



PU/PU direct moulding on sports shoes. CREDIT: STEVE LEE

POLYURETHANE AND THE SOLING MARKET

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Every shoe needs a sole of one kind or another and, as more are produced and bought, so the demand for soling materials also grows. This has been an inexorable trend, except for minor variations, for the past 30 years. The two factors driving this are demographics and an increase in disposable incomes. Despite all efforts to reduce it, the world's population is steadily growing. Between 2000 and 2007 it grew from 6.136 to 6.621 billion and is estimated to hit 7.130 billion by 2015 and keep on rising.

The world is also generally becoming richer and, despite current difficulties, enjoying an increase in disposable income. This is especially true for China and India which both have huge populations for whom footwear is suddenly changing from a necessity to a lifestyle statement, thus swelling overall consumption. Global footwear sales rose from \$29.742 billion to \$45.554 billion from 2000 to 2007 and are likely to reach 60.195 billion by 2015. In terms of pairs produced, the figures for the same two periods are 16.420,

18.950 (with a slight blip in 2007) and 22.660 billion.

This growth in production is naturally reflected in the output of soling materials across the world. Here the figures show 7.934 Ktonnes in 2000, 9.192 Ktonnes in 2007 (with a slow down from 2005 through 2007) followed by strong growth to 10.955 Ktonnes in 2015. The question is which soling materials will be needed to satisfy this growing demand?

SOLING MATERIAL

The answer lies in a further question: why do shoemakers use the different soling materials available to them? Soling materials fall into five basic groups: Thermoplastics, Sheet Materials, Vulcanised Preforms, Skins and Liquid 2-Component. Split this way, the overall soling materials market for 2007 outputs, as can be seen in the table at the beginning of the next page.

WORLD SOLING MATERIALS 2007 (Ktonnes)

Group	Products	Volume	%
Thermoplastics	PVC, TPR, TPU, EVA, POE	4.160	45.3
Sheets	EVA, VR, RR	1.850	20.1
Preforms	VR, NR, LR	2.100	22.8
Skins	L	0.562	6.1
Liquids	PU	0.520	5.7
Total		9,192	100.0

Key in order of introduction: L (leather), NR (natural rubber), VR (vulcanised rubber), RR (resin rubber), PVC (polyvinyl chloride), PU (polyurethane), TPR (thermoplastic rubber), TPU (thermoplastic polyurethane), EVA (ethylene vinyl acetate), LR (latex rubber), POE (polyolefin elastomer).

KEY FEATURES OF SOLING MATERIALS

Leather (L) – expensive natural material with a quality image but poor wear performance. Many consumers still believe most shoes have leather soles.

Natural rubber (NR) – natural material based on latex from Hevea rubber trees that is normally sold in sheet form as ‘Plantation Crepe’. It has poor properties as supplied with minimal resistance to solvents and oils but is used at low levels in conjunction with SBR (styrene butadiene rubber) to make VR and at high levels to produce LR. It has a soft tactility and distinctive smell which together form the basis of a ‘Natural’ concept for all rubber compounds.

Vulcanised rubber (VR) – tough, hardwearing and with a natural image even though mainly synthetic. Supplied as partially vulcanised blanks or strips it requires a high temperature process to complete the final vulcanisation step.

Resin rubber (RR) – variant of VR with a high hardness and stiff feel due to high loadings of fillers. Sold in sheets, it is used to make pre-finished soles for women’s court and thin-soled casuals.

Polyvinyl chloride (PVC) – despite a poor image it has a dominant share in some markets due to its low price. While it is also easy to process, its properties drop off rapidly as density is reduced.

Polyurethane (PU) – offers the broadest range of end effects but is seen as difficult to use. It offers the widest range of densities and hardnesses of all soling materials and is a tough and high performer only surpassed by TPU. It needs special machinery to process it and waste is not recyclable.

Thermoplastic rubber (TPR) – excellent tactility but can be problematical with regard to solvent/oil resistance and bonding. Low density products are so far not very successful due to their poor properties. It is nevertheless associated with

natural products due to the inclusion of ‘rubber’ in the name—the only thermoplastic to have such an image.

Thermoplastic polyurethane (TPU) – high performance material mainly used for downhill ski boot shells, soccer boot plates and top-pieces for women’s court shoes. It is now penetrating the outsole market and has been successfully blown to 0.6 g/ml whilst retaining good properties.

Ethylene vinyl acetate (EVA) – has a strong image of being the ultimate in lightness due to its use as a midsole for sports shoes. However, it has poor compression properties and a boardy feel that together with poor slip resistance in the wet puts it at a disadvantage as an outsole material. There is a high level of waste when thermoformed, whilst complex machinery and moulds are needed for the injection process.

Latex rubber (LR) – key feature is softness and high tactility. Developed as a vulcanised rubber alternative to TPR, there can be problems with foot stability at low hardness plus poor tear strengths and low resistance to solvents in adhesives and finishes.

