Coatings that fall under the “high-performance” category have been around for many years and generally fall into two groups: thermosets and thermoplastics. Ceramics and sol gels are another group of high-performance coating products but are outside of the scope of this article. Products offering the broadest and highest performance usually are from the thermoplastic family of polymers.

Differences Between Thermoset and Thermoplastic Coatings

Thermoset and thermoplastic coatings differ in that thermosets undergo an irreversible chemical and physical change when cured, and cannot be softened or remelted. Thermoplastics, by comparison, soften and eventually melt when heated and solidify on cooling. They can be remelted when sufficient heat is reapplied. Typical thermoset products include epoxies, polyester-epoxies, acrylics, FBEs (fusion-bonded epoxies), and phenolics. Typical thermoplastic products include polyethylene, polyamide (nylon), PTFE (polytetrafluoroethylene), PFA (perfluoroalkoxy copolymer), and PEEK (polyether ether ketone).

When looking at the operating temperatures of coating products, there is a big difference between the continuous use temperature (CUT) of the different products within both the thermoset and thermoplastic coating groups. These products vary in continuous use temperature from <60°C to 260°C (<140 to 500°F). Some of the more exotic, expensive thermoplastic materials have even higher continuous use temperature, but because they are difficult to process compared with the more readily available thermoplastics, they are not discussed in this article.

Temperature Limitations of Thermoset Coatings

Thermoset coatings tend to be used as thin-film decorative products in many applications that do not have high temperature requirements. Some thermosets, such as epoxy coatings, find their way into many industrial applications. While they have good chemical resistance, they can be brittle in nature and are temperature limited. The higher performing fusion-bonded epoxies can operate at higher temperatures, but are still limited with regard to temperature compared with the higher-performing thermoplastic products.

Thermoplastic Coatings Offer High Temperature Resistance

Thermoplastic coating products that fall into the high performance sector (Fig. 1) and have high temperature resistance include PPS (polyphenylene sulfide), PTFE, PFA and PEEK. In the past, when engineers considered options for a high performance thermoplastic coating, the default options in many cases were PTFE and PFA. PPS was used mainly as an adhesion-promoting additive within liquid coating formulations. The high temperature fluoropolymer products have been available for decades with nothing new to challenge their position.

New Designs Demand Higher Operating Temperatures

As engineers develop new product designs for various industries, the trend is to design parts hav-
ing tighter tolerances and reduced weight, and parts that run faster and hotter and perform in more aggressive environments. Automotive, aerospace, oil and gas and high-specification electrical products are typical applications, with a diverse array of other industrial applications falling into this same area.

Service temperatures tend to move steadily higher with each new version of part design, and now, many of the coatings in previous designs are at their temperature limit and will not operate at the higher temperatures demanded by the latest design brief. This is where the choice of the correct high-temperature coating product is crucial if long term reliability and performance is to be realized.

**Alternative to Established High-End Coatings**

More recently, PEEK has been seen as an alternative to the established high-end coatings. It has been used in applications where high temperature performance, combined with chemical and wear resistance, are key engineering requirements. It is this unique combination of properties that sets PEEK apart from the other high performance coating products. No other polymer offers as broad a range of properties.

Most applications for high-performance thermoplastics require one or more of the following properties: continuous high temperature performance; chemical resistance; and wear, abrasion, and erosion resistance. In some instances, radiation resistance is a key requirement. PEEK fulfils all these requirements with the added benefit of low smoke toxicity compared with fluoropolymers and many other thermoplastic materials.

**Choosing a High Performance Coating**

Certain performance criteria have to be met when looking at the options for a high-performance coating. If chemical resistance and/or non-stick performance are the only requirements, then one of the fluoropolymers will no doubt work well. If there is a high temperature requirement as well as chemical resistance, then a high-temperature fluoropolymer such as PFA or PTFE may meet the requirements as long as there is no wear, abrasion or mechanical damage envisioned. A PPS or PEEK product may also be applicable.
chemical or corrosion resistance, the choices become more limited. This is where a PEEK-based coating offers a real value proposition and is, in many cases, the only solution to solve an end user’s problem.

PEEK-Based Coatings Performance

PEEK-based coatings have a high continuous use temperature of 260°C (500°F) and have a $T_g$ (glass transition temperature) of 143 to 157°C (288 to 313°F) depending on the type of PEEK. The chemical resistance of PEEK is second only to fluoropolymers and usually is only affected by concentrated oxidizing acids or halogens such as chlorine, bromine, and fluorine.

PEEK-based coatings have been used in aggressive environments, such as in oil and gas applications, mold tool coatings, replacing silver platings on needle roller bearing cages, industrial rollers, and even coatings on high-end rice cookers and cookware.

Conclusion

PEEK-based coatings were developed to fill the performance gap found in many of today’s existing coating technologies. They are the best solution for demanding applications operating in extreme conditions that require a broad combination of properties. This unique combination of properties can help processors and end users reach new levels of cost savings, performance and product differentiation.

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Fig. 5 — PEEK coatings are used in various high temperature applications such as this oven rack and rice cooker.