



Innovative Skills for an Old Vocation

Innovative Skills for Lasting

WP 04



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1 Introduction

This manual is a joint product of all partners from the Erasmus+ project "Innovative Skills for an Old Vocation" (ISOV, 2024-1-DE02-KA220-VET-000254492, <https://isov-project.eu/>). As all sectors, the sector of industrial footwear production faces the mega-trends of globalisation, digitalisation and sustainability. Main aims of the project are the development, pedagogical structuring and piloting of courses for apprentices, students and/or employees in industrial footwear production in Germany, Portugal and Romania, based on scientifically developed impact analyses on which of the dimensions of the trends influence which of the 18 Spheres of Activity (SoA) of the sector. The courses and the manuals refer to 12 chosen concrete SoA in which the participants are working, are supposed to work, or want to work.

Basic materials for the courses are the manuals. As the estimated impact of the dimensions respective sub-dimensions of the trends differ between partner countries and as the equipment of training providers with modern technology is differing, as well, the manuals follow a modular structure:

Chapter 2 documents the, partly shortened or updated, "state of the art" manual from previous projects "Integrating Companies in a Sustainable Apprenticeship System" (ICSAS, <http://icsas-project.eu/>) respective "Developing Innovative and Attractive Continuous Vocational Education and Training (DIA-CVET, <https://dia-cvet.eu/>).

Chapters 3-5 illustrate the expected impact of the various (sub-)dimensions of the 3 trends in the near future (up to 5 years) on the work-processes of the chosen SoA.

This approach has the huge advantage that, for example, if the sub-dimension "additive manufacturing" is estimated to have high impact on a certain SoA and a training provider has no 3-d printer, he can, with respect to this sub-dimension, rely on the "old" manual referring to subtractive manufacturing – but still impart the impact of other subdimensions, where the equipment is available.

Finally, chapter 6 offers a case study of apparent good practice, demonstrating not only what, but also exemplarily how to teach.

Or, to put it different, this manual should not be read as a "receipt", where all condiments should be added or imparted in a fixed row and a defined quantity – but as a "toolbox", aiming at inspiring trainers to impart not only "state of the art" knowledge, skills and competences (KSC) – but to prepare their apprentices, students or participants in continuous vocational education and training (CVET) for upcoming work-processes.

1.1 What the Lasting is about

Lasting: The upper lasted or pulled over and stuck down or tacked to the insole.

The upper is now 'lasted' or pulled over and stuck down or tacked to the insole.

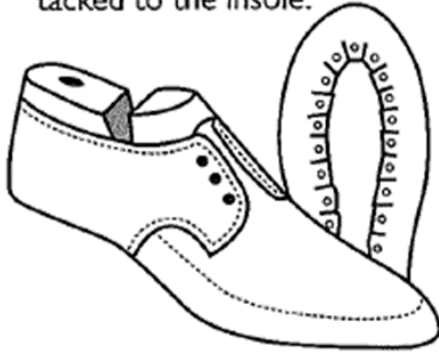


Fig. 1: The shoe lasting

Explain the different construction systems of the footwear models - specific characteristics and processes:

- Flat lasting/Cement lasting;
- Veldtschoen lasting;
- Slip lasting/Tubular / California / Strobel and Moccasin construction;
- String lasting;
- Goodyear lasting;
- Vulcanization lasting;
- Injection lasting.

Each construction method has a specific sequence of the lasting operations in accordance with the particular way of attaching the upper to the sole.

Explain the lasting operations, the production processes which your company uses.

This guide presents the essential subjects for the training, however these can be complemented with other sources of knowledge - books, teaching guides, ... in order to promote an autonomous professional performance in the trainees.

2 Manual from previous project

2.1 Footwear construction systems

Currently, we have a variety of styles of shoes and manufacturing techniques which are reflected in the assembly of footwear.

The footwear lasting involves the different connecting processes of the shoe elements - upper, insole and sole - according to the types of construction:

- Flat lasting/Cement lasting;
- Veldtschoen lasting;
- Slip lasting/Tubular / California / Strobel and Moccasin construction;
- String lasting;
- Goodyear lasting;
- Vulcanization lasting;
- Injection lasting;

The last is an essential element in the shoe lasting, considering the purpose of giving volume and shape, modelling the upper. After a correct use of the last the upper maintains its shape after the last has been removed. The last design must be in accordance with the design of the footwear model.

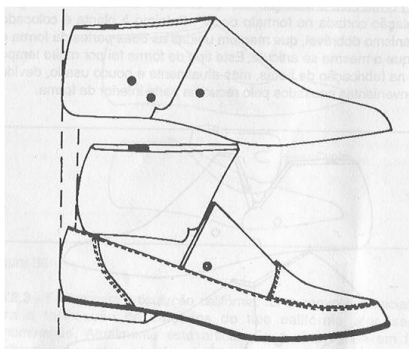


Fig. 2: The last

The lasting operations of the shoe are developed after the preparation operations of the upper, the components and the respective sole.

The correct preparation of the upper is fundamental for the quality of the lasting and the shoe: application and moulding of reinforcements, application of the system for closing the quarters, ...

Pre-lasting checks:

Regardless of the construction method to be used:

- The upper is sewn properly;
- The size of the upper and the components are according to the size of the last;
- The quarter tightening system is correct;
- The materials for the lasting are suitable and compatible with the materials of the shoe.

These are the important factors for efficient shoe lasting.

2.1.1 Flat lasting / Cement lasting

This lasting type is the most usual in different types of footwear and different materials.

Characteristics:

- The lasting edge is turned to the inside of the shoe and it is attached upon the insole through the glue;
- The sole is attached to the insole and to the upper through the adhesive/glue and/or the tacks/nails.



Fig. 3: The shoes with flat or cement lasting

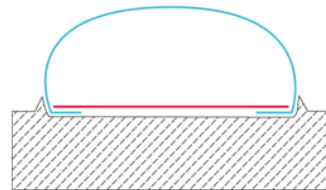


Fig. 4: Scheme of the flat or cement lasting

Traditionally, this type of the lasting has 2 or 3 operations:

- Forepart lasting;
- Side and seat lasting;
- or
- Forepart lasting;
- Side lasting;
- Seat lasting.

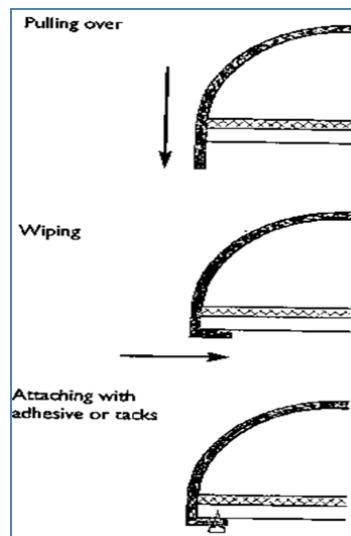


Fig. 5: Scheme of the flat or cement lasting

In support of the lasting, the uppers must be conditioned in the heat setting machine in order to better adapt the materials to the shape of the last, maintaining their characteristics and quality.

2.1.2 Veldtschoen lasting

Characteristics:

- The lasting edge is turned to the outside of the shoe;
- The upper is attached to the insole through a seam;
- The sole can also be sewn



Fig. 6: Shoe of the Veldtschoen lasting

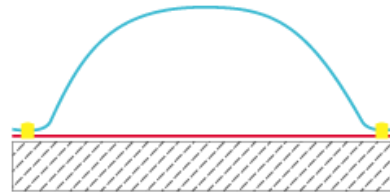


Fig. 7: Scheme of the Veldtschoen lasting

2.1.3 Slip lasting/ Tubular / California / Strobel/ Moccasin

This type of construction is often used in sports, comfort and safety shoes.

The main feature of this type of lasting: the upper is sewn to the insole making a bag. There is no lasting allowance. The last is introduced in under pressure.



Fig. 8: Slip lasting shoe

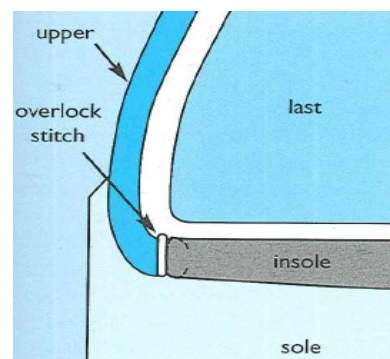


Fig. 9: Scheme of the slip lasting

In order to join the upper to the insole different types of seams, as well as the tubular construction, may be chosen.



Fig. 10: California lasting shoe



Characteristics California Lasting:

- The insole (in cloth or leather), the upper and the edge cover are sewn together at the top. All the construction is based on this seam;
- There is no real lasting;
- The shoe is shaped and the edge cover is turned inwards.
- The sole is attached/glued by the normal process;
- No insock is required.

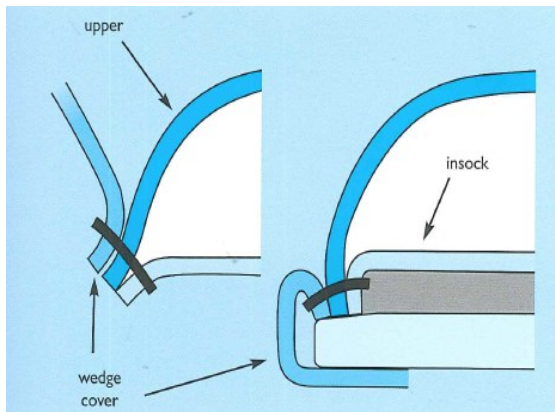


Fig. 11: Scheme of the California lasting

2.1.3.1 Strobel lasting

This is a similar construction which is characterized by sewing the upper to the insole through a specific seam; it took the name of the machine in which it is made - Strobel.