Polyolefin elastomer (POE) – elastomeric polyethylene produced by metallocene catalysis to co-polymerise ethylene and other monomers such as octene. It has a naturally low density in the solid of 0.85 g/ml and can be foamed to very low densities. While there can be problems bonding unit soles to uppers, it is being used for direct moulding and as an addition to improve the performance of EVA midsoles.



PU sole units moulded in China. CREDIT: STEVE LEE

WORLD POLYURETHANE SOLING DEMAND (Ktonnes)

2001	2003	2005	2007	2009	2011	2013	2015
456	512	544	520	526	582	632	676

The real winners over the past 30 years have been the thermoplastics as they can be moulded on conventional injection machinery. The other big advantage is that, unlike thermoset materials such as vulcanised rubbers and polyurethane, all scrap can be recycled. The actual choice available to the industry, however, is in fact much greater than this primary list might suggest as these materials are also often compounded together. TPR's normally contain EVA and EVA can be mixed with POE, whilst TPU and PVC are also frequently blended. It is also increasingly common for several materials to be used to build up a complex sole such as VR/PU, VR/EVA, TPU/PU, TPR/TPR, where the combinations refer to outsole/midsole, with the latter having a lower density. The latest trend is towards blowing thermoplastics so that TPR/TPR, TPU/TPU and PVC/PVC combinations can be produced with the midsole having a low-density form.

WHAT POSITION DOES POLYURETHANE OCCUPY?

We have already seen that polyurethane is different to all the other materials in that, because of its two component liquid nature, it requires dedicated moulds and machinery. Indeed, during processing the sole mould acts as a 'reactor' where the final polyurethane is formed. In the case of thermoplastic and vulcanised materials it is only used to create the final shape, whilst in the case of sheet and skin materials, the soles are die-cut to shape. This means that switching between polyurethane and other soling materials has large technical and cost implications. For instance, if a factory is using polyurethane for direct moulding to the uppers then it is usual for that to be the only material in use. For unit sole moulders it is not so clear cut and many companies employ a variety of moulding machines in order to be able to produce sole units in all types of material.

A more important consideration, however, is that if a factory is buying unit soles then, within reason, the switching costs between different materials are minimal. A casual shoe manufacturer could for example almost certainly find nearly identical looking unit soles moulded in polyurethane, thermoplastic rubber, EVA, PVC and vulcanised rubber that he could use. The only constraint would be the aesthetic appearance delivered by the different materials and possibly the need to vary the type of adhesive used to bond the sole to the upper. Technical experts tend to forget that a black sole is a black sole whatever material it is made from and that it will perform satisfactorily as long as it meets the minimum property requirements for a particular application, so a shoe maker will usually go for the most cost effective option.

The best option will also shift as the prices of raw materials go into the different soling materials often

change at different times as at present, when there are very large and volatile swings in the price of oil. It should not be forgotten that the dominance of oil as a basic starting block for chemicals is being increasingly challenged by coal-based alternatives as its price increases. It is especially true in China, which has a large and expanding chemical industry based predominantly on coal and delivering a broad range of products with a completely different price structure to oil-based products. So where does this leave polyurethane?

This is the best information currently available and it is clear that despite steady growth in the early 2000s, that growth has not only halted but has gone into decline. The figure predicted for 2008 is around 500 Ktonnes, about 4% down on 2007 and 8% down on 2005. However, there are signs that a recovery is on the way and the new MDI production plants due on stream in 2009 should certainly ease the supply situation. The growth pattern of polyurethane systems for footwear is therefore expected return to a more normal shape over the next few years. But the pressure of the price factor cannot be ignored nor, as we have clearly seen, can the fact that shoemakers will still have a wide choice of materials to choose from.

FUTURE PROSPECTS FOR POLYURETHANE

Statistics indicate global consumption in the footwear industry fell in 2007, will probably witness a further drop in 2008 and not start recovering until 2009. This is due to two key factors—the rapid increase in the price of raw materials and the supply problems of pure MDI prior to the range of new plants coming on stream in 2009. However, due to the ever increasing demand for soling materials of all types and the lack of any significant introductions of new soling materials in the last ten years, polyurethane will continue to expand over the next 7-10 years.

The only constraints will be the ability of systems houses and sole moulders to absorb price increases in raw materials and a continuation in the expansion of the key MDI supply position. If there are positive steps taken in these two areas then polyurethane should continue to expand and could reach a level of around 676 Ktonnes in 2015. Whilst this is still a significant expansion on the 2007 level of 520 Ktonnes, it is a lot less than the predictions that were being made as recently as last year when the 2015 figure was predicted at around 750 Ktonnes. This demonstrates very clearly the degree of pressure that the global polyurethane footwear market has come recently. 

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