



The amir system.

CREDIT: KLÖCKNER DESMA

Footwear Fundamentals

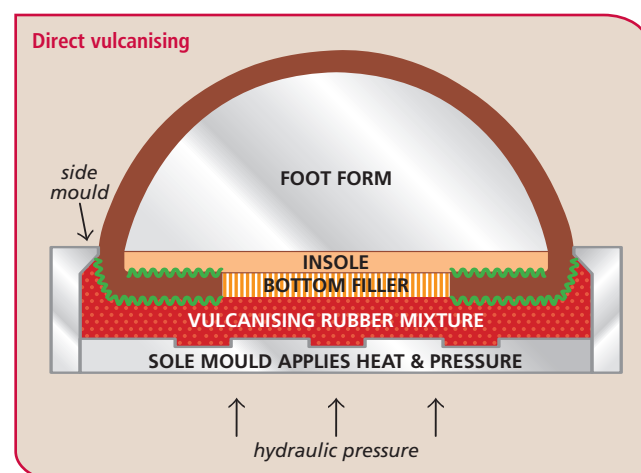
WHICH CONSTRUCTION? Part 2

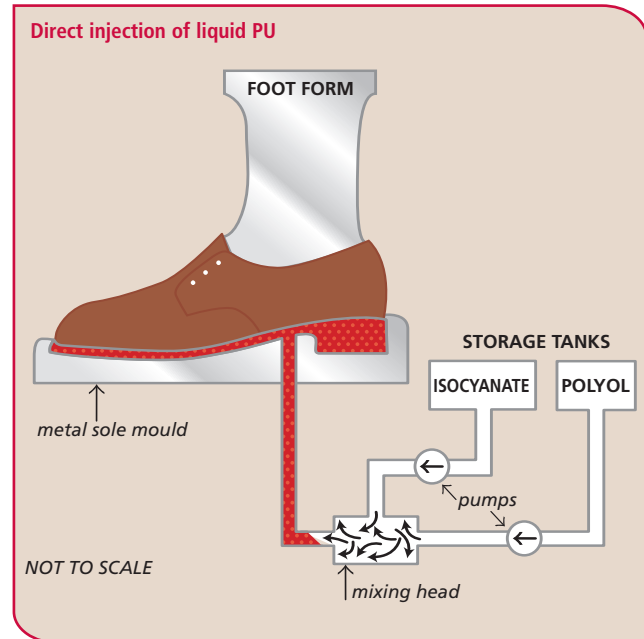
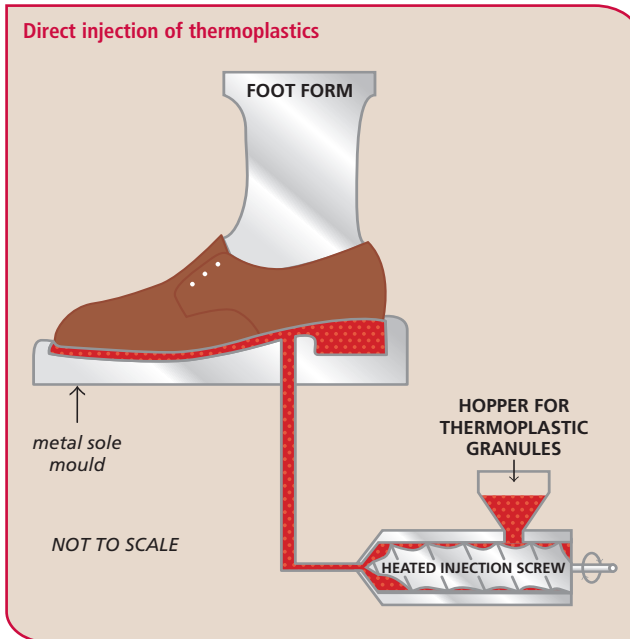
In part one, we looked at the historical development of footwear constructions and dealt specifically with the welted, veldtschoen and cemented methods. These all need lasting machines as part of the process although, in the case of the veldtschoen, variants have appeared where they are no longer needed. This second part includes a number of constructions that also do not use them but are nevertheless used to produce a wide range of footwear types.