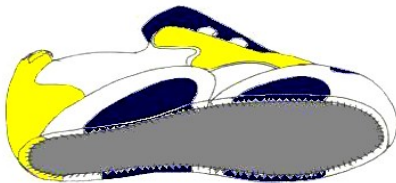


Fig. 12: Strobel lasting shoe

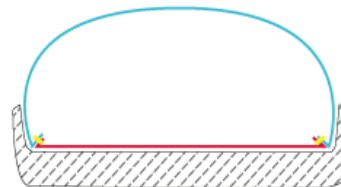


Fig. 13: Scheme of the Strobel lasting

2.1.4 Mocassin lasting

The mocassin lasting can be considered a variant. The upper acts as the insole and it is extensive to enclose the lateral part of the foot with an "apron" or a coupled part so, by using the seam to attach this part of the shoe to the upper, it also becomes decorative.

Characteristics:

- Bag-shaped shoe made from a piece of leather (upper) that surrounds the plantar surface, manually sewn to an apron;
- The upper is sewn to the sole (although the original mocassin did not have sole).



Fig. 14: Mocassin shoe



Fig. 15: Scheme of the moccasin lasting

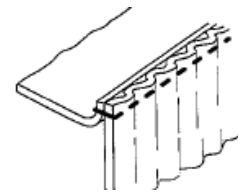


Fig. 16: Mocassin seam

2.1.5 String lasting

Construction system similar to the flat or cement lasting, under pressure to prevent the spreading of the upper/vamp over the last, tightening the lasting edge on the plantar surface of the insole.

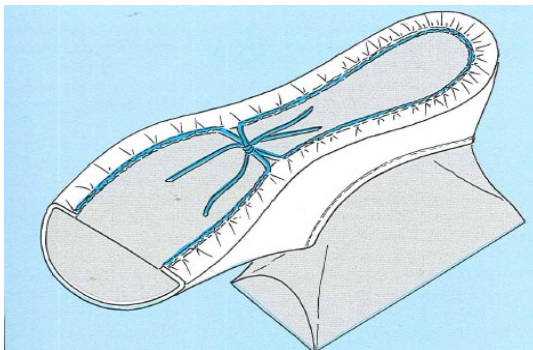


Fig. 17: String construction 1

After all the components of the upper/vamp have been sewn together, a strong thread is applied around the lasting edge of the upper/vamp using a specific sewing machine.

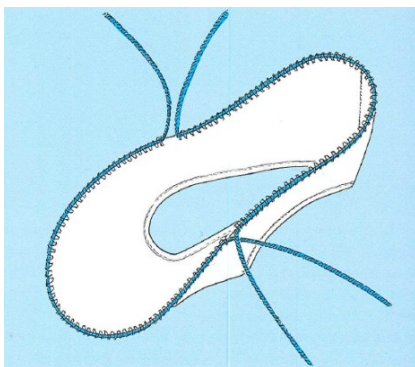


Fig. 18: String construction 2

Then the upper/vamp is placed either straight over the last or over the last of the moulding machine. Finally the thread should be well stretched, thus pulling the upper over the last. This operation can be performed manually or mechanically.

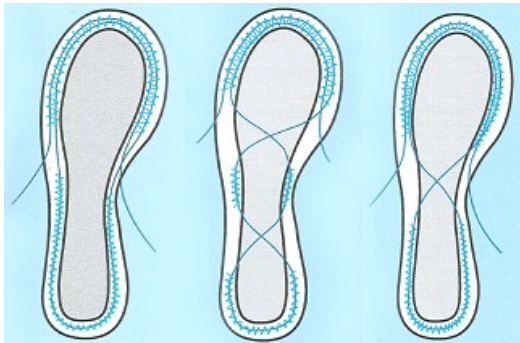


Fig. 19: String construction 3

This type of construction is widely used when there is application of the sole by injection system.

2.1.6 Goodyear lasting

Goodyear construction consists of the following elements: Upper, Insole, Shank, Midsole, Welt, Sole.

Characteristics:

- Use a insole with a pre-cemented rib;
- The lasting edge is turned towards the inside of the shoe;
- The surplus material must be eliminated,
- The welt, the upper and the rib are stitched. This seam is not visible in the finished shoe.
- The filling is used to fill the space to the height of the rib. This filling also brings a supplementary comfort.
- The midsole or the sole is attached to the welt through the seam. This seam is visible in the finished shoe.



Fig. 20: Goodyear lasting shoe

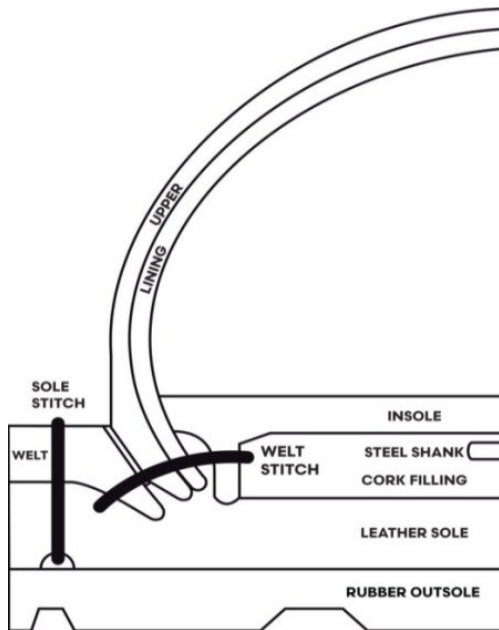


Fig. 21: Scheme of the Goodyear lasting

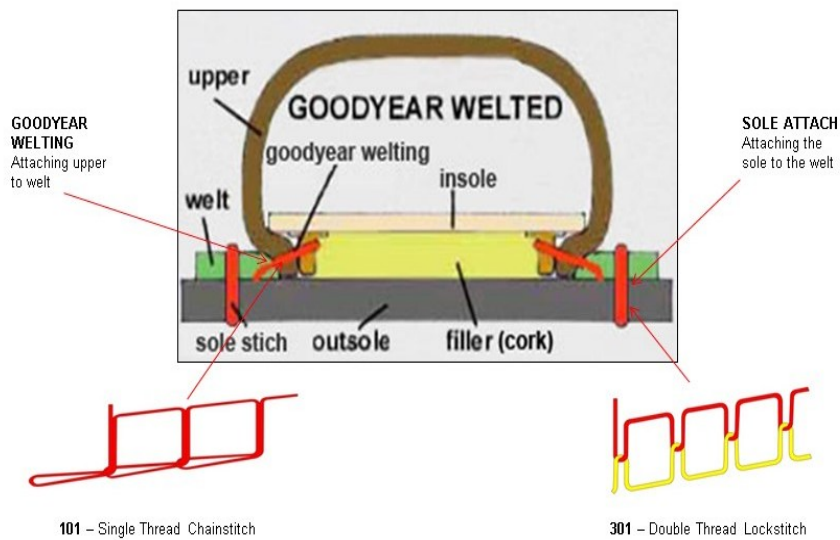


Fig. 22: Scheme of the Goodyear lasting;

<http://www.coatsindustrial.com/pt/information-hub/footwear-expertise/goodyear-welted-footwear>

2.1.7 Vulcanization Lasting

Characteristics:

- The upper preparation is similar to the California, Moccasin or "String-lasting";
- The last is made of metal;
- Rubber strips are applied in a mould;
- The mould is closed (last with the upper) and subject to heating - vulcanization;
- After the operation, the sole has the desired configuration



Fig. 23: Vulcanization lasting shoe

2.1.8 Injection Lasting

Characteristics:

- Technically, it could use any lasting type as a base, however the most used are: Tubular, moccasin, string lasting.
- The last is made of metal;
- A heel is placed;
- The mould is closed by the shoe already assembled on the last;
- The granulate is liquefied and injected - PU, TR and PVC;
- The sole can present various profiles, imitations, colours or combinations – different design.

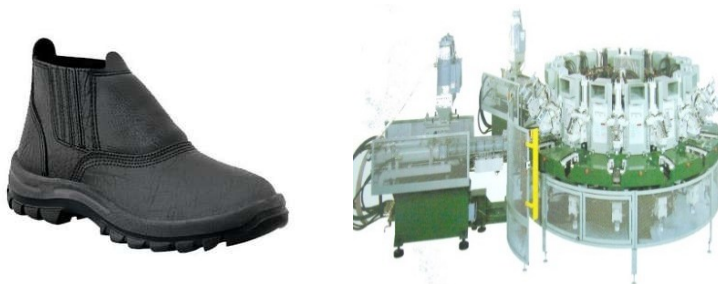


Fig. 24: Injection lasting shoe

2.2 Lasting Operations, Machines and Tools

2.2.1 Last

The last is a utensil used in the process of creating and manufacturing footwear, replacing the foot in this process.

