



Thermoplastic elastomers

IMAGE: SHUTTERSTOCK / PETE SALOUTOS

The phenomenal growth in the importance of sports shoes to the global footwear market over the past forty years cannot be over estimated. It has not only changed the type of shoes a large proportion of consumers choose to buy for everyday wear but has also propelled an increasing sophistication of sports shoes in general and running shoes in particular. While some say that many of the claims made by sports brands in the past have contained more marketing hype than actual performance enhancement, there can be no doubt that some of the soling materials that have been developed over that time have had a real and lasting impact.

One that particularly stands out is EVA (ethylene vinyl acetate) which for many years has dominated the market for sports shoe midsoles. It is lightweight, absorbs impact shocks well and is competitive as regards cost. It has however started to come under pressure from newer and more complex materials such as PU (polyurethane) and TPU (thermoplastic polyurethane) which offer better performance and longer effective life. A further polymer which, while less well known, is also gaining wider usage in sports shoes is TPE or, to give it its full name, thermoplastic elastomer.

Thermoplastic elastomers are block copolymers which are made up of a combination of rigid polyamide blocks and soft polyether blocks. Manipulating these blocks and the ratio in which they are combined allows a wide range of materials to be created spanning the flexibility spectrum from very hard and rigid to very soft and flexible. The greater the proportion of polyether, the lighter and softer the material produced. This is also achieved without any need for additional plasticisers as is the case with many other similar materials. Furthermore, they offer a highly desirable combination of the toughness traditionally associated with polyamides and the flexibility and elasticity more often seen in polyethers and polyesters.

KEY PROPERTIES

A leading producer of TPEs for footwear, and sports shoes in particular, is the French company Arkema with its Pebax range of materials. In fact, the trade name Pebax is actually derived from the chemistry involved to produce it, PolyEther Block Amide. A look at the physical properties of Pebax elastomers demonstrates just how the performance levels of modern footwear polymers continue to advance. These

resins are extremely light and usually more than 20% lighter than competitive polymers such as TPU or a TPC (COPE) as can be clearly seen in *Figure 1*.

They also offer extremely efficient energy return during repeated cycles of flexing. This very low hysteresis level (lag in response of a material in reacting to changes in the forces affecting it) means that a high percentage of the energy put into flexing the polymer by the impact of an athlete's foot when running is returned during rebound. Comparatively, they also offer a much lower energy loss factor (ELF) than materials like TPU (*Figure 2*).

Comparisons aside, TPU in general is nevertheless an excellent elastomer that provides good performance but Arkema says that its Pebax elastomers have a higher level of energy return because of two contributing factors. The rigid polyamide (PA11 or PA12) block in the polymer backbone inherently has low hysteresis, so this content in the block copolymer really improves energy return. The second factor is in the nature of the layering effect of soft polyether blocks with rigid polyamide blocks. This creates a natural spring effect within the polymer make up that gives the resin an extra kick.

Because of the low glass transition temperature (the temperature region where the polymer transitions from a hard glassy material to a soft rubbery one) of its polyether phase, the energy loss factor of Pebax resin remains low even in sub-zero environmental conditions. This allows the material to maintain its flexibility and display almost no increase of its elastic modulus compared to other materials that can experience cold stiffening and even become brittle, making them susceptible to cracking (*Figure 3*). Furthermore, it also has extremely high cold impact resistance so it is ideal for use in footwear aimed at winter sports. In fact, one of the earliest footwear applications for TPE was for ski boots where it continues to be widely used today.

Pebax is also easy to process and standard injection moulding equipment can be used with either steel or aluminium moulds. Overmoulding is also possible and offers a wide range of combination possibilities including other grades of Pebax, TPU (preferably ether type), PVC, leather and coated parts. The overmoulding technique is widely used to manufacture soles of athletic footwear such football and soccer cleats. The adhesion of the elastomer onto inserts can be optimised by adjusting the process parameters.

