QUADRANT

SOLVAY SPECIALTY POLYMERS
More Products with More Performance™

Technical Article Lenzburg, Switzerland

TURNING UP THE HEAT

Extending the limits of engineering plastics for development-oriented markets

Demand for higher-level product performance combined with the drive for greater efficiency and a more environmentally-friendly approach, is creating new challenges for product developers in their material choice.

Add to this the growing multitude of legislative guidelines, and weight savings, emission reductions and more efficient resource use have become essential elements in the decision-making process.

Plastics have consequently captured selected areas previously reserved for metals or other high performance traditional materials with benefits such as lower weight, insulation properties and moldability, well established within the community of design engineers.

However, to further extend the potential for plastics in demanding applications, continuous research in polymer chemistry to advance properties is required to fill both the end-user knowledge gaps and performance gaps that exist. For example, to take plastics into aggressive environments of extreme thermal and mechanical load; or into the development-oriented markets of food production, medical/life science, chemical processing, energy/renewable energy, and the semiconductor industry, where cutting-edge is of the essence.

Temperature resistance and friction & wear resistance are critical requirements for these applications and markets. It is here that advances in high performance polymer materials, so called Engineering Plastics, are essential for the development of solutions that address all the challenges out there.

Solvay Specialty Polymers is the global leader in high performance plastics. It works in partnership with Quadrant EEP, a world leader in plastic material solutions for engineers and designers, to evolve its innovative resin materials into manufactured engineering plastics that understand and answer the needs of development-oriented markets.

“Achieving reliable performance of high performance plastics, especially if they need to perform under extreme conditions is challenging,” says Dr. Wolfgang Funke, Sales Development Manager at Solvay Specialty Polymers.

“To yield the enormous blend of properties of resins in semi-finished parts requires deep understanding of the material by the manufacturer as well as a high level of developmental effort. That is why we are very specific in our choice of Quadrant as a partner capable of bringing out the best from our products.”

“Pushing the limits of engineering plastics is a cornerstone of our business model,” comments Mr Paul Simmons, Business Development Manager Europe,Quadrant EPP. “Superior in performance to metals and other materials, our specialty engineering thermoplastics and composites can support design engineers in finding the best solution in existing choices. Through collaborative developments we can take this a step further to take the capabilities of semi-finished plastics and conversion processes to new performance levels.”

Mr Simmons and Dr Funke examine the current focus areas for progress in engineering plastics – temperature resistance, and friction & wear resistance – highlighting some of the challenges facing designers and the manufacturing community, and potential solutions.

Temperature Resistance

Extreme environments regularly equate to extremely high temperatures. With an increasing emphasis on information technology in daily life, higher speed robot-based manufacturing or best-yet performance on the race track, society is asking more and more of its appliances and machinery without looking to compromise safety.

High temperature resistance of plastics is therefore critical to their use and acceptance in these environments.

Temperature resistance has become the most important criteria to categorize polymers and in many cases correlates with price. Different failure mechanism defining the temperature resistance like oxidation, degradation of the polymer chain and decrease of mechanical properties above glass transition Tg or melting temperature Tm, have led to different strategies to boost the temperature resistance of polymers.

The family of imidized polymers (IP) including polyimide (PI), polyamideimide (PAI), polybenzimidazole (PBI) and polyetherimide (PEI) chemically, all contain at least one imide (or imidazole) linkage per repeat unit which is formed via a heterocyclic ring closure reaction imparting extreme additional thermal and mechanical strength of the material.

Solvay Specialty Polymers' Torlon® PAI resins Polyamide-imides take advantage of both properties of polyamides and polyimides to create synergies of elasticity, elongation, toughness, melt processability and various other characteristics. The resins can be processed in a variety of manners from extruded, compression- or injection molded parts to coatings, films, fibers and adhesives.

Like most amorphous polymers, the mechanical properties are relatively constant up to the glass transition temperature (Tg), which for polyamide imides is 275℃. High level performance is achieved through the aromatic backbone with the imide linkage raising the glass transition up to 275℃ after curing. The amide in combination with the ether linkage provides processability, ductility and stiffness.

