



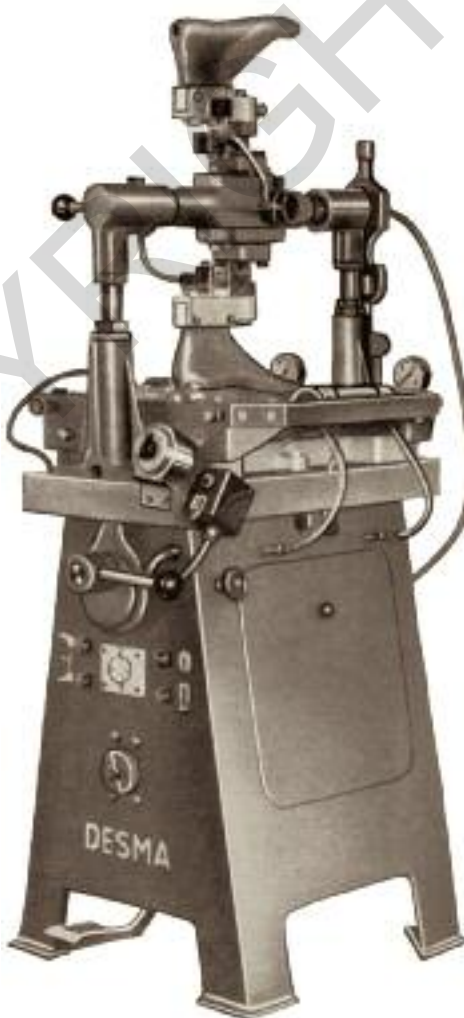
Quadwrap trainer.
ALL CREDITS: DESMA

70 years of innovation

Desma is one of the best known machinery names in the footwear industry. From humble beginnings in the aftermath of World War II, it has become a major supplier of sophisticated moulding machines and automated systems worldwide. Founded by Herbert Ludwig as Deutsche Spezialmaschinen Co. U.E. in 1946, it initially produced a variety of products among which were simple sole presses and roughing machines for the footwear industry. In the 70 years since, it has introduced some machines and systems that have had a significant influence on footwear manufacture.

VULCANISING

The first appeared in 1955 in the form of a simple vulcanising press for direct moulded slippers, the Desma 100 (the company had been renamed by them). It was a single station machine, electrically heated to give a ten minute operating cycle. It saved a large number of separate operations and, although crude by today's standards, had a real impact on the German footwear industry. The 200, 201 and 202 machines that followed were able to produce other types of footwear including sneakers and basketball boots. Desma machines have been used by many manufacturers of sports footwear ever since.



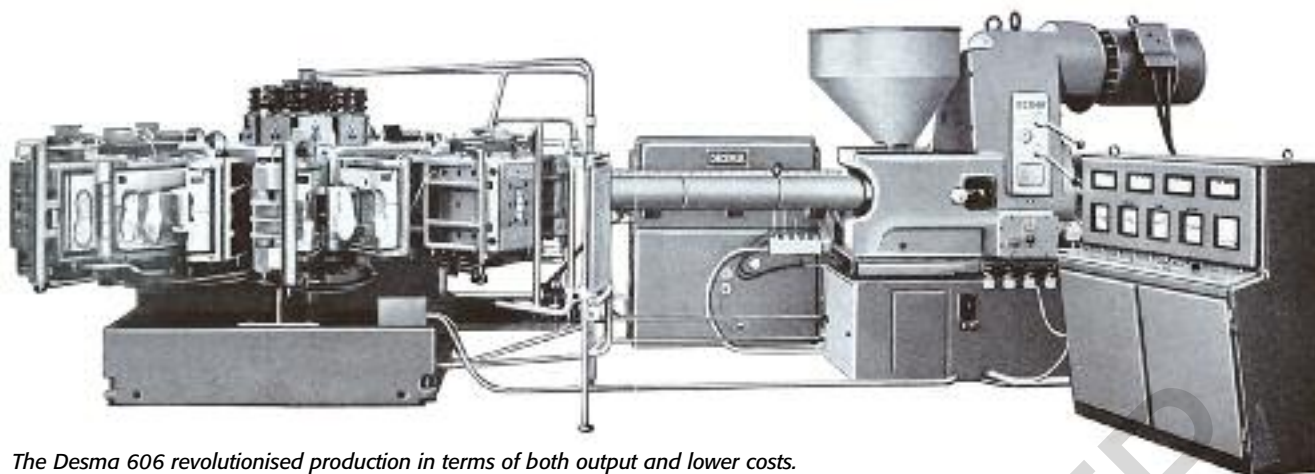
The Desma 100 set the company on its path of innovation and development.