DIRECT VULCANISING

Combining methods one and three (as shown in part one *World Footwear* November/December 2008), direct vulcanising became widespread in the 1950s. Lasting and bottom preparation is basically the same as for cemented except that tacks rather than adhesive are used to counter the high in-mould temperatures involved in vulcanising. Chrome tannage leather for both upper and lining must also be used for the same reason. The lasted shoe is then slipped, pulled on to a metal foot form and a shank and heel filler attached before it is lowered into a mould into which a weighed blank of semi-vulcanised rubber has been placed. The mould is closed and the bottom plate raised hydraulically to apply heat and pressure which causes vulcanisation to take place over the course of 10-15 minutes depending on the amount of rubber involved.

This slowness of processing calls for many moulding machines, moulds and foot forms if any real volume is to be produced. It therefore requires long runs on just one last and mould combination. It does however produce an extremely hard wearing boot or shoe. Vulcanising has now been superseded by the much faster direct injection of PU and TPU except for specialised safety and climbing boots, or military footwear where performance outweighs cost and production runs are longer.





DIRECT INJECTION MOULDING

Combining either methods one and three or two and three, this is now a key sole attaching method for a wide range of shoes where the short run flexibility offered by the cemented construction is not important. It can use a wide range of polymer-based thermoplastics such as PVC (polyvinyl chloride), TPR (thermoplastic rubber), TPU (thermoplastic polyurethane) or POE (polyolefin elastomer) which can all be moulded on conventional injection machinery. This provides a good deal of flexibility depending on mould design, plus their scrap can be recycled. PU is on its own in that it requires special machines and any scrap is pure waste.

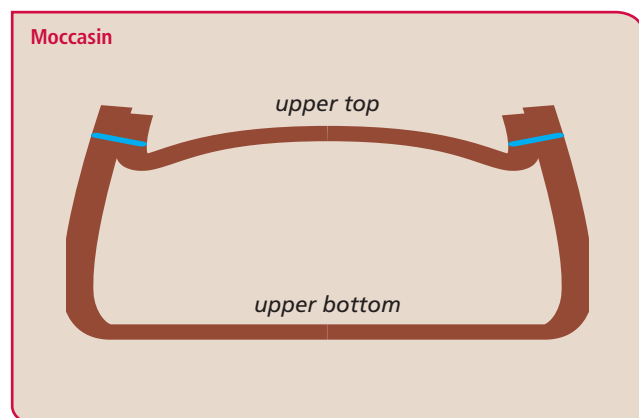
There are close similarities with vulcanising except that the sole is injected on to the lasted shoe in molten (thermoplastic) or liquid (PU) form inside a closed mould. Thermoplastic compounds are supplied in granules which are melted in a cylinder to a semi-molten state before being squeezed into the mould by a rotating screw. The shoe then moves round a rotary set of workstations while the compound cools. It is slipped, allowed to cool further and any flash removed. The latest generation of moulding machines coupled with multi-part moulds has also made it possible to combine different compounds and/or densities to create soles for every surface and activity. With good roughing and adhesive application on the upper, direct injection can also provide a better sole bond than cemented due to the fact that there is 100% surface to surface contact.

PU on the other hand uses no heat and, instead, liquid polyol and isocyanate are piped to the injection head, mixed and poured into the mould, where a chemical reaction takes place to form a cellular sole with a tough and durable outer skin. Because PU is so viscous, good sole bonds can be achieved with just roughing of the shoe bottom and/or sides. Rotary machines are again used to allow the reaction to take place and fully stabilise. Mould fit needs to be very good as otherwise PU will produce excessive flash.

In-mould pressure with PU is however much lower than with any of the thermoplastics and this allows the lasted upper to remain on the last providing the latter has been made to sufficiently fine tolerances. This has been achieved by some last manufacturers through the use of highly sophisticated CAD-controlled last milling machines that use the same digitised input data taken from the model last as supplied to the mould maker to maximise mould fit. Despite the fact that PU soles are light and hard wearing, the wastage factor, relative inflexibility compared to thermoplastics and a world shortage of the MDI that is essential for its manufacture, has meant that PU still only accounts for a relatively small percentage of the direct soling market.

