

Desert Boot by Clarks Originals



FOOTWEAR TECHNOLOGY

In this, the second of a two-part article, *World Footwear* looks at the machinery needed to process natural rubber into vulcanised.

Vulcanised rubber (part 2)

Natural rubber is produced as a sheet material often referred to as plantation crêpe, so one of the simplest approaches to making a rubber sole is to simply cut out the shape of a sole from the sheet. As natural rubber softens on contact with solvents, it is easy to build up a structured sole unit from several thin sole and heel shapes by using solvent as the bonding agent.

This approach is still used to produce both artisanal footwear as well as up-market products such as the famous Clarks Desert Boot, still much in demand nearly 70 years after its creation. It is, however, a labour intensive procedure that does not lend itself to any degree of automation. In addition, crepe rubber soles are inherently susceptible to attack by solvents and oils which limit their useful life.

VULCANISATION PROCESS

When it comes to moulding the more usual type of soles required by shoemakers, it is necessary to see what machinery is available. Traditionally, vulcanised rubber unit soles have been made using compression moulding, which involves single or multiple daylight hydraulic-presses heated by steam, oil or electricity to a temperature of 160-180°C.

Blanks of partially-vulcanised milled rubber sheet are cut to the correct shape for the sole so that one piece runs the whole length of the mould plus an extra piece for the heel. These are pre-heated in an oven to around 110°C to help to reduce the cycle time, and then manually loaded into moulds—usually a pair set side by side—in a daylight press. Once all of the moulds have been loaded, the press is activated and the components are compressed for a period of between four to ten minutes until the rubber is fully vulcanised.

The weight of the blank is usually 2-8% more than the weight required in the final product and this excess material ensures that the mould is fully filled and all of the air is forced out of it. As the press platens close the mould, the excess rubber is squeezed out into flash grooves, taking the air with it.

It is often very difficult to remove all of the air traps on a unit sole and various techniques are used. One, called bumping,

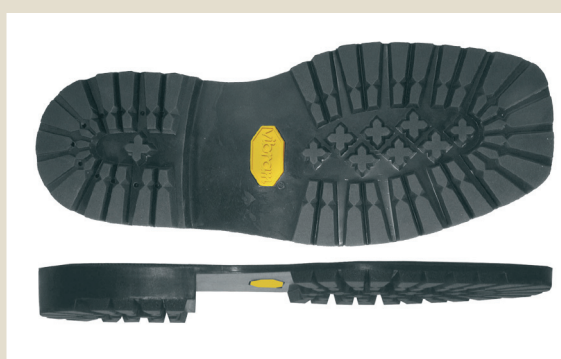
involves releasing and applying the full pressure several times in rapid sequence. Another, which can be used if the air traps are consistently in one place, is to drill a fine bleed hole through the mould at the appropriate position. The shape and number of blanks placed in a mould can also alter the flow of material and hence the level of air trapping. This is still very much an art and depends more on experience than any science.

CARRARMATO SOLE

One of the classic vulcanised rubber soles is the Carrarmato produced by Vibram spa. It was the first to be made of vulcanised rubber, the first invented by Vitale Bramani, the first intended specifically for mountaineering, the only one to have scaled all the highest summits in the world and the highest selling Vibram sole ever. An indication of its success is that the Carrarmato is one of the most copied products in the entire history of the industry and the only sole to have given its name to a type of footwear.

It is now a universal product sold all over the world for mountaineering, industrial, and casual applications. It even appears on luxury footwear in super-light foam compounds. Over 20 Vibram designs have sprung from the Carrarmato and the company sold over 500,000 pairs worldwide in 2006. ►

Vibram Carrarmato



WORLDFOOTWEAR

DIRECT MOULDING

The situation is different for the direct moulding of vulcanised rubber to an upper as this is a much more complicated process. Low pressure moulding was used in the 1930s to produce slippers with vulcanised sponge rubber soles but, the direct vulcanisation of hard rubber soles was unknown until the late 1940s when Señor Mediano pioneered it in Spain under the term CEMA (Construidores Españoles Máquinas Automáticas). In the 1950s, C&J Clark introduced it into the UK and it is from this time that a high pressure vulcanisation moulding technique was fully developed in order to produce good quality soles by direct moulding.