The final appearance of the shoe and the comfort of the foot depend, to a large extent, on a good design and proportionality of the measures of the last.

2.2.1.1 Functions of the last

- Reproduce the characteristics and dimensions of the human foot;
- Serve as base for the dimensioning of the parts that make up the footwear;
- Serve as base for the assembly and finishing of footwear;
- Determine the style/design of the shoe in its development.



Fig. 25: Lasts

2.2.1.2 Materials

PVC, wood, metal. PVC is the best alternative for the manufacture of lasts. The material is generally polyethylene of medium or high density, which determines good properties in abrasion resistance, high temperatures and deformation. The metal is used for vulcanization and direct injection.



Fig. 26: The last: replace the foot in the design and manufacture of the shoe

2.2.1.3 Elements of the last

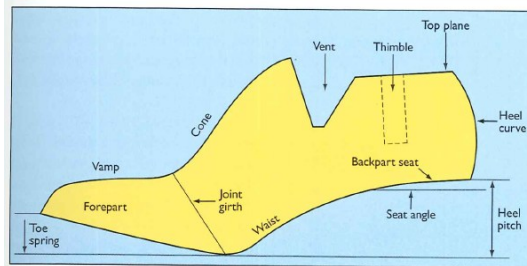
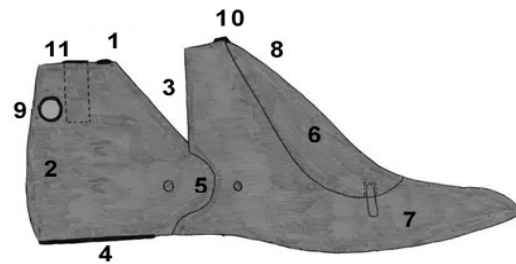


Fig. 27: Elements of the last



There are elements in the last that offer specific and complementary information that facilitate a correct use

- | | |
|-----------------|---------------------------------|
| 1. Coloured dot | 7. Scoop block fixing pin |
| 2. Reference | 8. Spring |
| 3. Size | 9. Hole for manually unmoulding |
| 4. Metal sheet | 10. Scoop block's position hook |
| 5. Hinge | 11. Thimble |
| 6. Scoop | |

2.2.2 Applying the insole to the last

2.2.2.1 Insole

The piece that represents the plantar surface of the foot, located on the sole, reinforcing it and serving as support to the lasting edge of the upper.

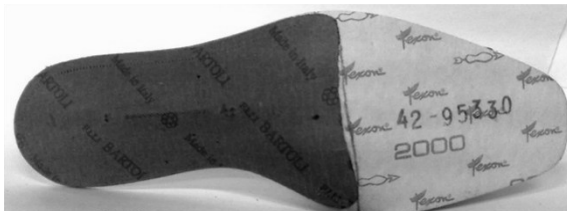


Fig. 28: The insole

Materials

Cardboard, leather, fabric, reinforcement screen, carbon, steel ...



Fig. 29: Insole: pieces

The elements

The insole base – Represents the foot plantar surface.

The shank – Steel elongated piece placed between the plantar and the heel to give stability and support the curvature of the plantar vault.

Reinforcement of the insole or heel - Reinforcement piece located at the back of the insole, allowing a correct fixation of both the shank and heel.

Function: The insole serves to support the lasting edge of the upper and its temporary fixing to the last is necessary during the assembly process.

Different means can be used:

- Staples / Nails
- Glue/Adhesives
- Band
- Pins (Unifast System)



Fig. 30: How to attach an insole using the machine

2.2.2.2 Application on the last

The position of the insole on the last depends of the lasting type

Flat/cement lasting: The edge of the insole should be 0.5 to 1mm inside the last's featheredge.

Veldtschoen lasting: The insole edge should be about 18mm from the last's featheredge.

Goodyear lasting: The edge of the insole should be at the last's featheredge, with the edge of the rib (part placed in the insole serving as a support for the upper edge) being placed between 3 and 4 mm from the edge of the insole.

There are other lasting types, such as California, Goodyear, Injected, Vulcanized, etc., in which the insole is already applied in the sewing sector

2.2.2.3 Safety and health

- Remove your hands from the staple outlets of the stapling machine - avoid perforations on the skin;
- Remove your hands from the glue injectors of the attaching insoles machine - avoid burns;
- Remove your hands from the machine stopper of the attaching insoles machine - avoid entrapment;
- Switch off the machine whenever it is not needed.

2.2.3 Glue/Adhesives

2.2.3.1 Glue/adhesives

Sticky substance used to join two surfaces, whether of the same nature (Rubber with rubber) or of a different nature (Rubber with leather).

2.2.3.2 Bonding / cement

The bonding of two surfaces through a chemical which is the glue.

For a good bonding it is necessary that

- The glue adheres well to surfaces - ADHESION.
- Ensure the bonding of these surfaces through two glue films, allowing them to interlace to become one, very compact and well cohesive - COHESION

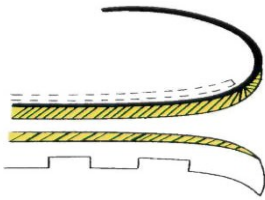


Fig. 31: Glue adhesion process in materials

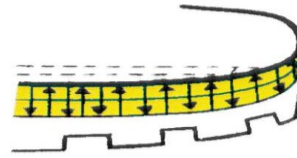


Fig. 32: Cohesion of the glue in the gluing process

2.2.3.3 Types of the glues/adhesives

Aqueous glues

Aqueous base composition; absence of toxicity; (e.g. bonding of certain types of linings, bonding of counters and socks); it can't resist the action of plasticizers and materials with high grease content.

Solvent glues

Composition based on organic solvents, very toxic and flammable; Used in operations subject to great efforts - for bonding soles.

- Polychloroprene / Neoprene
- Polyurethane

Hot-Melt glues

Move from solid to liquid under the action of heat.

These are used in various machines and especially in forepart lasting and side and seat lasting machines. They may be presented in granules or in string.



Fig. 33: Hot-melt glues

Glues	Characteristics
Polyamide	• Polyamide based. • Drying time 3-6 sec. • Melting temperature 160 ° C
Polyester	• Polyester based. • Drying time approx. 3 sec. • Melting temperature approx.230 ° C

Fig. 34: Tabel of glues

2.2.4 Toe puff moulding

2.2.4.1 Humidify and / or reactivate toe cap

This operation makes the toe puff malleable and increases the malleability of the leather, so that through the lasting process of the toe cap, it moulds properly to the last.

There are certain materials that can't be subjected to water vapour and / or high temperatures (above 60°C), such as: Crust, nubuck, suede, some synthetic materials (vinyl, lycra, etc.)



Fig. 35: Operate in the moulding machine



Fig. 36: Operate in the moulding machine

2.2.4.2 Safety and health

- Keep hands away from moulds - avoid skin burns;
- Switch off the machine whenever it is not needed.

2.2.5 Forepart lasting



Fig. 37: Forepart lasting machine

The upper is moulded onto the last (cap and sides) and fixed through glue, applied directly by the machine (fusible glue), or manually applied in the pre-assembly stage.

This operation is extremely important because it is from here that the shoe starts to take shape.



Fig. 38: Position the upper on the last

It is possible to detect any problems coming from previous manufacturing sectors:

- Technical pattern making errors;
- Incorrectly shaped counters;
- Incorrectly moulded uppers;
- Leather defects;
- Leather with little malleability;
- Incorrect stretching direction;
- Misplaced parts;
- Irregular stitching;
- Lack of seams;
- Irregular punches;
- etc.



Fig. 39: Centre the shoe in relation to the pincers and teflon

The equipment must be pre-prepared taking into account the characteristics of the last (toe type, width and high or low heel) and material (skin resistance, malleability and lasting edge width) to avoid or minimize defects.

Prepare the equipment taking into account the characteristics of the last and material:

1. Teflon
2. Glue injector
3. Glue nozzles
4. Plates
5. Pincers/Tweezers
6. Table, boat or elevator

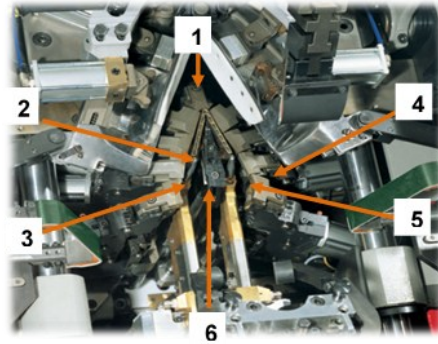


Fig. 40: Prepare the equipment considering the last and material

In order for the shoe to be lasted correctly, certain factors must be taken into account:

- Set the pincers pressure (medium pressure 6 to 8 bar)
- Define hammer pressure (average pressure from 2 to 6 bar)
- Define the teflon pressure (average pressure from 2 to 4 bar)
- Adjust the temperature of the fusible glue (240 ° C to 280 ° C)
- Humidifying or reactivating the toe puff;
- Centre the upper on the last;
- Position the last next to the toe pincers;
- Standardise the length of the toe according to the size of the shoe;
- Adjust the upper to the last;
- Finish the operation after performing the previous items

2.2.5.1 Solutions for any problems

Folds in the forepart area

- adjust the teflon to the toe of the last;
- decrease elevator route;
- reactivate and / or humidify the upper toe;
- increase hammer pressure without marking the leather

Cracked / broken upper in the toe area

- decrease elevator route;
- decrease elevator speed;
- adjust the elevator by positioning it so that the pincers catch less material;
- decrease reactivation and / or humidification;
- position the table with the same inclination of the pincers.

