



RAMS

SERGIO DULIO

Bottom roughing and cementing cell with three robots.

ALL CREDITS: ATOMLab

Shoemaking has existed since the very early dawn of civilisation when our ancestors had, over time, developed the ability to manufacture protective garments for their feet. They then began trading such garments by selling them to other people who had the same need but lacked either the capacity or willingness to provide such items for themselves. Not yet an industry but a rudimentary form of craftsmanship complemented by an ability to commercialise the finished product. It was not until the end of the 19th century that the first shoe machines made their appearance, easing the job of workers and allowing the first forms of large scale organised work that fostered greater and greater throughput capacity in what we can call the first shoe industries to appear in advanced economies.

Since that time, we can identify the building blocks of modern shoe industries in a number of very clear elements: the splitting of complex processes into a number of elementary tasks, the availability of machines of various complexity to support operators in the execution of different production

steps (mechanisation), specific layout of work posts dedicated to the execution of manufacturing tasks according to the various main phases of the production process and to the systems used to transport raw materials, components, semi-finished and finished items from one point to another on the factory floor (layout and transportation). Shoe factories across the world all more or less comply with the same basic scheme.

This is the scenario in which robots first appeared in footwear manufacture more than a decade ago. Robots were developed and initially used in industrial activities some 20 years before that and became one of the dominant technologies of the so-called Third Industrial Revolution. Sectors such as automotive, aerospace and metalwork were among the first to make use of these peculiar machines that were originally conceived to mimic and replicate the typical behaviour of a human arm; they were in fact initially called robotised arms.

When applied to shoe making, it was mostly in conjunction with the first automated lines for the manufacture of direct bottomed shoes. Their typical use was to perform specific operations such

as roughing the side of the shoe, flash trimming after the injection sequence and spraying release agent into the moulds; they therefore themselves acted like machines, executing well defined processing steps. This approach has survived until today and the majority of automation solutions seen on the market, including those for the manufacture of shoes with lasted uppers and cemented outsoles, are like that. Robots do the work on the shoes and, in some cases, transfer them from one point to another along the manufacturing line. This is not going to last for long, however, as new ideas are appearing that can change the way we conceive automation as applied to shoe making.

ORGANISATIONAL CHANGES

This also goes together with a change in the organisation of the manufacturing layout itself, moving from rigid set-ups with conveyor lines to more flexible and agile cell-based units served by robots. Forms of organisation in which workers are grouped in teams and use machines closely positioned in Kanban* cells, have been around for quite a while. They have become popular through being perfectly in line

with the manufacturing paradigm of the 'lean factory' which emphasises, among other factors, the centrality of human operators, their abilities and skills.

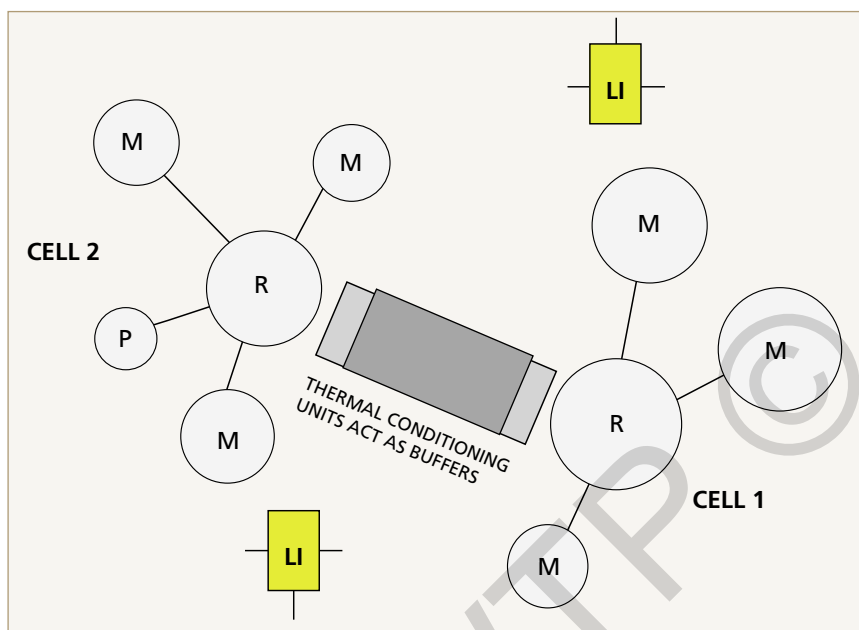
This is a valuable starting point for a revitalisation of this concept that takes further advantage of the thorough use of robots and their capabilities. It was the inspiration that led ATOMLab, the research and innovation division of ATOM Group, to develop, together with ATOM MB the division specialising in the manufacture of lasting and bottom preparation machines, RAMS: Robot Assisted Manufacturing System.