Up to 275℃ PAI resins belong to the thermoplastics with the highest strength and stiffness available on the market. Glass-fiber and carbon-fiber-filled grades retain their strength and stiffness at high temperature with the added benefit of low creep and excellent fatigue resistance.

PAIs have excellent chemical resistance toward hydrocarbons, oxygenated organics (ethers, esters, alcohols, etc.), sour gases and oils, but limited resistance to strong bases, amines and certain high temperature acidic environments.

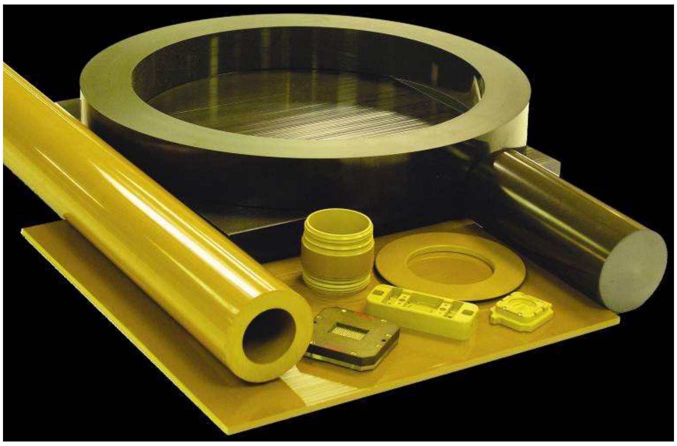

Photo caption 1: Duratron® PAI semi-finished and finished parts.

Quadrant offers the widest variety of PAI based semi-finished products to the design community, through its Duratron® PAI product range.

The material enables the development of semi-finished parts with metal-like performance, suited to use in repetitive-use, load-bearing operations.

Typical demanding applications include high temperature electrical connectors and switches, valve seats, chemical seals, oil drilling equipment, bushings, race car engine components and semiconductor parts such as chip nests and sockets. Graphite, carbon fibers and/or PTFE can be added to make PAI an excellent candidate for high wear applications such as bearings, thrust washers, large labyrinth seals, rotary compressor vanes, valves and seats, wear pads and even piston rings. The OI is 45 making this a solid UL-94 V-0.

Parts are formed by injection molding, extrusion and compression molding. PAI is unusual, however, in that injection molded and extruded parts should be post cured following a recommended cycle to maximize the chemical resistance and wear performance of the parts.

Friction & Wear Resistance

Excessive wear and friction are obvious consequences of the physically-demanding conditions to which moving parts in high-performance environments are subjected, such as yaw bearings in windmills, guiders in bottling lines, or rollers in the manufacturing of Photovoltaic Cells; to name just a few.

In the long history and experience of solving friction and wear application-related customer problems, a series of internal lubricants and additives are typically added to the base engineering plastic resin. For example, PTFE, Graphite, MoS_2, BN, TiO_2, and ZnS. Sometimes they are used in combination with different types of fibers, such as PAN- and Pitch- based carbon fibers, Aramide fibers or polymer blends.

The material choice of a PAI resin for friction and wear-critical applications is highly dependent on the overall characteristics specified by the design engineer.

For example, Solvay Specialty Polymers R&D staff have developed Torlon® PAI resins which are specifically designed for use under high compressive load. Other formulations focus on high speed applications under dry and lubricated conditions.

In addition to high compressive strength, modulus and excellent creep resistance, self lubricity and low coefficients of thermal expansions can make PAI resins prime candidates for wear surfaces in severe conditions. This includes systems where polymer components with low friction at low wear characteristics are required, but even more in surroundings in which low wear is demanded at high friction. This is possible due to the high softening temperature, and retention of strength and stiffness at elevated temperatures.

Wear-resistant grades of PAI resins deliver a combination of mechanical and tribological properties, which combined with inherent heat and chemical resistance, makes them an effective alternative to metal in high-temperature friction and wear applications—even when lubrication is marginal or non-existent. Selected grades can perform in lubricated environments at exceptionally high pressures and velocities (PV). The inherent lubricity is enhanced with additives in wear resistant grades.

