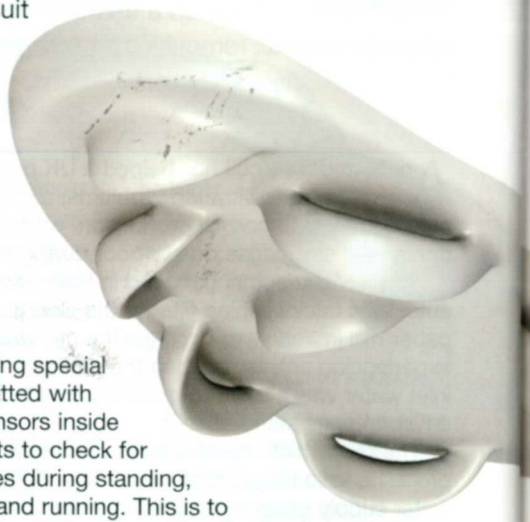
Rapid prototyping scores well on all fronts

The goal of mass customising manufactured goods to suit individual tastes is nearing reality. One firm is using laser sintering technology to tailor the design of football boots for individual players. Dean Palmer reports



The term 'mass customisation' stands for the idea of creating bespoke products in the price range of competitive, mass-produced products. Many manufacturing firms are acheiving this target with the help of IT and software.

The same concept can be applied to three-dimensional products by driving manufacturing direct from 3D CAD data.

The idea is that you create a basic design of a product – equivalent to the basic letter, or in 3D, a basic design of sports shoe outsole – the personal data is then integrated, for example, the shape of a foot and the name of a person. Finally, the two are linked to produce the 'individualised' outsole by laser sintering, with the person's name already written into it.

For Prior2Lever (P2L), laser sintering was the last missing link in the company's puzzle to make its business idea fly – the production of bespoke, high performance footwear for professional athletes. The vision of the founders is to allow for individualised, functional footwear to improve performance and at the same time to prevent injuries.

The firm has harnessed layer-by-layer fusing of plastic powder in an EOS laser sintering machine to manufacture the soles of the bespoke boots.

One leading Premiership player has already benefited. The individual, who unfortunately has to remain nameless for legal reasons, underwent an operation in 2003 for a foot injury and was subsequently injured several more times. Since wearing the P2L boots he has noticed an improvement in performance and is back training and competing for a first team place. P2L will also be working closely with Olympic athletes in a number of different disciplines.

The unusual name of the bespoke footwear manufacturing firm hints at the manufacturing process. It starts with the first director, Trevor Prior, consultant and podiatric surgeon and a globally renowned foot and biomechanics expert who treats Premiership players.

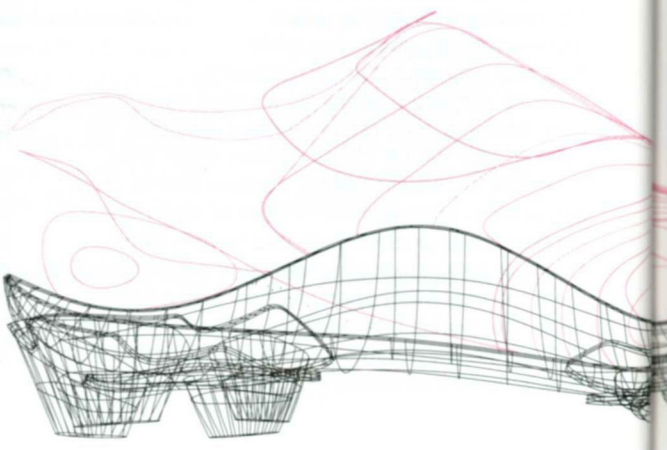
Prior assesses players at his London-based clinic using special insoles fitted with force sensors inside test boots to check for anomalies during standing, walking and running. This is to identify the optimum position for the person's feet for any given sport. By scanning a sequence of plaster of Paris casts of the feet, which are more accurate with each iteration, orthoses are prepared and tested. Finally, each foot, together with the orthoses, is digitally scanned.

From CAD to prototype model

The resulting point cloud data is passed to Prior's colleague, creative director Greg Lever-O'Keefe, who holds a masters degree in performance sportswear design at the University of Derby and whose PhD dissertation will be based on this work.

He converts the data into a solid CAD model, which in turn is used to CNC-machine a wooden or plastic last around which the boot is made.

The top part of the CAD model is flattened and post-processed to laser-cut the leather upper, which is stitched to the bespoke outsole that has been laser sintered.



This outsole is the secret ingredient in the recipe. Starting from a basic design, the important functional areas are adjusted in the CAD design, such as the orthotic shape on the upfacing side and the flex zones, according to the individual foot's needs or the position of the cleats.

The thickness of the sole varies in different areas, according to the weight of the player and the amount of flex required, at the same time providing excellent overall load distribution – much better than with a standard TPU (thermal polyurethane) football boot sole, which is overly flexible across the entire surface, including in the wrong places.