PVC MOULDING

The next major step involved experiments with PVC paste (the forerunner of granules) in the vulcanising machines and again using electrical heating to cure the material. By 1961, PVC granules for footwear soling had become readily available and, that year, Desma introduced the massive 15-tonne 606 machine. It caused a sensation as only two operators could produce 1,000 pairs of boots per day compared to 25 for 700 pairs using existing methods. It was followed by a succession of PVC injection machines including the 701, with the first one delivered to adidas. It proved to be a winner and no less than 1,500 were sold. Success by German sportsmen and athletes wearing footwear produced on this machine gave Desma's technology a tremendous boost in global markets.

ROTARY TABLES

For some time, Desma had been cooperating with the Foster-Yates company in the UK. It produced rotary tables for the production of plastic sandals, using PVC granules and extruder technology. Desma became its agent and, in time, developed its own version which featured the Maltese cross system (a gear mechanism that translates continuous rotary motion into an intermittent one)



The Desma 606 revolutionised production in terms of both output and lower costs.

as used in the earlier bonding presses. The concept was originally developed by Swiss watchmakers and therefore extremely accurate. This meant that on a rotary injection moulder, the mould injection point was always precisely in line with the injection valve each time the table stopped.

There are two main types of rotary table, those for poured products and those for injected ones. In the former, pouring units—either manually or robot controlled—pass over the open mould and pour in the correct amount of material. The mould is closed and locked, and the material (usually foamed polyurethane) expands inside it until final hardness is reached. Those for use with injection moulding are characterised by the injecting of material into a closed mould, using low pressure units in front of the rotary table. Moulds on these tables, which may have 12, 18, 24 or 30 stations,

open horizontally.

The rotary table was perhaps one of the most significant developments the company ever made, and has become the central feature of the majority of Desma machines produced ever since. The varying number of stations catered for all sizes of factory output and the speed of operation resulted in greater efficiency and cost savings. It also made it possible to introduce increasing degrees of automation which, in turn, have led to the sophisticated manufacturing systems the company produces today.

POLYURETHANE

Desma's most defining decision, however, was to concentrate primarily on machines for moulding PU, a remarkable material that was totally unlike any other used for footwear soling. It offered the elasticity of conventional rubber with a higher load-