Quadrant offers a broad portfolio of material compositions tailor-made for friction and wear applications. They are particularly chosen and composed for specific applications, for example operating with little or no lubrication (food and pharmaceutical sectors), with limited or no maintenance access (off shore, renewable energy), or with specific combined properties (chemical and corrosion resistance, electrical insulating ability, physiological inertness next to good bearing and wear performance) offering distinct economical advantages.

For example, Techtron® HPV PPS offers a special combination of characteristics, such as wear resistance, load-bearing capabilities and dimensional stability, which makes it particularly suitable for diverse industrial equipment applications including industrial drying and food processing ovens, chemical process equipment (pump-, valve & compressor components), and electrical insulating systems and sliding parts. Or Ketron® CA30 PEEK carbon fiber reinforced grade, which combines high stiffness, mechanical strength and creep resistance.

Compared to unreinforced PEEK, the carbon fibers considerably reduce thermal expansion and provide 3.5 times higher thermal conductivity. This dissipates heat from the bearing surface faster, improving bearing life and pressure-velocity capabilities.

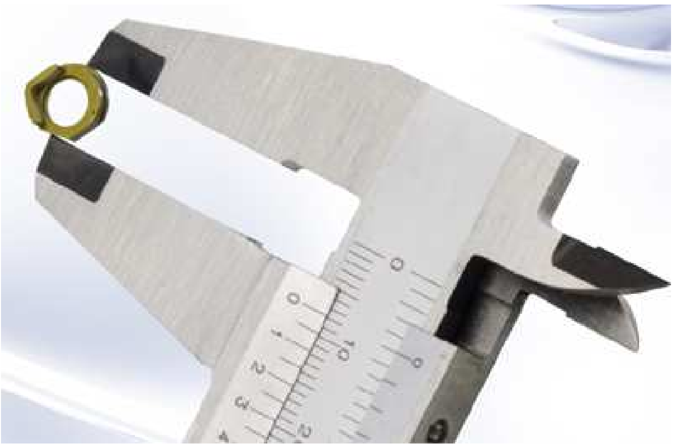

Photo caption 2: Duratron® PAI frame for a scanning piezo element in an edoscope

Duratron® T4301 PAI offers excellent dimensional stability over a wide temperature range. This extruded Duratron® PAI grade excels in severe wear applications such as non-lubricated bearings, seals, bearing cages and reciprocating compressor parts.

More to come?

As we see here, engineering plastics have a lot to offer the highly-demanding environments of development-oriented markets.

Continued collaboration between the plastics and the manufacturing community, and technological innovation are essential to progress such cutting-edge, alternative material solutions that respond to the environmental, end-product performance and manufacturing efficiency needs of plastics processors and product developers.

Engineering plastics are rising to the challenge.

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Photo caption 3: Torlon® Finished Parts - Check Balls