Folded or creased insole

- increase elevator route;
- check the positioning of the insole on the last (0.5 to 1mm inside the featheredge of the last);
- increase the distance of the pincers from the last (0.5 to 1cm);
- position the table with the same inclination of the pincers;
- check the position of the heel support in relation to the last (focus on the heel zone);
- check the position of the hammer (must be between the toes and the instep).

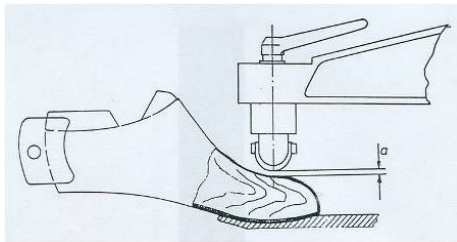


Fig. 41: The Importance of the Machine Adjustment and the correct positioning of the shoe

2.2.5.2 Safety and health

- Keep the machine engine off while making the necessary adjustments;
- Remove hands from the pincers/tweezers - avoid bruising the fingers;
- Keep your hands off the back of the heel - avoid getting caught;
- Remove your hands from the injectors of the glue - avoid burns;
- Use protective gloves - avoid burns caused by the fusible glue;
- Activate the safety device of the machine (knee pad) in case of emergency;
- Switch off the machine whenever it is not needed.

2.2.5.3 Setting the height of the heel counter

It allows to position the heel counter in its correct measurement. The comfort of the foot while walking strongly depends on the height of the heel counter; if it is lower than the appropriate measure, the foot comes out of the shoe and if it is higher it is uncomfortable and it may even injure the Achilles tendon.



Fig. 42: Lasting pliers: tool to adjust the height of the shoe

The height of the heel counter, depends on the size and heel of the shoe:

- High-heeled shoe:

$$\text{Heel counter Height} = \text{Size} \times 4/3 + 5 \text{ or } 6 \text{ (mm)}$$

- Low heeled shoe:

$$\text{Heel counter Height} = \text{Size} \times 4/3 + 8 \text{ (mm)}.$$

These formulas are not applied rigidly, it depends on the company, the aesthetic touch and the characteristics of the model.

In a practical and faster way there are those who use the formula: Size + 20 (mm).

2.2.5.4 Safety and health

- Use the support of the last - avoid excessive effort;
- Remove your hands from the lasting pliers when pulling the heel counter to the desired position - avoid bruising.

2.2.6 Side and Seat lasting

The upper is moulded onto the last (side and back) and fixed through glue, applied directly by the machine (fusible glue) or manually applied at the pre-assembly stage (solvent glue).

Note: The quarters, inner and outer, must be at the same level. The outer quarter should never be higher than the inner because it causes discomfort due to the actual anatomy of the foot.

When the sides are closed manually, the inner quarter must be the first one to be glued, as it facilitates the positioning of the outer quarte.

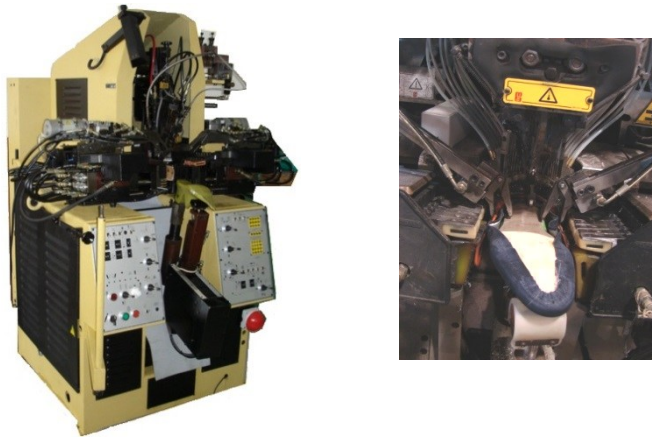


Fig. 43: Side and seat lasting machine

The equipment must be pre-prepared taking into account the last's characteristics (size, height and width) and the thickness of the material:

1. Teflon
2. Pincers
3. Fingers
4. Toe support
5. Side support

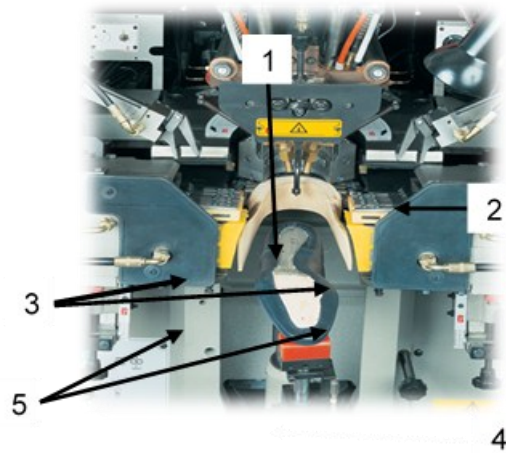


Fig. 44: Machine adjustment: Teflon's sorting and positioning, pincers positioning, toe and side support, proper pressure

2.2.6.1 Solutions for any problems

Change in height of heel counter

- increase or decrease the elevator route;
- raising or lowering the toe cap support;
- moving away or bringing closer the last's support block in relation to the teflon (about 0,5 cm);
- position the hammer so that the insole is at the teflon level

Cracked/broken upper in the heel zone

- decrease the elevator route and/or lower the hammer;
- increase the reactivation

Folded or creased insole

- lower the elevator route so that the insole is at the teflon level;
- position the toe cap support so that the last is horizontal;
- position the last's side supports so that the fingers adjust to the insole as much as possible.

Insufficient sealing of the quarters

- position the last side supports so that the fingers adjust to the insole as much as possible;
- position the toe cap support so that the last is horizontal;
- lower the position of the lateral pincers in order to grasp more material.

2.2.6.2 Safety and health

- Position the foot next to the emergency pedal when making the necessary adjustments;
- Wear protective gloves - avoid burns on the skin caused by the fusible glue;
- Switch off the machine whenever it is not needed.

2.3 Conditioning units / Steamers/Heat setting

The quality of the product and the efficiency of the production processes imply the use of transport equipment, conditioning equipment, drying tunnels, humidification of the uppers and reactivation of glues. In addition to the fastness of transport between workstations, there are important technical aspects to the efficiency of the lasting operations and the quality of the product.

2.3.1 Conditioning units / Steamers

Automatic equipment that through humidification or humidification and heat conditions/shapes the materials to the last, promoting a greater effectiveness in the footwear lasting operations and a better configuration of the shoe. It also promotes the transport of the product between workstations.

2.3.1.1 Heat Setting

This equipment usually associate heat with the air circulation, which promote a contracting action of the materials and a consequent moulding of the shoe to the last, ensuring a correct size and a better configuration of the shoe. With the association of hot air circulation, they become fast acting means and consequently contribute to reduced production times. However, its use requires considering the characteristics of the materials and a preparation and compatible regulations.

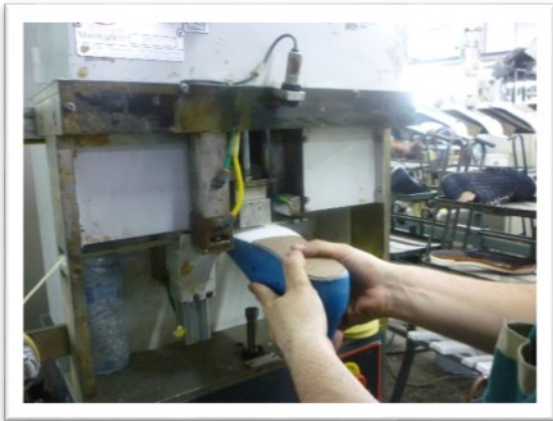


Fig. 45: Heat setting

Material	Process
Suede, nubuck and floater leather	Moist air at 120°C / Dry air at 120° - 130°C
PVC - coated leathers	Dry air at 120° - 130°C
PU and PVC - coated leathers	Dry air at 100°C
PU - coated materials	Dry air at 120°C
PVC - coated materials	Dry air at 100°C
Fabrics	Dry air at 100°C

Fig. 46: SATRA Recommendations. These values are just reference points. Each equipment and its technology must be taken into account

2.4 Example: Lasting at Carité / Portugal



Work-based learning / Applying the insole on the last; Source: Carité



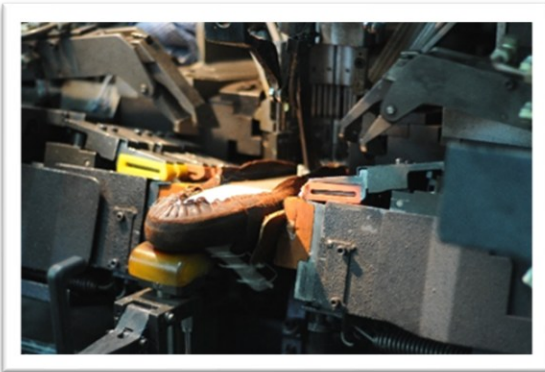
Work-based learning / Positioning upper on the last; Source: Carité



Work-based learning / Forepart lasting; Source: Carité



Work-based learning / Heat setting machine;
Source: Carité



Work-based learning / Side and seat lasting; Source: Carité



Work-based learning / Side and seat lasting;
Source: Carité

3 Globalisation in Lasting

Globalisation has had a significant impact on industrial processes in the footwear, as well as in lasting sector. As markets have become increasingly interconnected, companies have begun to adopt technologies, materials and production methods from different parts of the world. This has led to improved efficiency, reduced costs and higher quality end products.