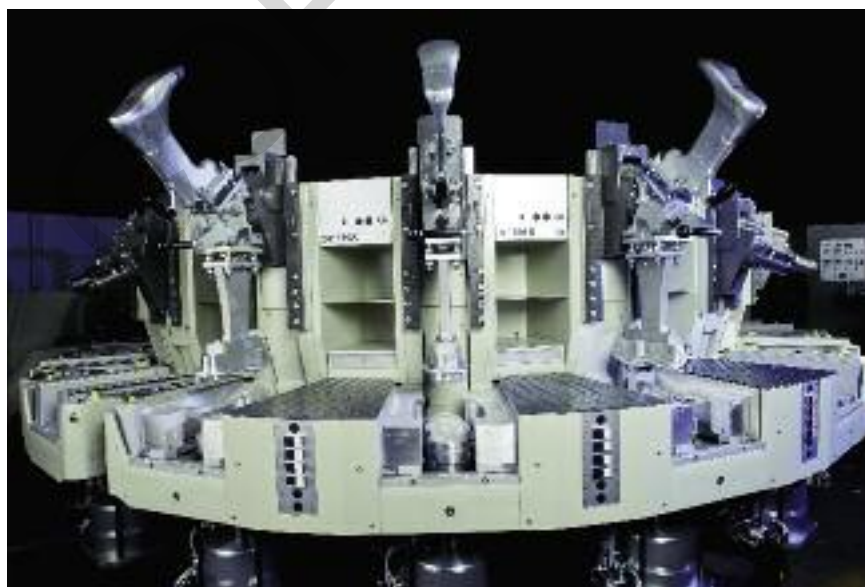
bearing capacity, was abrasion resistant and had an extremely long life. It also showed excellent insulating properties and was both heat and cold resistant.

PU is an organic polymer, either polyester or polyether. Both are two component systems consisting of a prepolymer and a polyol blend. The two components are pumped, metered and mixed, then immediately poured or injected into a mould which acts as a reaction chamber where the final thermoset polyurethane structure is formed. This is totally unlike all other soling compounds, so specialised machines are required to process it.

Desma was convinced that PU was the material of the future and, once again, its remarkable capacity for innovation came into play. The key to success with PU moulding was the accurate mixing of the liquid components and precise measuring of the mixed material into the mould cavity. Desma's answer was its 'low pressure' mixing system. This consisted of a conically shaped, high speed screw fitted to a mixing chamber with a tolerance of only 0.5mm. This provided high performance, excellent quality and was, at the same time, self-cleaning. This important development made Desma the world leader in PU moulding technology.

AUTOMATION

The company produced increasing numbers of machines for processing PU based on its mixing head and rotary head technologies. At the same time, it began to look at what else it could offer footwear manufacturers to increase output, quality and efficiency while, at the same time, providing further opportunities for itself. It realised early



The rotary table concept marked a significant milestone for both Desma and the footwear industry in general.



Sole extraction robot.

on that robots and automation could play a vital part in cost-effective production of high quality footwear. Their great advantage was that they could be programmed to perform a given task with absolute precision and at a consistent rate of output, time after time.

However, they also required serious investment in development time to enable them to do so. Rather than undertake such a complex task from scratch, Desma began to cooperate with ABB in Sweden in the early 1980s, when ABB lent it a robot for trials. This was adapted to the special needs of the footwear industry and the first production IRB 1000 robot was supplied to adidas in early 1987. It was an immediate success and other customers

soon followed. Constant improvements and updates enabled them to be used in an increasing number of footwear specific applications.

At the same time, Desma was also working on an automated work flow system that would allow robots to be integrated into a total manufacturing entity. This was AMIR, (automated machinery and material flow technology with integrated robots). The system contained an amalgamation of all known conveyor technology for bringing goods to and from all the machines and work centres on a production line using data technology and with links to production planning, operational data capture and processing. AMIR rationalised and streamlined production,

reduced variables and, once again, provided Desma with another footwear industry first.

Over time and working closely with its customers, Desma developed robotic solutions for a wide range of key shoemaking operations that included roughing, cementing, spraying mould release agents, flash trimming, last slipping and many others besides. Any or all of these could be incorporated in an AMIR system to provide fully automated production from lasted upper to finished shoe.

DESflow

Thermoplastic polyurethane (TPU) is created by a reaction between a diisocyanate and one or more diols. Denser and harder than PU, it has high elongation and tensile strength properties. It proved to be superior to PVC for many applications, ranging from dress shoe to studded sports shoe soles, where the actual sole was comparatively thin. However, producing small batches of TPU soles proved expensive due to the time needed to effect changes in the material itself, whether in terms of colour or some other property, between each batch. Desma's DESflow system, introduced in 2000, solved this problem and made TPU an increasingly attractive soling material.

