The creation of 3D models is an important step in product development and they are being adopted more and more frequently as producers realise their value in significantly reducing the time to market of new products—which can mean the difference between launching a new craze and missing the boat in the sports footwear and sporting goods market. In order to examine the potential uses and opportunities for the further integration of rapid prototyping in the production of footwear, a team of experts at the French leather and footwear research centre CTC undertook a project to identify the products available and new developments in this field.

Rapid prototyping—shaping the future

In a highly competitive market such as footwear, manufacturers must react quickly in terms of design and production, as the number of collections continues to increase as a result of consumer demand and rival products. Therefore, the different elements, such as the sole and heel, that make up the finished product must be designed, developed and tested ever more rapidly and the methods used to achieve this have had to become extremely flexible. It is for this reason that 3D CAD has now become an essential tool in sports footwear production. However, in spite of the widespread use of highly technical design tools, the actual production of prototypes still follows the 'conventional' techniques of creating patterns, and 'exact' templates or moulds and this is the area where rapid prototyping could further speed up the process.

Rapid prototyping techniques already exist in many industrial sectors and have proved successful in accelerating the refinement of models and, in view of this, CTC has been monitoring the development of this technology for three years, in order to assess the relevance of such equipment with regards to the footwear and leather goods industries.

The research project aimed to evaluate the relevance of rapid prototyping tools in the fields of footwear and leather goods in an attempt to ascertain the potential to reduce the design cycle and identify the resources required to implement such technology. After examining the equipment available, CTC then invested in certain rapid prototyping solutions that were deemed most suitable for use within these fields in order to carry out a study to examine the potential for their integration into production processes. This involved identifying the best choices and essential developments required within design and production of the goods destined for these markets.

The tools of the trade

To produce a prototype using rapid prototyping technologies involves two main processes: CAD modelling and production of



the prototype.

This involves drawing the article in 3D using CAD software. CTC generally uses two CAD software packages, Romans CAD Software and SolidWorks, which allow the user to draw the article mould and verify its feasibility prior to the production phase. This 3D modelling stage lasts between one and five days according to the complexity of the article.

CTC acquired three types of rapid prototyping solutions to test during the study: 3D printing, lost wax processing and vacuum casting.

With the 3D printing method, digital modelling data is sent to a three dimensional printer, which then prints the article, layer by layer, by compressing minuscule droplets of wax, until it has produced an actual-size non-working prototype. This produces a rigid wax model which can then be used to confirm the article's visual aspect, volume and dimensions. Following the model's validation, a functional prototype can be produced using either a lost wax foundry machine to produce a metallic article or a vacuum casting machine to produce a prototype in a choice of materials ranging from flexible substances such as rubber to hard materials such as ABS. The prototype can then be assembled with other articles such as attaching a heel or gluing a sole on an upper mounted on a last.

Fast reactions

Many prototypes for footwear have been produced over the years in an attempt to estimate the time and costs involved in producing a prototype. Following its research, CTC came to the conclusion that 3D printing was more suitable for both footwear and leather goods prototypes in terms of the results produced by this equipment and in terms of costs, when compared with other technologies. Moving from a wax prototype to a functional prototype takes two days whilst 3D printing is fast. A 60mm heel takes only seven hours to print and a European size 34 heel takes just five



hours. Therefore, a full-size heel with a simple geometrical shape can be modelled in a single day and 'printed' overnight. The silicon mould for vacuum casting can then be prepared the next day and after drying the mould for twelve hours, the prototype of the heel, produced in a rigid ABS material, can be completed the following day. Therefore the whole prototyping process for such a heel can be completed in as little time as three days thus saving a significant amount of time compared with traditional methods.

Extra dimensions

In addition to the obvious savings in man hours, which could realistically be reduced further still, these new working methods allow producers to respond to market requirements more quickly. The digital format offers easy communication between remote sites, which could be further enhanced through increased communication between the CAD designers and the production floor.

However, this is not a step that should be made without seriously considering the implications involved in terms of the company's general organisation of design and production as it could require specific support, both on a technical level and in the development of team knowledge and their working habits.

Moving from 'traditional' prototyping to rapid prototyping is not as simple as some may believe as rapid prototyping requires the use of different procedures to enable physical objects to be reproduced in three dimensions.

Although they are produced more quickly using data obtained through CAD systems, without the need for special tooling and in much less time than using traditional techniques. They are often produced by adding material—either point by point, or layer by layer—which is the total opposite of traditional machining techniques which are created by removing material. On a more positive note, rapid prototyping, or more specifically, rapid tooling can be used to produce small runs of articles in the 'right material', using conventional manufacturing techniques—a method which first appeared in the 1990s—whilst an emerging technology, rapid manufacturing, enables articles to be produced in the 'right material' without tooling using rapid prototyping techniques.

In the "I want it and I want it now" society of the 21st century, producers cannot afford to sit back on their laurels. Getting products to market in as short a time as possible is now arguably on a par with developing new styles in terms of securing success and competitiveness. Fortunately, as the footwear market continues into the future in a whirlwind of new technology, rapid prototyping may help producers keep pace.


CTC

Prototype production methods

The wax foundry machine

The art of smelting and shaping copper and bronze dates back a long way indeed and although smelting regulations and modern foundry equipment are resulting in a slow technical evolution, foundry operators still work in much the same way as their predecessors during the Middle Ages or the Renaissance.

The starting point is always a wax article, obtained nowadays by creating a 3D print of a 3D article, modelled using CAD software. For each article produced, new wax is needed, hence the name 'lost wax' and in order to produce several copies of a prototype, a mould must be produced in an elastomer. Casting streams, also made of wax, are then attached to the article and are in turn used to cast the metal. Together, this is known as the 'nest' and is covered with a refractory mortar such as plaster. The next step is called 'dewaxing' when the wax, in its refractory gangue, is placed in an oven at a temperature of at least 750°C, depending on the type of refractory. This melts the wax, leaving an imprint, whilst 'baking' the mortar to harden it. On removal from the oven, the molten metal is then poured through casting funnels, to fill the imprint left by the melted wax and the mould is broken and disposed of once the rough cast has been removed.

Finishing involves removing the casting streams, cleaning the article and then giving it a polished finish or patina as required.

The alloys used most regularly are aluminium, bronze, copper, brass and zamak (a zinc, aluminium and magnesium alloy which sometimes also contains copper) With a melting temperature of around 400°C it is a heavy duty alloy which is easy to work with and does not rust, therefore making it ideal for moulding under pressure as it is also very fluid.

Vacuum casting

Moulding using vacuum casting enables small- and medium-sized series of articles to be produced within a very short time and at a reduced cost. Duplication using vacuum casting enables around 20 articles including complex shapes—vacuum cast in silicon moulds—to be produced in polyurethane resin. Silicon tooling works by duplicating a physical model produced by rapid prototyping methods such as Stereolithography, 3D wax printing, digitally controlled milling, etc., using a viscous or charged resin. The wide variety of polyurethane resins now available also means that an equivalent to the final material can be found with which to carry out functional tests on the product including rigid, semi-rigid, flexible and transparent resins, as well as resins charged with fibre glass, high elasticity and those resistant to high temperatures, ensuring that virtually every type of thermoplastic material used in production can be simulated whether it be ABS, polypropylene, polycarbonate, PMMA, elastomer, etc. Furthermore, the moulded articles can be tinted in the mass, repainted, chromed, embossed with a grain or have a 3D decoration applied to them.