In the lasting process, globalisation has facilitated access to more advanced adhesives, automated equipment and international quality and safety standards. At the same time, it has promoted the standardisation of technical procedures, ensuring greater consistency between production batches manufactured in different countries.

3.1 Demographic Factors

- A falling birth rate and a longer working life
- Changes in values and cultures

Demographic change determines how people move and migrate. Whether a population is growing or declining, ageing or young, has an impact on economic growth and employment opportunities in countries of origin, as well as on migration policies in countries of destination.

Demographic and economic migration is linked to poor labour market conditions, high unemployment and the overall health of a country's economy. Pull factors include higher wages, better employment opportunities, a higher standard of living and educational opportunities. If economic conditions are unfavourable and appear to be at risk of deteriorating, a greater number of people are likely to emigrate to countries with better prospects in these areas.

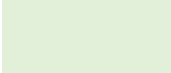
The decline in the birth rate is a global phenomenon, driven by factors such as increased educational attainment among women, women's emancipation, access to contraception, economic uncertainty and changes in lifestyle, leading to women having children later in life and fewer children per woman, resulting in an ageing population. The strain on healthcare and pension systems, and the need for labour, with national records of reduced natality, lead to an insufficient replacement rate. Within lasting sector, how can these situations be resolved?

	Implement measures that work as family support policies (benefits, parental leave, child care, and other measures adapted to each company)
	Promote internal support policies on gender equality to share parenting responsibilities
	To ensure the timely transfer of knowledge and skills from older to younger generations, thereby enabling the continuity of the work
	Improving economic conditions and job security

Globalisation has been bringing about profound changes in the values and organisational cultures of the footwear sector, which are also reflected in technical processes such as lasting. The interaction between different cultural contexts and industrial practices has led to the adoption of new standards of quality, efficiency and responsibility, influencing the way work is carried out in the production environment.

In lasting, these changes are reflected in the adoption of more sustainable methods, a greater emphasis on workplace safety, and growing concern about the environmental impact of the adhesives used. At the same time, there is a greater diversity of technical approaches, resulting from the sharing of knowledge across different countries and cultures.

This context requires professionals not only to possess technical skills, but also the ability to adapt to different standards, values and ways of organising work. Globalisation thus contributes to a more dynamic and demanding working environment, where the quality of sole bonding depends as much on technical precision as on an understanding of global practices and emerging values. How can we integrate this subject in lasting processes?



Incorporate international best practices in sustainability, whilst promoting ongoing training in this area



Organise training initiatives on workplace ethics, working conditions and teamwork, in line with international standards and the company's objectives



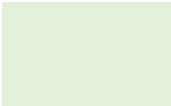
Promote a balance between the preservation of traditional techniques and the adoption of global practices

3.2 Economic and Social Factors

- Product diversification
- Change in consumption standards

Globalisation has played a decisive role in the diversification of products used in footwear manufacturing, fostering integration between different markets and supply chains. Trade liberalisation and technological advances have facilitated access to innovative materials from various parts of the world, such as eco-friendly adhesives and threads to stitch the soles.

This product diversity enables companies in the footwear sector to boost their competitiveness, respond more effectively to international trends and adapt swiftly to the demands of consumers, who are increasingly seeking comfort, sustainability and distinctive design. Globalisation therefore not only broadens the scope for choice and innovation, but also underscores the importance of efficient supply chain management and quality control in the production process. In lasting, this means that the change must be observed in:



Encourage the sharing of technical specifications for new products and components with footwear lasting workers, so that everyone is aware of their technical characteristics



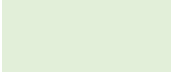
Teach how to carry out all the necessary adjustments and calibrations to equipment and tools suited to new materials and types of footwear



Promote greater flexibility on production lines, requiring more agile working methods, cross-functional teams and efficient resource management

Globalisation has brought significant changes in consumption patterns, directly influencing the footwear industry. Today's consumers are better informed, more discerning and exposed to global trends, which translates into a growing demand for distinctive, sustainable, high-quality and, increasingly, personalised products. At the same time, the speed at which trends spread shortens product life cycles, forcing companies to respond with greater agility and adaptability.

In the context of lasting, these changes entail a transformation of traditional production processes. It is no longer sufficient to produce standardised models on a large scale; it has become essential to ensure the flexibility to produce smaller, more diverse batches whilst maintaining high quality standards. The pressure to reduce response times and increase efficiency necessitates the reorganisation of lasting lines, improved communication between departments, and the adoption of technologies that support rapid and informed decision-making. To respond effectively to these new consumption patterns, the following measures should be implemented in the lasting process:

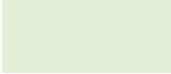
-  Making production systems more flexible, enabling rapid adjustments to new collections and customer specifications
-  Strengthening collaboration throughout the value chain, from suppliers to distribution, ensuring a faster and more consistent response to the market
-  Integration of sustainable practices, in response to growing consumer concern about environmental impact
-  Ongoing staff development, fostering technical skills and adaptability to new requirements

3.3 Changes in Qualifications/Training/Knowledge

- Developments in qualifications and employability
- Technological evolution

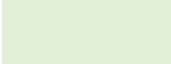
The footwear sector has undergone a profound transformation. What was once an essentially artisanal and manual craft has evolved into a cutting-edge technological industry. This evolution means that, in lasting, must move beyond the role of mere labourers to become specialised operators, capable of addressing issues of digitalisation and sustainability.

Employability today depends not only on speed of execution, but also on versatility. The introduction of computerised lasting machines and laser cutting systems requires basic digital skills and the ability to identify faults in the production flow. To ensure competitiveness in the labour market and the efficiency of the lasting production line, the following practices are recommended:

-  Training in new technologies: mastering the basic programming of automatic lasting machines and UV bonding systems
-  Sustainability literacy: understanding the properties of new eco-sustainable materials (such as biopolymers or recycled films), which require different drying temperatures and times to traditional materials
-  Functional versatility: gaining experience in various roles within the lasting line (from setting up the upper to finishing). A professional who understands the process from start to finish is far more resilient to market changes

The footwear industry has evolved from a labour-intensive sector into a hub of technological innovation. The transition from manual lasting to automated and digital systems is not intended to replace workers, but rather to enhance their precision and reduce the physical strain of repetitive tasks.

The introduction of robotic arms for roughing and glue application, as well as computer-controlled machines for lasting the cap and seat sections, enables a level of uniformity that manual processes rarely achieved. This technological advancement requires the assembly operator to evolve into a systems manager, capable of interpreting data and adjusting parameters in real time. To keep pace with this technological leap and ensure maximum efficiency on the lasting line, the following guidelines are recommended:



Sustainability in processes: implement UV or infrared drying and bonding systems, which are faster and more energy-efficient than traditional ovens



Advanced ergonomics: using technology to adjust workstation heights and material flow, thereby reducing joint strain on staff



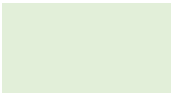
Golden rule: technology is a precision tool. The success of modern shoe lasting lies in the synergy between the master shoemaker's 'keen eye' and the accuracy of the software

3.4 Markets and Consumers

- Technological developments in commerce and industrial processes
- Product diversification

Technological progress in the footwear sector does not take place in isolation within the factory; it is a direct response to the new demands of global trade. Today, the speed at which a consumer orders a pair of shoes online dictates the pace of the production line. This integration between the sales front and the factory floor is what defines the country's competitiveness.

In the lasting section, technology has been moving beyond the purely mechanical to the digital realm, allowing operations such as the adjustment of pressure and temperature according to the model entering the production line, which is identified via RFID or barcode. The practical application of this development is reflected in three key pillars:



Introduction of collaborative robotics: in glue application and roughing, the robots work side by side with the operator, ensuring millimetre-level precision that prevents waste and improves sole adhesion



Smart logistics: the lasting line is now linked to smart warehouses that release components (uppers, soles) only at the precise moment of production (Just-in-Time)



Create a digital simulation of the lasting line to identify bottlenecks before starting production of a new collection

Globalisation is no longer simply about exporting large batches, but has become a challenge requiring an immediate response to global trends. Competitiveness does not lie in volume, but in product diversification — the ability to produce a variety of models, using different materials and catering to specific niche markets (luxury, sports, orthopaedic or sustainable) on a single production line.

Diversification requires the lasting department to be the 'elastic heart' of the factory. Whilst global trade demands speed, assembly requires precision. The practical application of this strategy is evident in the constant adaptation of:

Material hybridisation: with globalisation, a range of technical materials has emerged (neoprene, 3D knits, exotic leathers). During lasting, different bonding pressures and temperatures must be applied depending on the reactivity of each component

Digital traceability: using data-reading systems that automatically inform the machine of the exact pressure to be applied to the sole of a specific model that has just arrived at the press

Multicultural quality control: training staff to meet the specific requirements of each market

3.5 Regulation and Legislation

- Compliance

In the context of globalisation, footwear production is governed by a strict legislative framework that acts as a guarantee of quality and access to international markets. It is not enough simply to last a shoe; it is necessary to ensure that the entire assembly process and the components used comply with safety, health and environmental protection directives, such as the European Union's REACH regulation.