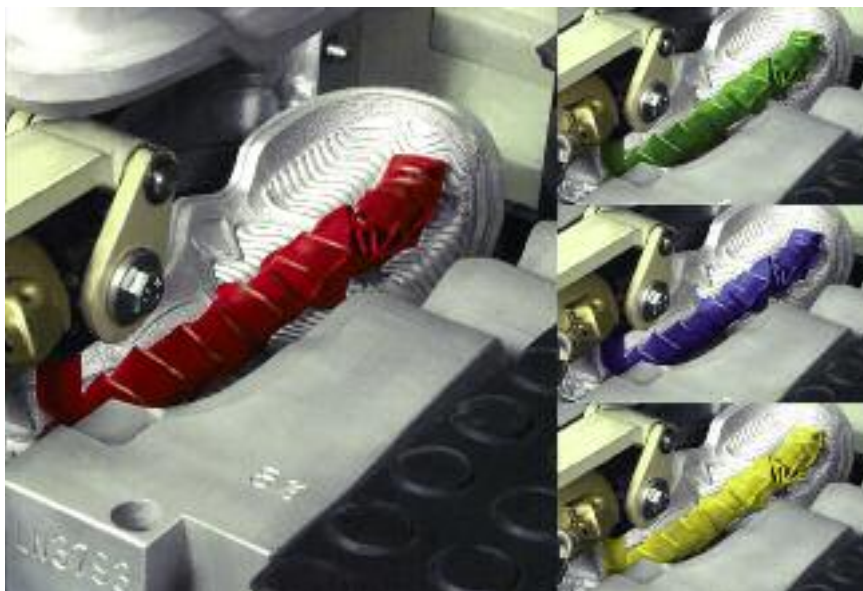
The process was basically simple in that it involved pouring a hot liquid thermoplast on to the bottom plate and then pressing it into the mould. As the TPU was not injected through any runner channels, there was no friction to impart stresses to the material itself, so the finished sole had better properties than one produced by injection technology, with fewer flow marks and less waste. As the material was well distributed throughout the mould cavity, it did not have to be forced to flow over the total cavity in order to fill it. This offered cost savings in terms of both machine and moulds, as the latter could be aluminium rather than steel.

PROCESSING CELLS

As remarked earlier, automation had been shown to produce consistent high quality at a lower unit cost. Achieving the best possible soling bond on cemented footwear had long been a problem due to the number of variables involved. In the early 2000s, Desma developed automated solutions for



Amir automated production system.



Casting by the DESflow process.

applying sole attaching adhesives to both sole units and lasted uppers under the brand name amir C. The key elements involved were the Sole Processing Cell, Upper Processing Cell and Upper Processing Line.

Perfect sole adhesion in the stuck-on process depended on how well the upper and sole were prepared before the adhesive was applied, something that had always been difficult to achieve consistently even with automatic roughing machines. The idea of replacing the brush with a laser was tried and seemed to work well. It was fast, could rough only where wanted, cope with multiple materials in the same upper and all with no residual dust. As no pressure was put on the

upper material or seams, changes in material had no effect on the roughing action and, in addition, any contour could be followed. However, the shoe was still fixed while the laser moved and this limited its potential. Desma reversed this approach and in 2008 demonstrated a laser cell where the laser remained fixed while the shoe moved through all dimensions so that any part of the upper could be reached. This gave total flexibility and proved a great success.

Desma's Sole Processing Cell appeared two years later. A sole was fed in at one end and emerged at the other fully treated and ready for attaching. It was fast and applied only the exact amount of adhesive required, so

significant cost savings could be made. The subsequent upper processing cell operated in a similar manner whereby the operator only had to deliver the lasted upper to the cell via a delivery station. All necessary manufacturing steps were then performed by a robot operating within the cell. Most sole units have a slight side wall so that they are bonded to the upper two dimensionally for greater strength. The laser robot could be programmed to rough the lasted upper with total accuracy to any contour to match the sole, something that was extremely difficult to do by any other means.