Photo caption 4: Torlon® Finished Parts - Seal Rings

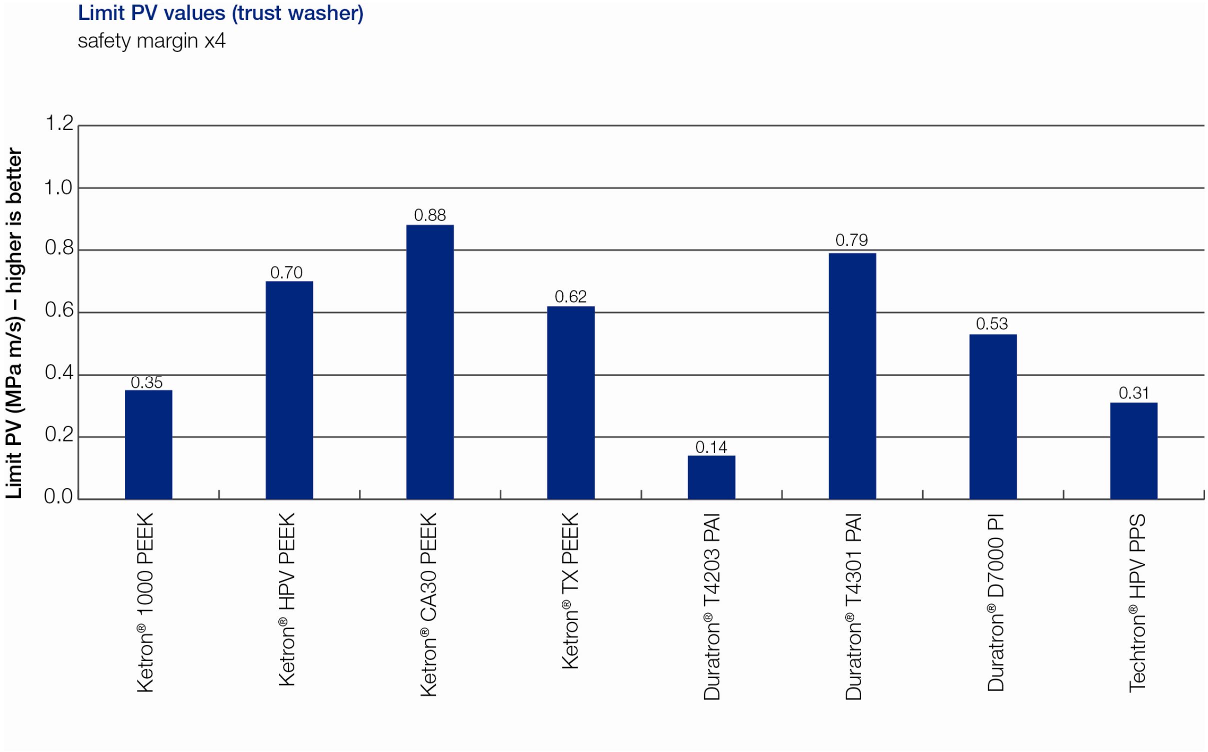

Photo caption 5: Quadrant High Performance Plastics – Limiting PV Test Values

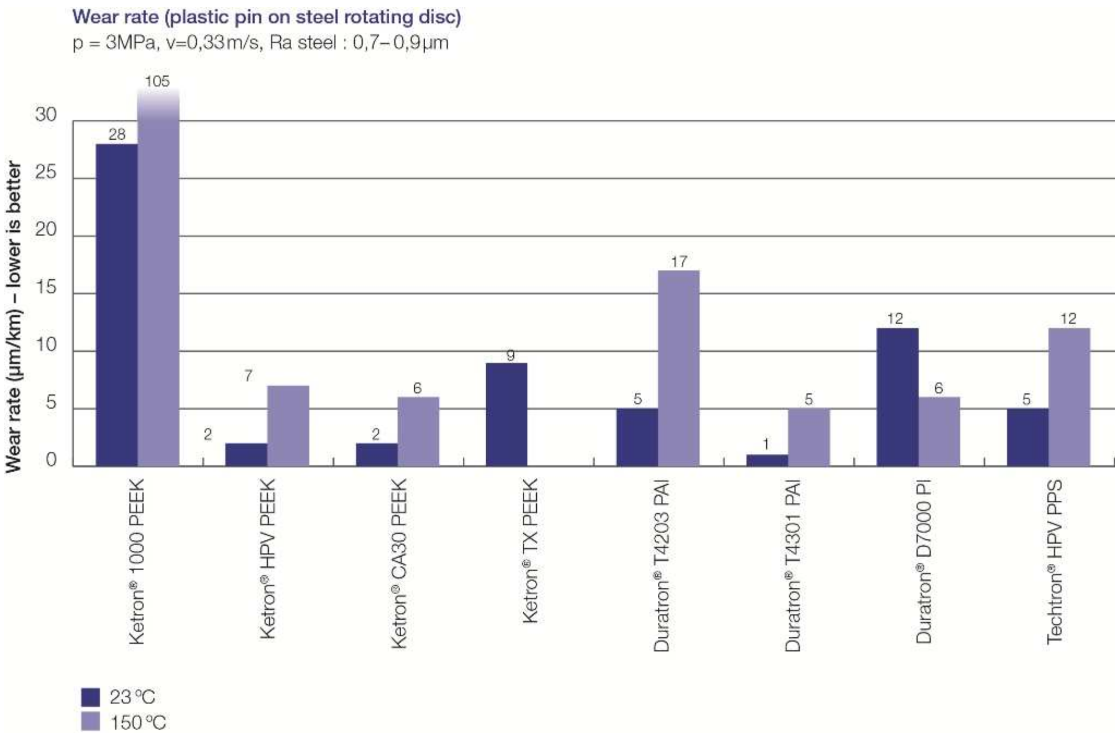