Legislation prohibits the use of hazardous chemicals (such as hexavalent chromium or certain adhesives containing harmful solvents) during lasting. Compliance with these standards is vital for exporting to demanding markets.

Depending on the type of footwear (such as safety or work footwear), the construction must comply with standard EN ISO 20345, which sets out requirements for the steel toe cap, sole puncture resistance and slip-resistant properties. In lasting sector is very important to improve these measures:

Keep up-to-date in mother tongue at workstations where adhesives and primers are applied, ensuring that operators are aware of the risks and the necessary PPE (Personal Protective Equipment)

Adjust lasting workstations in accordance with ergonomic standards to reduce musculoskeletal injuries, thereby reducing absenteeism and increasing productivity

4 Sustainability in Lasting

Sustainability in footwear lasting plays a key role in reducing the industry's environmental impact. This process should prioritise the efficient use of materials and equipment, minimising waste whenever possible. Choosing components with a smaller ecological footprint, such as water-based adhesives and recycled or certified raw materials, also contributes to more responsible practices. Furthermore, sustainability at this stage must incorporate a circular economy approach.

This involves designing footwear that is easier to dismantle at the end of its useful life, thereby facilitating the recycling or reuse of its components. In this case, the lasting process should prioritise techniques that allow materials to be separated without compromising the product's quality and durability.

4.1 Green Awareness

- Education for sustainability
- Eco-labelling for footwear & digital transparency

Education for sustainability involves integrating environmental, social, and economic principles into the organisational culture. In the footwear lasting sector, this training should encompass all levels of the company, from management to line operators. It is important, therefore, to promote responsible practices within the entire production process. Workers must be made aware of the importance of using resources efficiently, reducing waste, thereby contributing to a more sustainable working environment. Training should include:

- Awareness of the responsible use of materials and energy
- Knowledge of applicable environmental standards
- Good practices for occupational health and safety
- Promotion of preventive and responsible behaviours

Eco-labelling in footwear manufacturing is an important tool for communicating a product's environmental performance throughout its life cycle. Through recognised labels and certifications, it is possible to provide clear information on the origin of materials, the production processes used and compliance with specific environmental criteria.

During the lasting phase, care must be taken to ensure that the components used are correctly identified, thereby guaranteeing traceability and compliance with the requirements set out by eco-labelling schemes. This involves selecting certified suppliers, using safe substances and reducing the environmental impacts associated with manufacturing. Therefore, workers must observe the following points:

- Consumption of natural resources during production
- Chemicals used and their compliance with applicable regulations
- Be aware of the possibility of reusing, repairing and recycling

4.2 Sustainable Design & Circular Economy

- Reusability, repairability, disassembly & recycling
- Sustainable, biodegradable & regional materials selection

Sustainability in the lasting sector must be integrated into a life cycle perspective, promoting the efficient use of resources and reducing environmental impact at all stages of the product. Reuse, repair, disassemble and recycle are fundamental pillars of an approach aligned with the principles of the circular economy, contributing to waste reduction and material recovery.

Reuse - consists of using the product for the same purpose for which it was designed, without significant changes to its structure. In the context of footwear, it should be promoted through:

- Durable and resistant products
- Using high-quality materials
- Encouraging donation, resale or second-hand reuse
- Collection and redistribution programmes

Repair - allows footwear to be restored to working order, preventing its premature disposal. To facilitate this process, the following measures should be adopted:

- Development of models with replaceable components (e.g. soles, insoles, laces)
- Availability of replacement parts
- Provision of clear maintenance and repair instructions

Disassemble - is an essential process for enabling the efficient separation of the different materials that make up footwear. A design geared towards disassembly should:

- Minimise the use of permanent adhesives and complex mixtures of materials
- Favour assembly systems that allow mechanical separation
- Clearly identify the materials used
- Incorporate eco-design criteria from the product development stage onwards

Recycle - consists of transforming waste into new raw materials or products. In the footwear sector, it must be ensured that:

- Materials are selected with a view to their recyclability
- There is adequate segregation of components after disassembly; Recyclable materials with recycled content are preferred
- There is adequate segregation of components after disassembly

The selection of sustainable, biodegradable and locally sourced materials is a key factor in reducing the environmental impact of footwear manufacturing. In lasting sector, priority should be given to the use of raw materials from renewable sources, produced using responsible manufacturing processes and backed by recognised certifications, whilst ensuring quality and performance.

Choosing biodegradable materials helps to reduce waste at the end of a product's life cycle, facilitating its natural decomposition and easing the strain on waste management systems. Whenever possible, preference should be given to local or regional suppliers, thereby promoting shorter supply chains with a lower carbon footprint associated with transport.

The selection of sustainable, biodegradable and locally sourced materials is essential for reducing the environmental impact of footwear manufacturing. Priority should be given to the use of renewable, recycled or certified raw materials, whilst ensuring quality, durability and compliance with the product's technical requirements.

4.3 Energy and Process Efficiency

- Green energy integration and smart energy systems
- Efficient machinery and Lean Management

The integration of green energy and smart energy systems into footwear manufacturing is essential for reducing energy consumption and the emissions associated with the production process. The use of renewable energy sources, such as solar or wind power, helps to reduce dependence on fossil fuels and improve the environmental performance of operations.

The implementation of smart energy management systems enables real-time monitoring of energy consumption, the identification of wastage, and the optimisation of equipment usage during the various stages of lasting. These systems also allow energy levels to be automatically adjusted to production requirements, thereby increasing efficiency and reducing costs. In lasting sector, what can be done to contribute in this subject?

- Ensure that equipment is properly maintained
- Train staff to use resources efficiently
- To foster a culture of continuous improvement

The use of efficient machinery and the application of Lean Management principles in footwear lasting are key to optimising resources, reducing waste and increasing productivity. Modern, energy-efficient equipment improves operational performance, ensuring greater precision, lower energy consumption and reduced material wastage.

The Lean approach focuses on eliminating activities that do not add value, promoting simpler, more organised and continuous workflows. In practice, this involves reorganising workstations, standardising processes and systematically identifying opportunities for improvement. Lean Management aims to systematically eliminate waste throughout the shoe lasting process.

4.4 Resource Efficiency

- Reducing emissions, water and electricity consumption

Sustainability now plays a central role in the footwear industry, particularly when considered in the lasting phase, where a number of processes with a direct impact on resource consumption and pollutant emissions are concentrated. Reducing emissions, water consumption and energy use in lasting is essential to minimise the environmental impact of the production process. Adopting efficient practices not only helps to conserve natural resources, but also improves operational performance and reduces costs.

With regard to emissions, one of the main sources is linked to the use of adhesives and solvents in the lasting process. Replacing traditional adhesives with water-based alternatives or those with a low volatile organic compound (VOC) content significantly reduces the release of harmful gases into the atmosphere. At the same time, the modernisation of equipment and improved ventilation on production lines contribute to a safer working environment with a lower environmental impact.

When it comes to electricity consumption, optimising lasting production processes is essential. The introduction of more energy-efficient machinery, combined with the automation of certain operations, helps to reduce energy wastage. Measures such as real-time monitoring of consumption, the use of LED lighting and the implementation of preventive maintenance plans help to ensure that equipment operates at maximum efficiency, avoiding unnecessary consumption.

In short, reducing emissions, water consumption and electricity use in lasting depends on an integrated approach that combines technological innovation, operational efficiency and a commitment to people. By implementing these improvement proposals, companies in the sector can not only reduce their environmental impact, but also position themselves more sustainably and competitively in the global market.

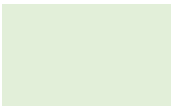
4.5 Chemical Safety

- Compliance with restricted substances
- Innovations in green chemistry

Sustainability in the footwear industry is not limited to the management of natural resources or energy efficiency; it also involves strict compliance with standards relating to the chemicals used throughout the production process. This aspect is particularly important during the lasting stage, as this is where various adhesives, solvents, foams and other materials that may pose risks to the environment and human health are used.

Compliance with restricted substances lists (RSLs) is now an essential requirement for companies in the sector. These lists set limits or bans on the use of certain chemical compounds, such as phthalates, heavy metals, formaldehyde or hazardous solvents, which may be present in materials or introduced during lasting. Failure to comply with these standards, may result not only in negative environmental impacts, but also in risks to workers and consumers, as well as legal and commercial consequences.

In order to achieve this, companies should:



Replace hazardous substances with safer alternatives. For example, using water-based adhesives instead of organic solvents significantly reduces exposure to toxic compounds



Providing staff training on the safe handling of chemicals and the importance of compliance helps to foster a more responsible and safety-conscious organisational culture



It is also worth noting that compliance with restricted substances is often aligned with international regulations, such as REACH in the European Union, which underscores the need for companies to keep abreast of constant legislative changes

One important consideration is the choice of auxiliary products with safer formulations, such as primers and activators that are free from hazardous substances, or those with a lower environmental impact. These products are often biodegradable, have a shorter persistence in the environment and are designed to maintain high levels of technical performance, ensuring the durability and quality of lasting operations.

