance, dimensionally stable under components,excellent dielectric strength | Electrical applications like circuit breaker insulation, switchgear, cases, housings, capacitor and resistor encapsulation, automotive parts, and coatings |
| BMC (Bulk Molding Compound) | Highly rigid, impact resistant, exceptional physical and aesthetic properties, high strength-to-weight ratio | Appliance parts, electric and electrical components, HVAC components, industrial light housings, automotive, recessed lighting baffles |
| Diallyl Phthalate (DAP) | Virtually no post-mold shrinkage, high impact resistance, resistant to sudden and extreme jolts and severe stresses, recommended for very high temperatures, chemical resistant, fungus resistant | Cross-linking agent, thermosetting molding powders, casting resins, and laminates, military, electronic components |
| Epoxy | Virtually no post-mold shrinkage, high impact resistance, resistant to sudden and extreme jolts and severe stresses, recommended for very high temperatures, chemical resistant, fungus resistant | Adhesives, protective coatings in appliances, industrial equipment, aircraft components, pipes, tanks, pressure vessels, tooling jigs, and tooling fixtures |

Thermoset Materials

| Name | Properties | Applications and Uses |
|---|---|---|
| Melamine-Formal-dehyde | Extreme hardness, excellent colorability properties, and arc-resistant non-tracking characteristics. | Rugged dinnerware, household goods, various electrical applications, bonding, adhesives, and coatings |
| Phenolic | Excellent dielectric strength, great mechanical strength and dimensional stability, resistant to high heat, wear resistant, low moisture absorption, can be machined easily | Adhesives, casting resins, laminating resins, electrical and electronic Applications, automotive, appliance handles, frac balls, and knobs |
| Polyimides | Known for thermal stability, good chemical resistance, excellent mechanical properties, exhibit very low creep and high tensile strength, inherently resistant to flame combustion, most carry a UL rating of VTM-0 | Electronics, medical tubing, adhesives, gears, covers, bushings, piston rings, and valve seats |
| SMC (Sheet Molding Compound) | Very high volume production ability, excellent part reproducibility, and it is cost effective. | Electrical applications, corrosion resistant needs, structural components at low cost, automotive, and transit |
| Thermoset Polyester | Low cost, high strength-to-weight ratio, stability, great retention of physical properties at high temperatures | Appliance parts, electric and electrical components, HVAC components, industrial light housings, automotive, recessed lighting baffles |
| Urea-Formaldehyde | Very hard, scratch-resistant material with good chemical resistance, electrical qualities, and heat resistance | Electrical and electronic products, decorative products, laminates, and chemically resistant coatings |

**Thermoset as a Metal Alternative**

Thermoset plastics have been successful in replacing traditional metal materials where they can provide value through improved performance at a lower cost.

Thermoset Performance Benefits:

- Less Weight
- Design flexibility
- Dent resistance
- Corrosion resistance
- Heat resistance

WATER TANK CONVERSION
Significant cost savings were achieved by converting this stainless steel part to plastic. The part is used inside the steamer boxes of fast food steamers for food preparation.

Thermoset plastics are well suited to demanding requirements because they have the capability to withstand heat and pressure for long periods of time without failure, they are impact resistant, and they have exceptional electrical insulating properties. Their dimensional stability, creep resistance, chemical resistance, stiffness, and high temperature capabilities make them the preferred material where reliable performance in adverse conditions is imperative and can be used as a cost-savings alternative for metals.

Phenolic and Polyesters are the two most commonly used materials for metal replacement. The ability to mold these materials into complex shapes makes them cost effective and also eliminates the need to machine features of a design which allows for closer tolerances. Dimensional stability of these materials guarantees that close tolerances can be controlled and repeated continually within ten-thousandths of an inch.