Developing Innovative and Attractive CVET programmes in industrial shoe production

Train-the-Trainer Manual

New Materials

IO 3

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Content

1 Introduction

1.1 Aims of the DIA-CVET Project

The aims of the Erasmus+ project «Developing Innovative and Attractive CVET programmes in industrial shoe production» are

- to develop, pilot and implement comprehensive courses for the Spheres of Activity (SoA) of foremen in industrial shoe production on European level; available in English (EN) as well as in DE, RO and PT,
- and to develop a sector qualification framework level 5 and 6 and to reference existing or newly drafted national qualifications from Germany, Portugal and Romania.

1.2 Manuals to Guide Tutors and Trainers

The purpose of the manuals is to prepare designated trainers for their role and to provide content and support. Due to the nature of the SoA of foremen, they do not include specific forms of training; but we suggest a blended approach. Successful Continuous Vocational Education and Training (CVET) programmes combine theoretical lessons with application of the acquired Knowledge, Skills and Competences (KSC) in real work environments. The tasks of a trainer are to

- impart SoA-specific KSC,
- demonstrate operations which the learners are expected to learn to perform,
- introduce the learners to each new task and supervise them during their first approaches,
- organise and supervise blended activities (i. e. projects),
- guide them towards an independent performance of the tasks of the respective SoA.

The manuals are not meant to replace a textbook. They are meant to provide support to the trainers to plan and execute their teaching. The trainers are invited to gather more information from other sources.

1.3 Refer your training to the business process of industrial shoe production

Industrial production is a complex process, where the Sphere of Activity, described in this manual, is embedded in the business process. Before you start the training on a specific SoA, please make sure that the learners are familiar with the other SoA of industrial foremen in shoe production.

For example, the learners should be introduced to the types of products the company manufactures and their intended use, the different customer segments, the distribution channels etc. They should be aware of the product creation and manufacturing processes, i.e. product design, pattern making, purchasing department, production planning, and all production departments to warehouse and logistics.

The production process (not part of DIA-CVET, for insights see: http://icsas-project.eu/) is in the core of the business process; the SoA of DIA-CVET play a preparatory, supporting or accompanying role (see Fig. 1).

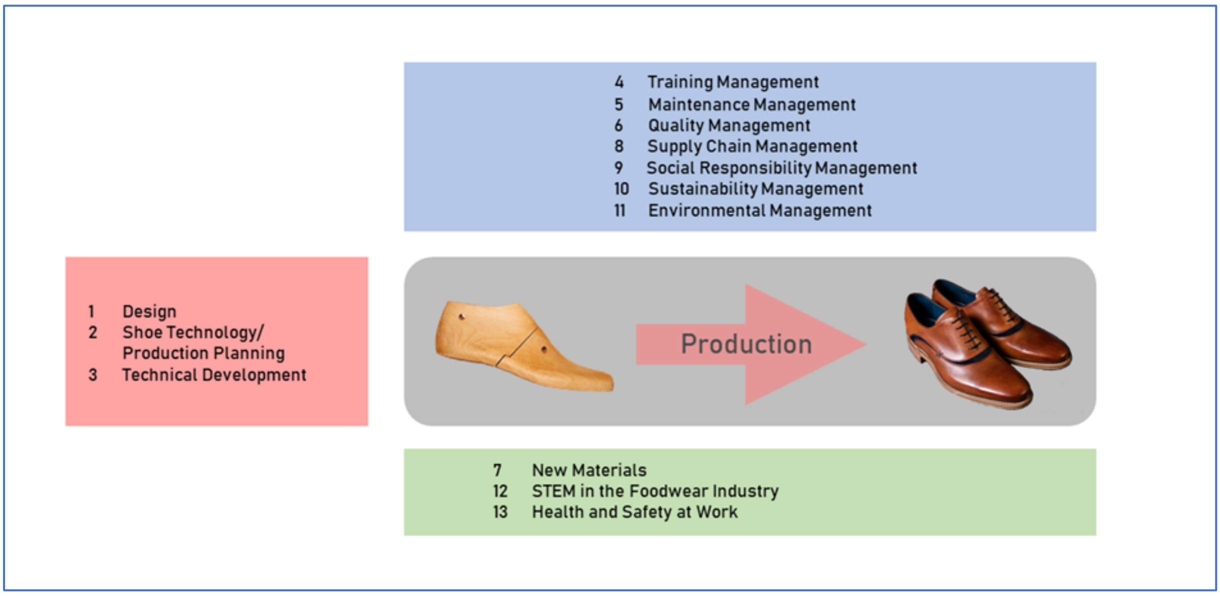

Fig. 1: Spheres of Activity of DIA-CVET and their relation to the production process.