THE CELL

The basic element in RAMS is the single manufacturing cell. At the centre of each cell there is a handling robot which provides manipulation from machine to machine or from machines to work posts. Each cell incorporates two or more machines. These can be either specialised automatic or semi automatic shoe machines, or robots performing specific processing tasks on the shoe. Machines are connected logically to the Local Intelligence of the cell and physically to the hardware device that hosts it. This is either a classic PLC or a more advanced hardware device called FPGA (Field Programmable Gate Array) on which ATOMLab has been working for some time.

Cells can include a combination of machines and work posts with human operators or, in some cases, can be composed only of work posts attended by operators. Machines are connected to the Local Intelligence unit through a universal machine connector that ensures an easy configuration of the cell and plug to produce compatibility. This exploits two main functions by providing a power supply to each machine through a centralised cabinet that distributes power to the peripheral units and also carrying the data link between machines and the Local Intelligence unit. This is currently based on Ethernet, though other wired or wireless data communication standards such as ETERCAT are under evaluation.

Cells are linked one to the other, rather like a gigantic molecule, through Bonds. These provide both a cell-to-cell transfer capability and buffering between cells. Typically, they are thermal conditioning units such as heat setters, dryers, reactivators and chillers, performing



Cells are linked together by Bonds which are generally thermal conditioning units such as heat setters, etc.

thermal stabilising or activation functions. Complex systems can then be created, combining a number of cells and bonds. Finally, Local Intelligences communicate with each other through a high level bus for process synchronisation and supervision. Field data, machine status and product tracking data are fed to a SCADA supervisory control and data acquisition system and visualised through an appropriate HMI, human machine interface, on a cell and system level, as well as remotely through the cloud. This is a highly modular concept where single elements can be plugged one to another as with Lego bricks, to create very complex and sophisticated systems.

BENEFICIAL FEATURES

There are several features in RAMS that are worthy of comment. To begin with, it is designed to be fully compatible with standard lasts having no special provisions. We know that this, in one way or another, has been a factor in hindering the penetration of robot automation in many shoe companies. Asking them to adopt special lasts that also tend to be more expensive, is something that not all of them are ready to accept, especially if they produce relatively cheap products. RAMS is the first automation system that adjusts to the company's equipment and not vice versa. This has forced ATOMLab engineers to think of radically new ways of manipulating

both lasts and shoes.

The key element in this philosophy is the use of a patented adaptive gripper to comply with different last shapes and sizes. The gripper has four fingers and is very similar to a human hand in that it can gently but firmly hold the shoe, adapting to its shape and coping with the different sizes and structures lasts can exhibit. The fingers are controlled by a pneumatic system through which the appropriate gripping force can be set. It has been designed to handle lasts from the bottom side (where the outsole is attached), taking advantage of the fact that all the automatic machines used in the manufacturing process for pounding, pre-roughing, roughing and cementing, etc., all operate with the bottom of the shoe uppermost. However, there are also situations in which the last must be handled from the topside, where the thimble hole is located. ATOMLab is therefore designing another kind of smart gripper incorporating a high resolution camera, to firmly grab the last from that side to perform operations that require a different handling approach.