SPORTS SHOE APPLICATIONS

These polymers are increasingly to be found in a variety of footwear applications. For running shoes, they are primarily used in midsole components including torsion bars, plates and other components such as heel counters. For extra rigidity and spring-back, Arkema also has glass and carbon fibre filled grades that produce very stiff components and plates for the most demanding of applications. Besides running shoes, many track and field spikes are made with Pebax polymer plates as, for example, Puma's Bolt evoSPEED track spike, due to its extreme lightness and high energy return.

Other cleated applications such as football, soccer and baseball boots also utilise the material for the outsole as well as some midsole components. For these sports it is very

Figure 1 - Comparative densities

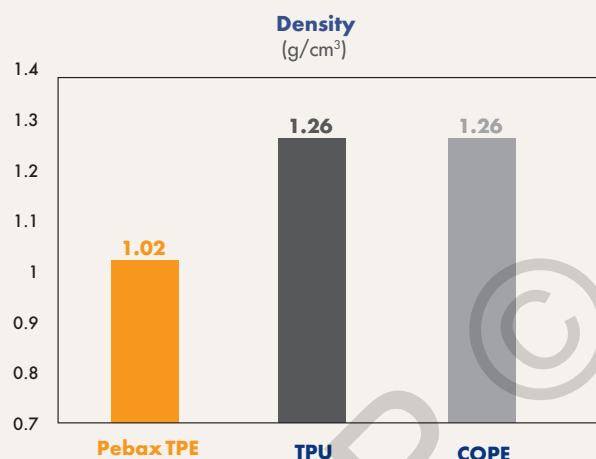


Figure 2 - Comparative energy loss

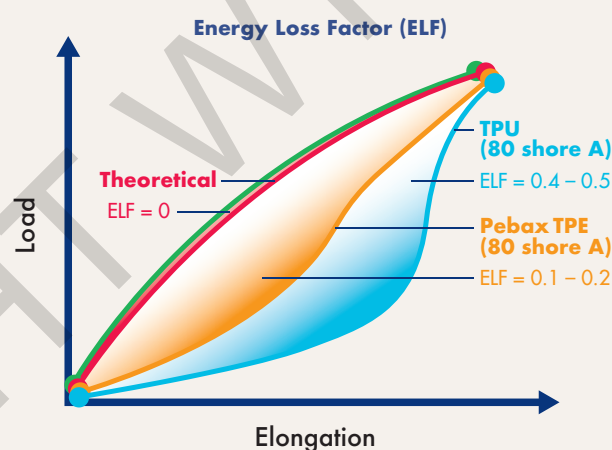
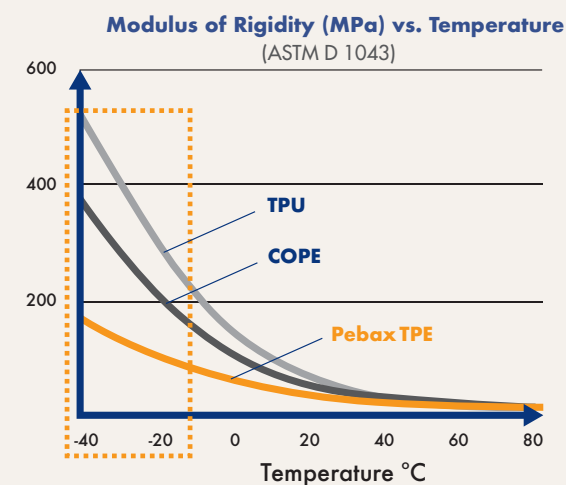


Figure 3 - Comparative rigidity



common to see glass and carbon fibre filled grades used to add rigidity. For cleated footwear especially, the Ross Flex test is an important indicator for long-lasting, high performance cleats. Pebax grades can endure more than 50,000 cycles, even at cold temperatures (-40°C) and up to a 90° bend angle without breaking which Arkema says is far better than even the best TPU grades can achieve. 🚫

NOTE: Pebax is a registered trademark of Arkema France.