DRAKE

CASE STUDY:

Ultem 1000 Solves Multiple Performance Challenges for Satellite Antennas

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Antennas for satellites placed in space orbit have to perform on several fronts, from minimizing RF interference to having a combination of physical properties that ensures dependable communications for years. Ultem 1000 has proven it measures up to the requirements.

RF TRANSPARENCY FOR SIGNAL INTEGRITY

Communications satellite antennas require materials of construction that do not attenuate or distort radio waves being transmitted and received. Particularly in high-frequency transmission, RF interference can affect signal integrity and potentially cause loss of important data.

Ultem 1000 PEI, a high-performance polymer, has gained wide recognition as a material for injection molded and machined satellite components that helps avoid this problem. Among non-metallic candidates for these applications, Ultem 1000 stands out because of its superior RF transparency. Radio waves that pass through components made from the material maintain exceptional integrity, assuring high quality and efficient communications.

STRENGTH, TOUGHNESS, AND STABILITY AT THERMAL EXTREMES

Communications satellite antennas must function dependably for extended periods in space orbit, where temperatures can swing quickly from cryogenic levels to thermal extremes from direct solar radiation. Ultem 1000 performs well in this environment. The material's glass transition temperature (Tg) or softening point is 218°C, and it maintains high structural strength at temperatures approaching that mark. In addition, where extreme cold embrittles many thermoplastics, Ultem 1000 maintains its toughness and impact resistance to withstand the high vibrational forces satellites experience during vehicle launch, transport and placement in orbit. The material also offers good dimensional stability in spacecraft applications exposed to broad swings in temperatures.

PROPERTY RETENTION AFTER RADIATION EXPOSURE

Long-term exposure to radiation in outer space can degrade both metals and plastics. Ultem 1000, however, has proven it can maintain its mechanical properties in antenna components exposed to gamma, atomic oxygen, and other forms of radiation encountered in space orbit over the life of satellite equipment.

EXCEPTIONAL DIELECTRIC STRENGTH

Dielectric strength defines the voltage that insulating materials can withstand before breaking down. Ultem 1000 PEI's dielectric strength of 830V/mil (as measured by ASTM D149 is the highest among thermoplastics, making it a preferred material for aerospace applications where electrical insulation is a key requirement.

LIGHT WEIGHT

In any equipment that must be transported into space orbit, every gram of weight savings that doesn't impede dependable performance has significant value. Ultem 1000 affords this benefit for satellite antennas. Its properties are well-suited to the application and its environment. It also has a high strength-to-weight ratio without the reinforcements or modifiers required in certain other polymers or thermoset materials to achieve properties approaching those of Ultem 1000.

AEROSPACE INDUSTRY AND UL FLAMMABILITY RATINGS

An added reliability factor, Ultem 1000 meets FAA 25.853 standards for flammability and smoke generation and is used in many military defense and commercial aircraft interior applications. The material also satisfies Underwriters Laboratories' UL 94V-0 and UL94-5VA flame class rating requirements.

PARTS PRODUCTION VERSATILITY ALIGNED WITH DRAKE'S CAPABILITIES

As an amorphous thermoplastic resin, Ultem 1000 can be melt-processed into several forms, all within Drake Plastics' production capabilities. These include injection molded parts, as well as extruded stock shapes, which are then machined into components. Each of these methods for producing parts has advantages that relate to quantity requirements and cost efficiency. Another option involves machining near-net shapes. It often provides a viable transition step between quantities best suited to machining and the higher production volumes typically associated with injection molding.

INJECTION MOLDING

Injection molding Ultem 1000 - and most thermoplastics - is typically chosen for parts whose high unit volumes justify an investment in production tooling. The process utilizes material most efficiently compared to other production methods. Once the machines and tools are set up, high quantities can be produced quickly with consistent quality.

Importance of process control:

Because of the severity of the satellite's environment, it is important that the "data sheet" properties of Ultem 1000 are maintained during injection molding. A capable injection molder will define the ideal melt temperature and pressure profiles for the material prior to processing. Drake Plastics, for example, has developed state-of-the-art process controls that it installs in the molds. The technology monitors and maintains the right melt temperatures and pressures real-time. The investment in this advanced level of process technology minimizes molded-in stresses, prevents material degradation and achieves Ultem 1000's optimum properties for long-term performance in antenna components.

CNC MACHINING FOR PROTOTYPES AND PRODUCTION QUANTITIES

CNC machining affords several advantages depending on quantities required, part complexity, and the stage of development of the application. The manufacturing method involves machining components from Ultem 1000 extruded stock shapes, such as rod, plate, or tube. While there is usually more material loss with machining than with injection molding, Drake specializes in extruding high-performance plastic stock shapes in efficient sizes that minimize the amount of material lost in machining.

Machining Prototypes

For satellite antennas slated for injection molding, machining prototypes from Ultem 1000 stock shapes may be a practical first stage in a product development project. Parts can be machined quickly without a major tooling investment, then tested to validate their performance. If testing dictates the need for design modifications, machining can make the changes quickly.

Finish-Machining Complex Molded Parts

Machining parts from Ultem 1000 stock shapes also works well for relatively low production quantities where an injection molding tool may be cost-prohibitive. It can also reproduce part designs that are too complex for injection molding. In such cases, machining may be the preferred method for production, or it may be used to add design features to parts after they are injection molded.

NEAR NET SHAPES

In cases where machined quantities exceed projected levels but where long-term unit volumes cannot be defined accurately to justify investing in production injection molds, near-net-shapes can be an attractive interim step.

Low-cost injection molds can be made to produce parts to near-net sizes that roughly approximate the configuration of the satellite antenna. The molded blanks are then finish-machined to exact design specifications.

Near-net-shapes afford a combination of low-cost tooling and minimal material loss in finish-machining compared to machining parts fully from stock shapes. The technique can provide an economical option for mid-range production quantities with fast turn-around times until forecasts justify investing in full-production injection molds.

SUMMARY

Ultem 1000 is a lightweight thermoplastic that offers distinct advantages over other engineering materials for communication satellite antenna components. Its superior RF transparency and durable physical properties are key factors that allow the material to withstand the high vibrations and the broad range of extreme temperatures encountered in launch and in space orbit. Additionally, Ultem 1000 affords high structural strength and durability without the need for fillers or fiber reinforcements that can lessen RF transparency. The amorphous thermoplastic can also be machined from stock shapes or injection molded to achieve complex part configurations.

It is also important to note that processing conditions can significantly affect a polymer's data sheet properties. Drake Plastics' investments in process technology help ensure the performance that engineers expect and require when specifying Ultem 1000 and other high-performance polymers for their applications.