A typical element of rigidity in the current generation of robotic automation systems is the need to separate robots and operators by physical barriers due to the kind of robots that are typically used. In most cases, standard industrial robots are often preferred to cooperative ones because they tend to be faster and also, on average, cheaper. RAMS is designed



A four-fingered gripper gently but firmly holds the last or shoe, automatically adapting to its shape and size.

to work with no rigid protections because operator safety is guaranteed by active light barriers that slow the robots down when someone enters their working area and stops them completely when they get too close. As soon as the area is cleared, the robots resume working as if nothing had happened. This allows for rapid installation and flexible reconfigurations of manufacturing cells. With provisions of this sort, industrial robots can work like cooperative ones.

Another special feature of RAMS is called 'machine self awareness'. This means that every single machine, including handling robots that can be considered manipulation machines, must be aware of the environment around it, beginning with the capability of identifying the individual shoe to be processed. The enabling technology in this case is the Radio Frequency Identification (RFID) of each individual component of the shoe. In the current implementation of the system, every last is fitted with a thin, low cost RFID tag. This carries all the relevant identification and process data, and is interrogated by readers mounted on the machines and distributed around the cell. This allows a complete tracking of work in progress, especially if we consider that the use of RFID tags will soon be extended to all the main components of the shoe (it has already been tested in the upper and is going to be adopted in the insole, outsole and heel).

FURTHER ELEMENTS

Modularity and easy reconfiguration are other important aspects of RAMS. Its architecture is intrinsically modular, so simple cells, partial systems or complete manufacturing set-ups can all be created by 'plugging' together machines and robots in a very straightforward manner. Once the manufacturing sequence is defined and the machines selected, cells are created by placing machines in their defined positions, connecting them to the power supply and networking them with the Local Intelligence. Each cell is then physically connected to the others through the bonds described earlier and networked with the high-level system control unit.

This process is expected to be much easier and faster than in traditional systems partly due to the fact that, because of its compliance with the 'plug and produce' concept, machines will be automatically recognised by software modules at various levels that will not need any reprogramming. The only additional effort is specifying the picking points for the robots that need to be redefined every time a cell is configured, or a machine changed or moved. ATOMLab is working on this aspect, too, with the aim of giving the robots a self-adjusting capability whereby they will be able to understand how the workspace around them has changed and will correct their handling task accordingly.

FURTHER DEVELOPMENT

There are many new things along the path that ATOMLab is thinking to progressively introduce in order to expand the capability of RAMS. These include the incorporation of Augmented Reality technologies for the presentation to operators of process information and for machine maintenance, a full integration with the CAD/CAM software platform developed by Shoemaster International (another company in the ATOM Group) and, eventually, a complete harmonisation of its architecture with the Internet of Machine cloud base infrastructure that ATOM Group is building for all its equipment. RAMS is currently under intense development in cooperation with the first pilot customers who are working with ATOMLab to adopt the new technology as part of their manufacturing process.

Work on physical prototypes is proceeding hand in hand with the development of 'digital twins', a further concept that, together with advanced robotics, augmented reality and RFID tagging, are part of the Industry 4.0 framework. In this instance, a perfectly functioning copy of the real system also exists in the virtual world, where its operations can be studied and simulated in order to assess performance well ahead of the final implementation of the system. This allows it to work on many parallel virtual pilot plants while focusing on just one physical prototype, thus speeding up the whole development process.

RAMS is a new yet very promising manufacturing solution that, not without good reason, its designers have described as being 'human centric' because it has been conceived with the purpose of eliminating non added value operations in the manufacturing process while also giving the relevant roles of operators in the few highly demanding tasks that still remain, the highest possible value. This perfect synergy between high tech and high touch is ATOMLab's vision for the future of shoemaking.

**Kanban is a technique for managing a standard development process in a highly efficient manner. 🌀*