MOCCASIN

Combining either methods two and three or two and four, this construction is very old and almost everyone will have worn a pair at some time in their lives. In its simplest form, it has just two pieces of upper material. A large piece is wrapped round the foot from the underneath and sewn round the forepart to a small centre panel or 'plug' to create a 'bag'. This is the type of moccasin worn for centuries by Native Americans who made them from the hides and



sinews of the buffalo they killed for food. Simple and functional, the moccasin construction can today be used to produce a wide variety of footwear in all price ranges depending on how far you want to go and the materials and labour that are available. However sophisticated it might become though, it will still follow the same basic principle.

Only basic sewing machines are needed to create the main panel, plug and saddle of today's average moccasin. These components are then sewn together either by hand or on a Ciucani-type lockstitch machine. These are capable of producing a variety of moccasin seams of exceptionally consistent quality and appearance. A last is then forced into the resulting bag and the rear portion of the upper lasted by hand on to a half insole. Moisture and heat are then applied to set it to the last's shape and a sole stuck on before the last is removed.

There have been some notable variations away from the simple direct attachment of the sole which are worth mentioning. The popular Boat or Deck Shoe type of casual moccasins are force lasted, heat set and the last slipped before a sole unit is lock-stitched on to the bottom. This results in a highly flexible and hard wearing shoe. The smarter traditional American 'Penny Loafer' moccasin has a through or mid-sole stitched on in the same way, to which an outer sole is stitched around the edge, a heel attached and the edges finished in the same way as a welted shoe.

SEWN-IN SOCK

This construction again combines both two and three and two and four. It also lends itself well to direct injection moulding whereas the moccasin does not. The edge of the upper is sewn to a sock cut from a non-stretch fabric or non-woven using an over-lock machine of the Strobel type. This machine has in fact been used so extensively that the construction is often referred to as 'Strobel Stitched'. The resulting bag is then steamed to soften and warm it before being pulled on to either a last or moulding machine foot form.

It is the non-stretch quality of the sock that provides the lasting pull in this construction, so selecting the right socking material is paramount. In addition, upper patterns need to be very accurate and to have as much shape as possible sprung into them by the use of well placed seams, especially at the toe. While this is not usually a problem with multi-panel sports shoe uppers, simpler designs can place a

greater demand on the pattern cutter. This construction is ideal for many types of sports and casual shoes as it can be used with either walled stuck-on sole units or direct injection systems.

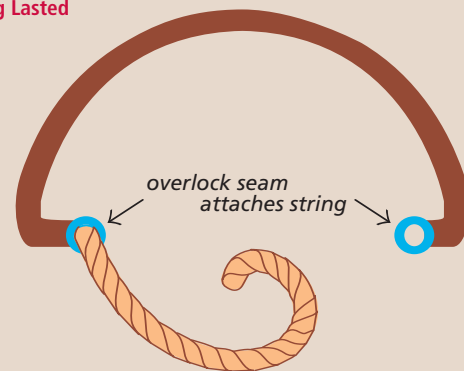
Slip Lasting – a variation known as Slip Lasting has an additional strip of material sewn round the edge of the upper. After force lasting, a platform is added and the strip lasted over by hand to cover its edges before attaching a sole. Once widely used for open-toed California type sandals it, like the turnshoe, is now rarely seen.

OTHER CONSTRUCTIONS

Two further methods can be considered here and both are aimed at low cost footwear.