The early days of directly vulcanising rubber to shoe uppers brought considerable problems to light, so Clarks formed CIC Ralphs Ltd. to develop and manufacture the necessary machinery. Many engineering difficulties had to be solved and then, when production tests started, a whole range of material problems arose. Many upper leathers, insoles and stiffeners could not withstand the high temperatures of the vulcanising process and the moisture content of these materials had to be strictly controlled. Even low moisture content produced charring of the upper and insole. To overcome this, upper leathers, insoles and stiffeners had to be wholly chrome tanned or have a high chrome content; no vegetable tanned uppers or linings could be used.

Overcoming these hurdles led to the development of one of the most successful direct moulding vulcanising machines ever made, the CIC Ralphs Type 400 Mark 6 twin station press. Because of the long cycle time required, it was usual for a number of presses to be set up in rows of six to eight each side, facing each other so that one operator could work all of the machines. This provided good productivity at relatively low cost and these presses were so well built that many are still in operation today.

CIC Ralphs Type 400 twin station presses



Courtesy of Haynes & Cann Ltd

DIRECT MOULDING SEQUENCE

The moulds used for direct moulding consist of four parts, a sole mould or piston, two side moulds and a metal foot/last. Because of the high pressure used, the moulds have to be securely fixed to the machine and are difficult to change quickly. The side rings are usually slightly cooler than the sole piston. In operation a roughed upper is force-lasted on to the foot, the pre-heated sole blank is placed on the piston, the foot positioned over it, the side rings closed on to the lasted upper and the piston moved upwards to a preset level. The rubber melts, flows to fill the mould evenly and vulcanises itself to the bottom of the shoe.

The adhesive that has been pre-applied to the bottom of the upper is also activated by the heat of the vulcanising rubber and ensures that an excellent bond to the leather is obtained. At the end of the cycle the machine automatically opens so that the operator can raise the foot to the demould position and remove the upper with its completed sole in readiness to repeat the cycle.

INJECTION MOULDING

Injection moulding machines for the production of vulcanised rubber components have been around for many years but were not very well developed for the production of vulcanised rubber sole units. Several companies, however, have considerable experience in suitable machines including Main Group from Italy and Klöckner Desma of Germany.

Main Group introduced its Incom Process in conjunction with the Star series of machines in 1992. The key innovation of the process was that the nozzle of the rubber injector could be inserted through the back of the mould, with the piston dropped down, so that the rubber could be injected as a ribbon along its length as the nozzle was slowly withdrawn. The piston was then raised and full clamping pressure applied. However, much less pressure was required compared to that needed if the rubber had been injected through a conventional injection port. The system was used to produce direct moulded footwear with either a solid vulcanised rubber outsole or a combination of a thin solid outsole and a thicker, lower density blown rubber midsole.

Desma was also active during the early 1990s but focused more on producing a machine that would combine a thin vulcanised rubber outsole with a microcellular PU midsole. It has been very successful and now has a fully viable system that produces consistent results. It has likewise developed a process for combining a thermoplastic PU outsole with a microcellular PU midsole.

SPECIAL DEMANDS

Working with rubber places special demands on machinery, materials and personnel. A key problem in combining vulcanised rubber with PU is the difficulty of achieving good bond levels between the two materials. In the early years Desma used a combination of a fabric mesh and an adhesive moulded into the top surface of the rubber, but this proved to be labour intensive and very difficult to manage.

Its solution was to use a rubber injector head that tracks over the piston in an open mould and extrudes pre-vulcanised rubber along the length of the mould as 'spaghetti'. This is then vulcanised by closing the mould and applying heat. When the

Desma rubber extrusion head



mould opens—prior to injecting the microcellular PU—a robot head is used to spray the surface of the vulcanised rubber outsole with a special adhesive, thus ensuring a good bond between the rubber and the polyurethane.

MOULDS

There is a big difference in mould construction for the different processes. Steel moulds are required in order to cope with the pressure and high temperatures of compression moulding and direct moulding using the CEMA/CIC type process. This means they are very heavy and so increase the difficulty of changing them. On the other hand they do provide a long working life, making them ideal for standard long-term designs. The lower pressure used in the Main Group and Desma direct moulding approaches allows normal aluminium moulds to be used, making things much simpler.

Vulcanised rubber soles are used in many types of footwear but are especially prevalent in the military and industrial boot segment where they are in great demand for their toughness, hard wearing properties and excellent heat resistance. As they are also extensively used in casual and sports shoes, the future remains bright for what, to many, is becoming quite old technology. 

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