

Best polymer selection for quality upgrades

At TCE we design, manufacture, and repair parts made of several different materials. We continually are involved with upgrading compressors and pumps with polymer seals. What we know about these materials, as they pertain to how we use them in rotating equipment, has improved over the years. In this issue of *Bearing Journal*, we will discuss the properties of Fluorosint®, Torlon®, and PEEK based products, as they relate to their use as seal materials in rotating equipment.

Introduction

Most plastics belong to one of two groups: thermoplastics or thermosetting plastics. Thermoplastics soften when heated and harden when cooled; they are melted and frozen into their desired shape during processing and can be remolded. Most thermosets harden when heated and change chemically during processing so they will never melt again. The materials we will cover here are all thermoplastics.

“Thermoplastic use in rotating equipment can increase efficiency and reliability”

When evaluating thermoplastics it is helpful to compare their thermal properties:

Tg: Glass Transition Temperature is the temperature at which the polymer chains of a thermoplastic become active

and the polymer begins to soften and become "rubbery".

Tm: Melt Temperature is the temperature the polymer begins to "melt".

HDT: Heat Distortion Temperature is the temperature the materials flexural modulus drops to 100,000 psi.

CUT: Continuous Use Temperature relates to "thermal aging" of polymers. The CUT is the temperature a polymer can be exposed to for 100,000 hours (11.4 years) and maintain 50% of its mechanical properties.

Subcategories under thermoplastics are amorphous (Torlon®) and crystalline (PEEK and Fluorosint®). Crystalline thermoplastics have a crystalline order structure below their Tg and become amorphous above their Tg. They can be used above their Tg with reinforcement, usually in the form of mica in Fluorosint® and carbon fibers in PEEK. Their Tg is usually well below their Tm.

Amorphous thermoplastics have no crystalline structure; their Tg is close to their Tm and they are not usually used above their Tg. They do not require reinforcement.

The Materials

Fluorosint® is considered an advanced engineering plastic. It is a crystalline high performance polymer with superior chemical resistance. Fluorosint® is Teflon® (PTFE, or polytetrafluoroethylene) filled with synthetic mica. This

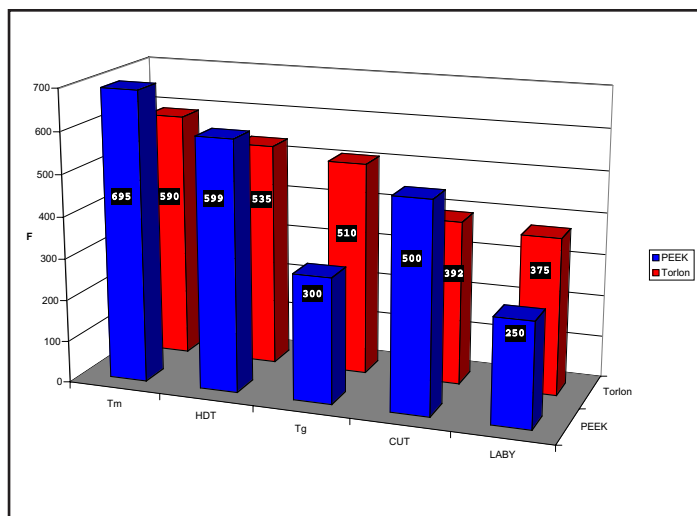


FIGURE 1

material, being Teflon® based, lacks strength (750 to 1200 psi tensile strength), and needs to be carefully evaluated for each application. The best application of Fluorosint® is smooth bore segments secured in a metal holder, which is rolled as an assembly into the compressor. Here, rotating laby teeth can cut into this very abradable material. It is an excellent choice when the seal teeth are machined onto the rotating element. Because of its low strength and the availability of superior materials, it is rarely recommended for use when the teeth are machined into the stationary part.

PEEK (polyetheretherketone), as used by TCE, is either filled with 30% carbon fibers (referred to as 1030) or 15% carbon fibers, 10% graphite powder and 2% PTFE (referred to as 1331). The carbon fibers are added for strength while the graphite and PTFE are added for lubricity. The 1030 material is usually used for pump wear rings, while the 1331 is usually used for compressor labyrinths. Due to the heat caused by the shearing of carbon fibers while machining, the 1030 is more difficult to machine. PEEK is highly resistant to chemical attack but will be attacked by concentrated, strong acids at high temperature. PEEK is sensitive to chromic, hydrofluoric, nitric, and sulfuric acids. It is unaffected by acetic acid, amines and hydrocarbons.