LOW PRESSURE MIXING

One of the most important factors in the production of PU soling is the stability of the processing conditions and, also in 2010, Desma announced its RGE 4011 mixing and injection unit. This used a combination of highly accurate gear pumps, a newly structured automatic screw changer, a sophisticated cleaning device and a brand new graphic user interface to enable manufacturers to achieve even greater product accuracy and consistency than ever before.

The unit employed low pressure mixing technology, where an auger was used to mix the polyol and isocyanate. As a result, all varieties of material could be processed, whether ether- or ester-based, as well as additional solid fillers even when they comprised a large proportion of the formula. The technology was able to handle such a huge variety of different polyurethane components that it set a new standard for efficiency and versatility.

A major advantage was consistency, as its digitally controlled component valves opened simultaneously and so guaranteed exactly the same mixing ratio all the time. This enabled a footwear manufacturer to deliver products of a continuous and totally consistent quality. The technology also had the ability to change the complete mixing ratio as well as moulding parameters, such as throughput and component combinations from shot to shot, without interrupting the production cycle. The shot weight remained exactly the same due to the use of precision gear pumps regulated by a control database where data on every moulding was stored.



Desma sole processing cell.

QUADWRAP

Despite technical advances made since the 1990s, footwear manufacture was still a complex process in terms of both the machines needed and the number of people to operate them. Desma thought that integrated design using PU could be an answer. Analysis of existing casual footwear suggested that the required visual and technical functions could all be achieved using just four layers of different density PU. The result was Quadwrap launched in 2014, where the shoe was broken down into four parts: a load bearing inner frame to stabilise the shoe and carry the lacing, a flexible upper to provide the desired visual aspects, a lightweight midsole to provide cushioning at low weight and a slip and abrasion resistant outsole.

All it needed was one Desma D522 low pressure rotary injection machine and two mould sets per size for left and right feet. The inner frame was directly moulded onto a carrier fabric pulled over a last (*Figure 1 left*). At the same time, the outsole (or wear pads) was produced in the second mould (*Figure 1 right*) and then the mid-sole injected directly onto it in the same mould (*Figure 2 left*). The last with inner frame on its carrier fabric was then transferred into this second mould (soles remained in mould two). The upper layer was finally injected into the cavity between frame, carrier fabric and sole (*Figure 2 right*), joining all four layers together without cementing. The process was completed by de-moulding, flash trimming, inserting an insole and threading the laces.

The table could have 24 or 36 mould stations, so with two moulds per shoe and four stations per pair and size, six or nine pairs at a time could be produced on one machine. The four PU layers were produced using two low pressure injectors and one micro casting head mounted to a six-axis robot. Another one sprayed release agent into the open moulds while a third moved lasts between moulds one and two plus the manually operated lasting and last slipping station. The machine could be operated by a single employee who force lasted the carrier fabric and slipped the moulded shoe. Although it took two turns of the table to produce a shoe, parallel processing in both moulds enabled cycle times of well



Desma RGE 4011 mixing and injection unit.

Figure 1 – Inner frame on textile fabric in mould 1 (left) and out-sole pads in mould 2 (right).



Figure 2 – Mid-sole (left) and complete shoe with upper in mould 2 (right).



** An example of a finished shoe is shown in the title image at the beginning of this article.*

below 20 seconds to be achieved.

70 years of developments in machinery and processes, many of them industry firsts and trend setters, is something the company can justly be proud of. But what about the future? Desma's young engineers think it lies in the Internet of things, Industry 4.0, smart factories and 3D printed shoes.

Clearly, the industry faces changes as profound as in the last 70 years with many exciting ones just around the corner. As we have seen, Desma has a tradition of pushing technology just that little bit further, so we can expect them to continue at the forefront of technical innovation whatever happens. 🚀