Tests involving cantilever flexing of laser-sintered soles to 45 degrees for 500,000 cycles

showed no stress cracking, but the current beta tests in training are needed to check performance under conditions of greater flexing, lateral movement and impact. Initial tests have proved very successful.

Third director of the P2L team is Volker Junior, a consultant for technology integration who specialises in layer manufacturing and mass customisation strategies. He brings commercial expertise to the business as well as a wealth of knowledge in laser sintering. P2L collaborates closely with the Munich company, with all outsoles to date made in the EOS demonstration area using files sent from the UK. Similarly, Lever uses the CAD support services and consulting support of Freedom of Creation, Amsterdam, a pioneer in the design for products produced by layer sintering.

Before opting for laser sintering, Lever said he looked at different ways of producing bespoke outsoles in small volumes of, say, five to 10, under a Sports Science Engineering and Technology-funded research project, co-directed with Dr Neil Hopkinson of the Rapid Manufacturing Group at Loughborough University.

A possible route is to CNC mill the soles directly from plastic by applying CAM software to create cutter cycles from the CAD model. One problem is that the plastic tends to burn, another is that the complexity of the shape requires five-axis milling, which is expensive. Another technique investigated was to produce an aluminium injection mould, but the cost was too high for such a small batch run.

As to the future, P2L says it will advance its product in several different areas. The aim is to further exploit the "freedom of design" that comes from using a layer manufacturing process. In outsole design, that could mean building in honeycomb structures to dissipate the forces generated by running, which are up to five times body weight and a major cause of injury.

In time, the technology could enter mainstream sports, with diagnostic equipment and foot scanners in high street shops downloading data to a laser sintering machine to allow mass customisation of footwear. Such a scenario is already a reality in lighting and furniture, albeit still at the exclusive end of interior design.

For the time being, P2L says the intensive testing of its boots by selected players will allow product development to be finalised. Time to market is crucial for success and the next World Cup is on the horizon. □

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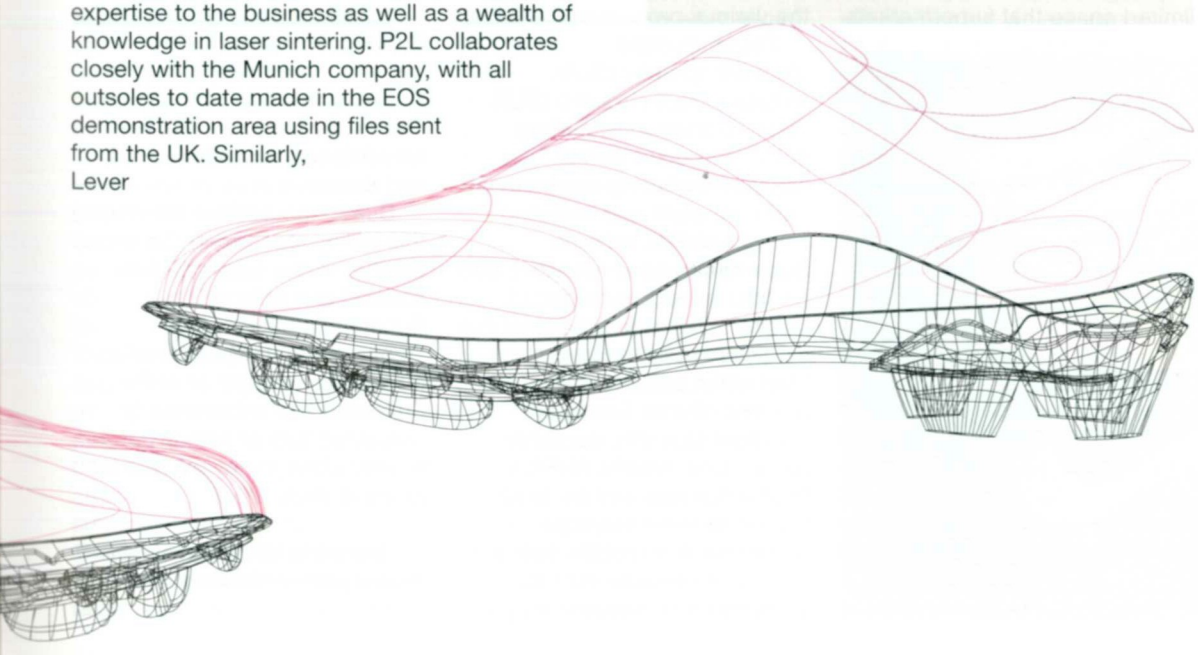

P2L is hoping to exploit the market for customised sports footwear by using advanced laser sintering technology and 3D modelling

Pointers

- For the build process in laser sintering, horizontal slices are taken through a CAD model
- The resulting slices, collected in an SLI file, are used to drive the EOSINT scanner to deflect a laser beam, which fuses layers of nylon powder to produce any given shape, like the complex outsole of a football boot, complete with cleats