Another use of PEEK in pumps is when it is combined with continuous carbon fibers. Here a carbon fiber ribbon is impregnated with PEEK, which acts as a binder. The ratio is about 70% carbon fiber, 30% PEEK. This is wound, under tension and heat, around a mandrel. This material is very strong in the direction of the fibers and has a low coefficient of thermal expansion (CLTE) in this direction. It is non-galling/non-seizing, has good impact resistance, good chemical resistance, and can be used at high temperatures.

Torlon® (PAI or polyamide-imide) is referred to as an imidized material, which is used in extreme service environments. Its properties usually classify this material as an amorphous

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Thermoplastics

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thermoplastic. The grade used by TCE is filled with 12% graphite powder and 5% PTFE, both added for lubricity. Note that no fillers are required for strength, making this material easier to machine than the PEEK products. Torlon® is hygroscopic, which means it can absorb moisture (to 5% by weight and 2% by volume). Proper design, machining, storage, and installation prohibit this moisture absorption potential from being a problem.

Torlon® is less resistant to chemical attack than PEEK. It is sensitive to amines, ammonia, oxidizing acids, and strong bases. It is unaffected by aliphatic, aromatic and halogenated hydrocarbons.

Which material to use

For smooth bore polymer seals in centrifugal compressors, Fluorosint® is often the material of choice. We rarely recommend Teflon®-based products (such as Fluorosint®) where the teeth are machined into the plastic.

The bar graph (Fig. 1) shows the thermal properties of PEEK and Torlon®. The "Laby" column represents TCE's current maximum use temperature for that material. The points to notice here are the Tg and CUT, which actually drive the maximum use temperature. The Tg for Torlon® is 510° F and for PEEK it is 300° F. The CUT for Torlon® is 392° F and for PEEK it is 500° F. The fillers have no effect on the Tg of the material.

The material of choice for centrifugal compressor labyrinths is Torlon®, assuming it will not be subjected to chemical attack and the temperature is low enough (usually below 350° F). If Torlon® is susceptible to chemical attack, then PEEK can be used provided the temperature is low enough (below 250° F).

In pumps, PEEK and continuous carbon fiber materials (wound) are used. The high CLTE of PEEK and the low CLTE of the wound material dictate where they are used. If running above ambient temperature, PEEK (1030) is used up to 250° F as the case wear ring. Between 250° F and 600° F the wound material is used as the impeller wear ring. Below ambient temperature, PEEK is used as the impeller wear ring.

Conclusion

Thermoplastic use in rotating equipment can increase efficiency and reliability. Understanding their properties is critical to successful applications.

Note: Torlon® is a registered trademark of BP Amoco; Fluorosint® is a registered trademark of DSM EPP; Teflon® is a registered trademark of DuPont

Recent engineered upgrades

- Kaydon Seal upgrades of complete Mechanical Seal Cartridges for 2 Hydrogen Recycle Compressors in a refinery, along with 4 spare seals and 4 repair kits.
- Ball and Socket Design Tilting Pad Journal Bearing Upgrades for 4 Compressors in a Chemical plant.
- 10" & 12" ball and socket tilting pad journal bearing upgrade on a 220 MW unit, based on TCE's Rotor Dynamic Analysis Study-successful recent start-up.
- Torlon seal conversions for 3 Air Compressors at an Ammonia Plant, on an expedited basis.

Ulrich joins TCE sales team

Turbo Components & Engineering would like to introduce the newest member of the TCE team, Ernest Ulrich. Ernest has joined TCE bringing a background of 20 years of technical sales experience in the oil and chemical industries. Ernest was most recently involved in sales with rotating equipment, marketing dry gas seals used in centrifugal and screw compressors for Flowserve (formerly Durametallik Seal Division). Over the years, he has had detailed experience working with end users as well as OEMs.



Ernest Ulrich

Ernest is a graduate mechanical engineer from the University of Houston. We feel Ernest and his technical skills will be a very positive asset to our sales team. Please help us welcome Ernest to TCE.

Polymer seals improve compressor performance

Our feature paper this quarter is "An Ethylene Plant Benefits from Polymer Labyrinth Seals." TCE's John Whalen and Nova Chemicals' Dwen Miller authored the paper, originally published in *Turbomachinery* magazine last year. The paper has a brief overview of polymer seals, discusses efficiency gains, reliability, installation, and follows with a case history. The case history discusses Nova Chemicals upgrade of three compressors at one of its ethylene plants in Canada. They improved two compressors in a cracked gas train and one in propylene service in 1996. Since that installation, Nova has installed polymer seals in three other cracked gas machines and one ethylene machine. Nova decided to install polymer seals to make their compressors more efficient, more reliable, and reduce seal installation times.

How can polymer seals do this? Give us a call or send us an e-mail and we will send you a copy of this paper to find out.

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