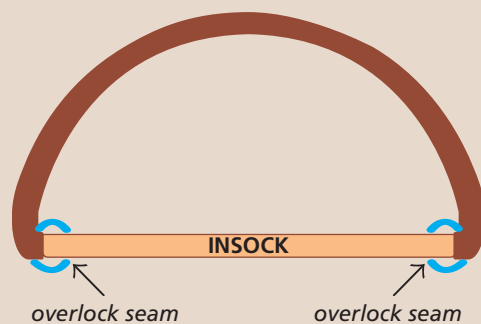
String Lasted – with simple fabric or PVC uppers, it is sometimes possible to string last the upper directly on to the foot form when injection moulding with thermoplastics. This involves attaching a length of string all round the edge of the upper using an over-lock machine and leaving long ends. The upper is placed over the foot form of a direct injection moulding machine and the strings are pulled by hand to effectively 'last' it over the foot form. The strings are secured, the foot form is swung round into the mould cavity and the sole injected on.

String Lasted

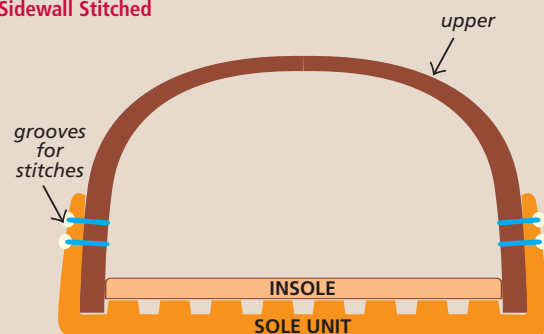


Side Stitched – this is the simplest construction for closed upper footwear. It is based on the use of a moulded sole unit with a raised side wall and a top lip to which the upper is stitched. Specialist machines are again available which can either perform a simple side seam or imitate a real moccasin

Sewn-in Sock



Sidewall Stitched



seam to match specially designed sole units. The upper is again force lasted but this time with the sole taking the place of a sock or insole. After heat setting and last slipping, a false insole is inserted to complete the shoe.

This is a very flexible and easy way to make footwear. The upper can either be given some shape by the careful use of seams or a soft upper material such as suede split can be used that will stretch easily under force lasting. Whilst this construction can be mass produced, it is particularly suited to situations calling for cheap basic footwear to be produced locally and involving a minimum of materials and components, a few simple machines and relatively unskilled labour.



Special last showing mounting plate

CREDIT: FAGUS

Several things combine to make this all possible. The lasts are equipped with a metal plate which provides a gripping point for the robots and allows adjustment at every stage of the process. It also facilitates removal of the last from the moulding machine by means of a detachable connection in the mould carriers which allow it to run through the remaining operations on the transporter completely independently. Unlike conventional moulding technology where there is one last per mould, here there are at least three, one on the machine and the others circulating through other operations. The transporter itself has pallets which can be stopped and held at work stations as required. Speed is constant except in the heat setter and cooling tunnel.

MACHINE-MADE BY ROBOTS

Robots have been used in the footwear industry for a number of years but it is only recently that anyone has come close to making shoes robotically. German company Klöckner DESMA not only produces direct injection machines for PU but also has extensive experience with industrial robots. It has combined this knowledge with the advanced lasts referred to earlier and the sewn-in sock construction to create an automated shoemaking system from closed upper to finished shoe.

Called amir (automated machinery and material flow technology with integrated robots) it is a clever mix of sophisticated technology with a simple footwear construction. A transporter which feeds in uppers and removes completed shoes as well as performing all pre-treatment and finishing operations is built around a rotary direct-injection machine. The result is shorter cycle times on a moulding machine that is always working at maximum efficiency leading to productivity increases of up to 30%.

There are of course umpteen variations on all the constructions described as shoemakers have always been resourceful when seeking ways to make a better product cheaper and in greater quantities. There have been welted shoes with a stuck-on sole (Barkerwelt) to create a lighter and closer finished edge. Welted Veldtschoens had the lining sewn in with the welt and with the upper turned back. This was then lasted and stitched down to the welt and a through-sole before the sole itself was attached with a second row of stitching. Very labour intensive to make, it was nevertheless extremely long lasting as it could be repaired several times merely by replacing the outer sole which also left the shoes' high water resistance unaffected. The future will demand greater simplicity and ever lower production costs but, whatever clever ideas come about in regard to new shoe constructions, they will be rooted somewhere in one or other of these basic concepts. 🍷