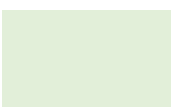
The implementation of green chemicals also requires adjustments to production processes. This may involve changes to application conditions, such as temperature, drying time or pressure, as well as training for workers to ensure the correct and effective use of these new materials. However, these challenges are offset by the environmental, social and even economic benefits in the medium and long term.

4.6 Social Responsibility

- Fair labour practices
- Community engagement and diversity, equity and inclusion

Sustainability in the footwear industry goes far beyond environmental issues, encompassing a strong social dimension as well. During the lasting phase — one of the most labour-intensive stages — fair labour practices play a central role in ensuring decent, safe and equitable working conditions. Promoting these practices is essential not only for the well-being of workers, but also for the credibility and accountability of companies in the global market.

Shoe lasting involves repetitive tasks, the use of specialised equipment and, at times, exposure to chemicals. In this context, ensuring safe working conditions is a priority. This entails providing suitable personal protective equipment, effective ventilation systems and ongoing training in occupational health and safety. The prevention of occupational risks must be a systematic practice integrated into the day-to-day management of production. What can be done to achieve these goals?



Implementing fair labour practices means respecting workers' rights. This includes decent wages paid on time, balanced working hours, adequate breaks and compliance with current labour legislation

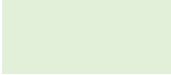
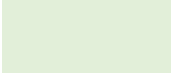


To foster an inclusive and respectful environment. Equal opportunities, regardless of gender, age or background, must be guaranteed, as must access to training and career progression

The integration of fair labour practices into lasting process is an essential pillar of a sustainable industry. By placing people at the heart of their strategy, companies not only fulfil their social responsibilities but also lay solid foundations for ethical, sustainable and competitive growth.

These practices are also enhanced when companies encourage the involvement of the local community, creating jobs and contributing to social development, whilst valuing diversity within their teams. By incorporating principles of diversity, equity and inclusion, footwear manufacturing facilities ensure a fairer and more innovative working environment, whilst strengthening their ties with the surrounding community.

Valuing diversity within footwear lasting teams, combined with active engagement with the community, fosters knowledge sharing and the sector's sustainable growth. Including a variety of professional profiles in footwear lasting, whilst ensuring equal opportunities, helps to create more dynamic and socially responsible working environments. It is, thus, very important to observe the following practices:

-  The lasting team comprises people of different ages and backgrounds, and should ensure equal opportunities in access to employment
-  The company adapts workstations to suit different needs and create opportunities for people in vulnerable situations
-  Employees receive training or develop activities on diversity and inclusion, with the objective promoting respect and fairness
-  The company promotes internal communication, clear and accessible to all staff and encourage them to be involved in internal decision-making
-  The company collaborates with local schools suggesting the creation or development of new professional profiles
-  The company collaborates with local schools suggesting the creation or development of new professional profiles and communicates with the local community, divulging its activities

5 Digitalisation in Lasting

Digitalisation has been profoundly transforming the footwear industry, introducing new ways of designing, manufacturing and monitoring lasting processes. Traditionally reliant on manual techniques and empirical knowledge accumulated over generations, the sector now faces the challenge – and the opportunity – of integrating digital technologies that enhance efficiency, precision and traceability.

In the footwear lasting phase, digitalisation enables greater automation of tasks, real-time data collection and analysis, and better integration between the different stages of production. Digital systems allow for strict control of critical parameters, a reduction in human error, and rapid adaptation to different models and specifications, allowing a more agile response to market demands.

Furthermore, the use of digital tools helps to improve working conditions by reducing repetitive and physically demanding tasks, and promotes more sustainable production by optimising resources and reducing waste. Simultaneously, digitalisation is helping transform the industry and making it more appealing to younger generations, attracting new talents to the companies.

5.1 A New Era of Robots

The advent of a new era in industrial robotics is profoundly reshaping production processes, introducing unprecedented levels of precision, autonomy and efficiency. Within the footwear industry, and particularly in sole bonding, robots are playing a central role in the transition towards smarter, more flexible and data-driven production systems.



Fig. 47: Robot in lasting sector. Credit: Autecautomation

5.2 Artificial Intelligence

- Image editing tools

In lasting, the use of digital images allows for detailed analysis of surfaces, adhesive application patterns and alignment between components. As such, they are essential for creating visual references that guide robots and equipment in performing tasks with high precision. To achieve this, it is essential that all sensors are properly calibrated.

Another important aspect is the standardisation and documentation of processes. Through image editing, it is possible to generate technical instructions and databases that support operator

training and the standardisation of operations. This approach facilitates communication between teams and improves the consistency of results.



Fig. 48: Robot in lasting sector, applying glue in soles. Credit: Autecautomation

5.3 Big Data

- Mass customisation

The concept of Big Data in the footwear industry refers to the ability to cross-reference information generated during production with consumer behaviour in the digital world. This integrated analysis enables the brand to shift from producing 'for the warehouse' to 'meet demand', thereby strengthening its market position.

Synergy between Production and Marketing:

- Mass Customisation: By analysing large volumes of online order data, the lasting line can adjust in real time to produce specific model variants that are gaining the most traction on social media or in digital campaigns.

Transparency and Product Storytelling:

- Big Data makes it possible to trace the 'biography' of every pair of shoes — from the origin of the leather to the drying time of the adhesive. This data is transformed into marketing content (such as QR codes on labels), enhancing the brand's perceived value through transparency and sustainability.

Logistics Optimisation for Micro-Components:

- Customisation leads to a significant increase in the variety of stock items. Big Data algorithms predict the consumption of specific components (e.g. a range of fluorescent colours or a technical lace) based on real-time configuration trends, thereby preventing stock-outs that would bring the customised lasting line to a standstill.

The Strategic Value of Information:

- The use of Big Data enables the factory to function as a smart ecosystem. Lasting ceases to be a static process and becomes a dynamic response to individual data, allowing the brand to offer a unique product with industrial efficiency. The result is the elimination of unsold stock and an immediate response to the changing preferences of the end consumer.

5.4 3D Printing

- Plastics; metals

The introduction of 3D printers into the footwear industry represents a significant step forward in digitalisation, enabling new approaches to the development, testing and optimisation of processes such as lasting. This technology, based on additive manufacturing, enables the rapid and precise creation of components and prototypes, contributing to greater efficiency and production flexibility.

In the context of lasting, 3D printers can be used to develop supports and positioning devices tailored to different footwear models. These elements ensure a more precise alignment between the sole and the upper, creating ideal conditions for adhesive application and pressing. The rapid customisation of these devices reduces set-up times and facilitates adaptation to short runs or differentiated products.

Furthermore, 3D printing plays an important role in the prototyping and validation phase. The ability to rapidly produce soles or experimental components makes it possible to test different materials, geometries and bonding solutions prior to large-scale production. This process reduces development costs and speeds up the launch of new products onto the market.

Integrating 3D printers with wider digital systems further enhances traceability and process control. Digital models can be easily adjusted, stored and shared, ensuring consistency and facilitating collaboration between engineering, production and quality teams.

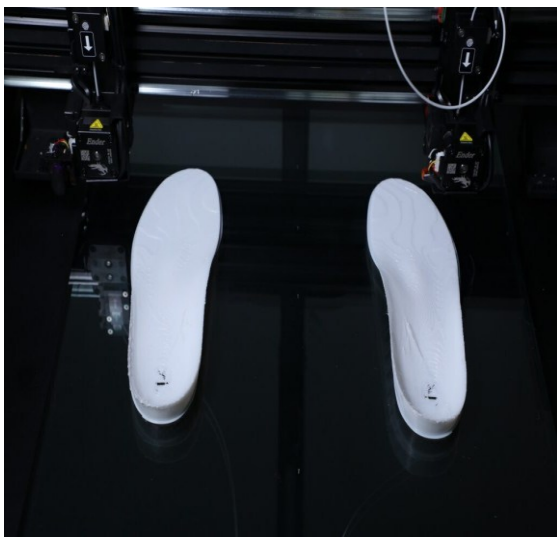


Fig. 49: 3D printed insole - Credit: Piocreat 3d

5.5 The Convergence of Digitalisation and Science

- Cyber-physical systems (CPS)
- Synergy between Digitalisation and Science

Cyber-physical systems (CPS) represent the close integration of physical components and computer systems, enabling the monitoring, control and optimisation of processes in real time. In an industrial context, these systems play a central role in the transition towards digitalisation and the paradigms of Industry 4.0, promoting greater efficiency, traceability and quality in production processes.

In the footwear industry, and particularly in the lasting process, the adoption of cyber-physical systems has been significantly transforming traditional production methods. This process, which has historically relied on intensive manual labour and has been prone to variability, now benefits from the incorporation of sensors, smart actuators and digital control systems.

The digitisation in lasting processes is based on the continuous collection of data from multiple sources, such as sensors measuring temperature, pressure, humidity and adhesive curing time. This data is processed by computer systems that automatically adjust the process parameters, ensuring optimal bonding conditions and reducing defects. For example, real-time monitoring of temperature and applied pressure ensures consistent bonding between the sole and the upper, thereby minimising quality defects.