Photo caption 6: Quadrant High Performance Plastics- Wear Resistance Rates

Photo caption 7: Torlon® Finished Parts – Thrust Washers

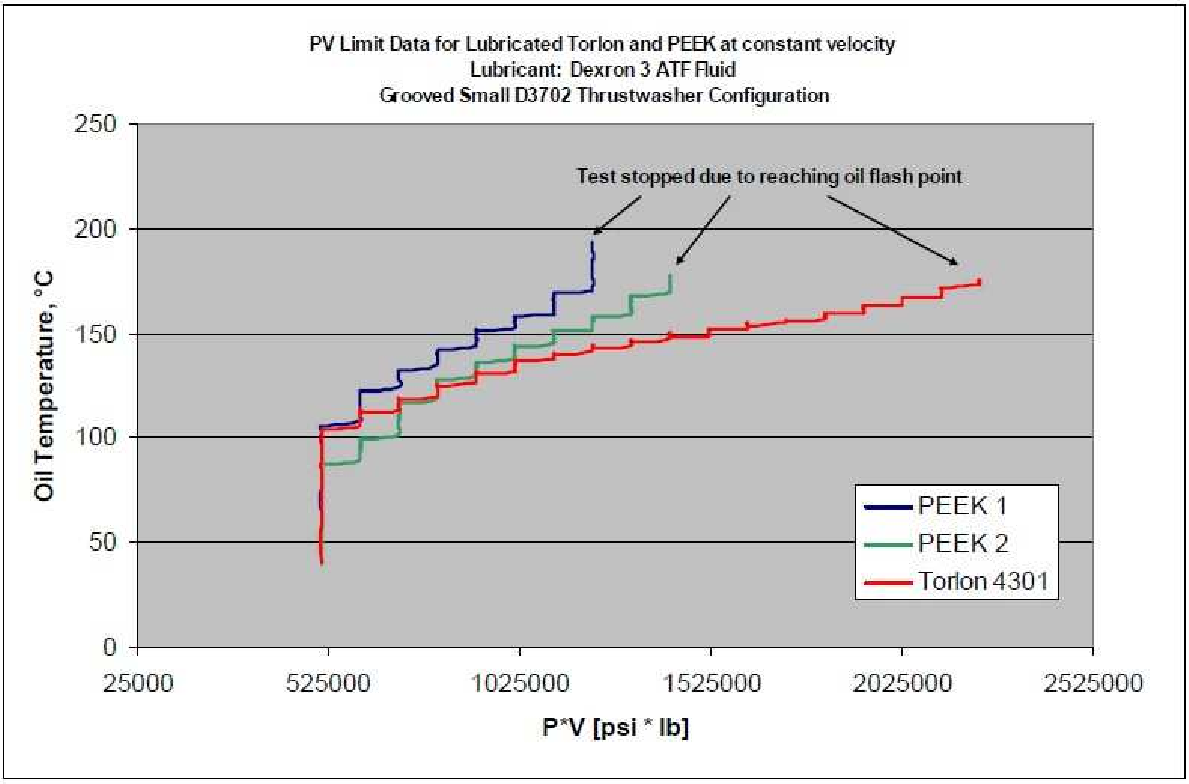

Photo caption 8: PV Limit Data for Lubricated Torlon and PEEK at constant velocity