In addition, cyber-physical systems enable integration with manufacturing execution systems (MES) and enterprise resource planning (ERP) systems, providing a comprehensive, real-time overview of the production line's status. This integration facilitates full traceability of each pair of shoes, from the application of the adhesive to the final product, which is particularly important for quality control and compliance with standards.

Another key aspect is the ability to perform predictive analysis. By using data analysis algorithms and machine learning, it is possible to anticipate equipment failures or deviations in the lasting process, enabling preventive action and reducing downtime. This translates into a significant improvement in operational efficiency and a reduction in costs.

Finally, the implementation of cyber-physical systems in lasting helps to standardise processes, reduce reliance on human factors and increase production flexibility. This approach enables faster adaptation to different shoe models and materials, effectively meeting the current market's demands for customisation and speed.

Synergy between Digitalisation and Science

The Era of Wearable Footwear

- The manufacture of footwear incorporating wearable technology represents the pinnacle of the convergence between industrial digitalisation and applied sciences (biomechanics, electronics and materials science). At this stage, the shoe ceases to be a purely analogue product and becomes a data-collection platform, requiring scientific precision in its construction to ensure the sensors function properly without compromising the wearer's anatomy.

Electronic Protection

- The application of materials engineering principles enables electronic components to withstand extreme pressure and heat during the bonding and moulding of the sole. Digital stress simulation (FEA) predicts how the wearable will behave under the user's weight, validating the design prior to physical lasting.

5.6 Virtual Reality and Augmented Reality

The introduction of immersive technologies in the footwear industry bridges the gap between digital design and physical production. Virtual Reality (VR) and Augmented Reality (AR) are essential tools for accelerating the learning curve and ensuring the millimetre-level precision required when lasting complex designs.

Applications and Operational Benefits

- Virtual Reality (VR) Training: Using VR simulators, new operators can practise critical steps – such as roughing the edges or adjusting the shape – in a safe digital environment without wasting materials. This ‘training science’ allows technical movements to be repeated until perfected before moving to the actual production line.

Step-by-Step Assembly Guides (AR)

- For technical or luxury footwear models with numerous components, AR projects stitching lines, gluing points or the alignment of trims onto the physical shoe. This eliminates the need to consult paper manuals and drastically reduces positioning errors.

Efficiency and Ergonomics

- These tools enable ‘hands-free’ lasting, with digital information displayed directly in the worker’s line of sight. The use of AR and VR not only boosts productivity but also reduces operators’ cognitive stress, transforming shoe lasting into a technologically assisted process that is safer and free from misinterpretation.

6 Case study and Project work

6.1 Case study of a training model

The Footwear Industry Vocational Training Centre (CFPIC) was established following a memorandum of understanding signed in Portugal on 23 December 1965 and commenced its activities in January 1966. Its mission is to provide specialised technical training that supports the development of the footwear industry and contributes to the growth of the national economy.

Committed to responding promptly and effectively to the industry's evolving skills requirements, CFPIC plays a key role in strengthening the competitiveness of the Portuguese footwear sector. To achieve this, it invests in the continuous development of workforce knowledge and technical competences through innovative training methodologies and the use of state-of-the-art equipment across its areas of expertise.

In this context, the lasting stage represents one of the most important phases of footwear manufacturing, as it has a direct impact on the product's quality, comfort, durability and overall appearance. In recent decades, continuous technological developments within the footwear industry have introduced advanced machinery, innovative materials and improved manufacturing techniques. As a result, both traditional and modern lasting methods are now widely used, each offering distinct characteristics, benefits and limitations depending on the production requirements.

Traditional sole attachment methods rely heavily on manual operations, requiring skilled operators to apply adhesives, position components, and control pressing processes. Although these methods provide flexibility for small production runs and customised footwear, they are generally more labour-intensive and may result in greater variability in product quality and production efficiency.

Modern sole attachment methods make use of advanced manufacturing technologies, including automated machinery and robotic systems. These solutions improve the accuracy of adhesive application, component positioning, and pressing operations, ensuring consistent quality and reducing production time. Automation also minimises material waste, enhances operator safety, and enables manufacturers to meet the demands of large-scale, high-quality production while maintaining greater process control and traceability.

The use of sustainable materials in sole attachment operations contributes to reducing environmental impact while supporting the production of high-quality footwear. Eco-friendly adhesives, recycled components, and responsibly sourced materials help improve resource efficiency and meet increasing global sustainability standards.

The integration of robotic systems enhances precision, consistency, and productivity throughout the sole attachment process. Automation also improves workplace safety, reduces material waste, and ensures reliable product quality.

	Technical Data Sheet	Model: Aveiro Ref: 39786 Date: 30/07/2026
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Lasting

N°	Operations	Resources	Materials	Notes
1	Prepare and clean surfaces	Sanding machine Compressed air gun	36-grit sanding belt	Round off the edge of the last
2	Apply adhesive to the soles	Manual	Solvent -based adhesive with 2 components	Drying time + -15min.
3	Reactivate, position and press	Reactivator Press machine	-----	Temperature of reactivation around 50°C
4	Clean and de-last	Manual De-lasting machine	Crepe rubber	Clean carefully to avoid damaging the leather
5	Nail the heels	Heel nailing machine	Heel nails Rullatti 22	From 37 to 39 – 5 nails From 40 to 44 – 7 nails

Revised Technical Data Sheet

Lasting

N°	Operations	Resources	Materials	Notes
1	Prepare and clean surfaces	Sanding machine/Robot system automation Compressed air gun	36-grit sanding belt	Round off the edge of the last
2	Apply adhesive to the soles	Manual/ Glue-spraying robot	Solvent -based adhesive with 2 components	Drying time + -15min.
3	Reactivate, position and press	Reactivator Press machine	-----	Temperature of reactivation around 50°C
4	Clean and de-last	Manual De-lasting machine	Crepe rubber	Clean carefully to avoid damaging the leather
5	Nail the heels	Heel nailing machine	Heel nails Rullatti 22	From 37 to 39 – 5 nails From 40 to 44 – 7 nails

6.2 Structure of a lasting exercise

Practical Exercise – Lasting

Objective

To carry out basic footwear lasting operations, applying correct technical procedures and considering the principles of sustainability, industrial digitalisation and the demands of the global market.

Context

The footwear industry currently faces new challenges relating to:

- reducing its environmental impact;
- the use of digital technologies in production processes;
- competitiveness in international markets.

During the lasting phase, operators must ensure quality, precision, efficiency and compliance with technical and environmental standards. Lasting involves a sequence of key operations in the manufacture of footwear and faces new challenges, directly influencing:

- the resistance of the product;
- the user's comfort;
- the durability of the footwear;
- the final quality of the finishing.

Practical Assignment

Situation

The trainee has been tasked with a lasting operations in a model of a sustainable casual shoe intended for export.

The model has the following characteristics:

- The upper is made from recycled materials;
- The sole is made from recycled rubber;
- Wherever possible, use water-based glue;
- Digital production monitoring and traceability;
- Comply with the quality requirements defined for domestic and international markets.

The trainee must carry out the lasting operations correctly, ensuring technical quality and compliance with environmental and safety standards.

Materials Required

- Upper assembled;
- Sole;
- Water-based/solvent-based adhesive;
- Lasting tools and equipment;

- Personal and collective protective equipment;
- Cleaning products;
- Digital device for recording the process.

1. Tasks to be accomplished

- Organise the materials and tools;
- Carry out the necessary adjustments for the operations;
- Check the condition of the equipment;
- Wear personal protective equipment (where necessary);
- Check the model's digital technical data sheet.

2. Surface's preparation

a) Cleaning

Carefully clean the surfaces to be bonded;

Remove dust and residues.

b) Preparation

Brush or roughen the surfaces where necessary;

Ensure good adhesion of the materials.

3. Applying the adhesive

- Apply the adhesive uniformly;
- Use the quantity specified in the technical data sheet;
- Observe the recommended drying times.

4. Attaching the sole

- Position the sole correctly;
- Press the sole;
- Check alignment, adhesion, and stability.

5. Quality control

Check:

- Bond strength;
- Finishing uniformity;
- Cleanliness of the product;
- Compliance with international quality standards;
- Digitally record the completed manufacturing process and any nonconformities.

Sustainability

- Whilst carrying out the work, the trainee must:

- Organise the workstations involved in the operations;
- Minimise waste of adhesive and materials;
- Separate waste for recycling;
- Use resources efficiently;
- Keep the workstation clean and tidy;
- Minimise the energy consumption of the equipment.

Digitalisation

The trainee must:

- Consult the technical data sheet in digital format;
- Use digital traceability systems;
- Record times and operations carried out.

Globalisation

Considering that the product will be exported to different markets, the trainee must ensure:

- The quality requirements defined by the verification sample;
- Identify the production batch through the digital system;
- Compliance with the model's technical specifications.

Assessment Criteria

- Workstation set-up;
- Technical execution of the lasting;
- Quality of the operations carried out;
- Compliance with safety standards;
- Application of sustainable practices;
- Correct use of digital systems;
- Organisation and cleanliness of workstations.

Final Reflection

After completing the activity, answer the following:

What difficulties did you encounter during lasting processes?

How can digitalisation improve production efficiency?

What are the advantages of using sustainable materials in the footwear sector?

Why is it essential to ensure international quality standards in the footwear industry?

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