2 New Materials for upper

The footwear industry has to respond to consumers' increasing demand for more durable, sustainable and innovative products. Durability translates in greater wear resistance maintaining features to reduce waste. Sustainability refers to non-toxic, recycled, recyclable and reusable products and materials and efficient manufacturing processes consuming less energy and from alternative sources aiming to reduce environmental impact as much as possible. Related to materials, innovative products offer enhanced features and increase greater satisfaction.

Regardless of the nature of the materials, we have to consider the impact of their manufacturing processes on the environment and also on the consumers' health.

2.1 Leather

Natural leather is the most common material used for manufacturing footwear and is considered a by-product of the food industry. It is a very versatile natural material that depending on the tanning process is available in a wide range of finishes and with excellent characteristics like flexibility, durability, tearing resistance, wear-resistance and breathability.

Tanning is a complex mechanical and chemical process of transforming animal hides into leather. The tanning process uses large quantities of water and chemicals therefore the industry is constantly trying to find new innovative solutions to reduce pollution and to obtain products that have characteristics comparable with the existing leather assortments, that contain less quantity of chemicals and also that can be easily disposed of.

Synthetic leather imitates the appearance of animal leather and is composed of natural and/or synthetic textiles (knitted, woven, or non-woven textiles) coated with a PU or PVC layer. It is generally considered that natural leather is superior to synthetic leather but with recent innovations (water-based synthetic leather, solvent-free synthetic leather, TPU synthetic leather, silicone leather, polyolefin leather and so on), synthetic leather can offer higher performance, protect health and can be animal-friendly and eco-friendly.

2.2 New leather and leather-like materials

Alternatives like chrome-free leather, biodegradable leather, plant-based leather and bio-fabricated leather have a lower environmental impact compared to animal leather. These new materials are not completely eco-friendly but have the prospect of being a very good alternative to animal leather in the future.

Chrome-free leather

Due to the environmental damage made by introducing metals into the ecosystem from the chrome tanning process, new chemicals are being researched.

One innovation is Ecotan Leather manufactured by Silvateam by using plant-based tannins combined with man-made additives. Another innovation is from Conceria La Veneta which developed a chrome-free tanned leather certified as biodegradable.

Fig. 2: Conceria La Veneta biodegradable leather. Source: https://www.concerialaveneta.com/en/biodegradable-leather.html

Nano Leather

Leather tanned or finished using nanotechnology can have excellent antimicrobial, self-cleaning, flame retardant, water-resistance and breathability characteristics. For example, silver-titanium dioxide nanoparticles are an ecological alternative to volatile organic biocides and organic solvents that are usually in leather and offer antimicrobial properties.

Plant-based Leather

Plant-based leather is made from mushroom, pineapple, banana, apple, cactus, green tea, coffee grounds and more and is cruelty-free, climate-friendly and has a low environmental impact.

- **Pineapple leather -** is made from pineapple leaf fibres, can be biodegradable is durable, flexible, soft, breathable, heat and water-resistant. Piñatex Pineapple leather www.ananas-anam.com/about-us/
- **Coconut Leather -** is made from waste products of the coconut industry and is biodegradable and compostable. Malai Coconut Leather https://malai.eco/
- **Apple leather -** is made from residues taken from industrial processing of apples, looks similar in appearance to real leather but has a paper-like feel which makes it easy to obtain different backings, coatings. **AppleSkin** - https://www.appleleather.com/
- **Cactus Leather -** is a sustainable alternative made from cactus leaves which has similar texture and properties compared to animal leather. **Deserto Cactus Leather -** https://desserto.com.mx/home

Fig. 3: Deserto Cactus Leather. Source: https://nordrepublic.com/de/desserto-cactus-leather/

Laboratory engineered leather

- **Fungi Leather -** Fungi derived leather is a sustainable and environmentally responsible alternative to animal leather. MYLO Leather https://boltthreads.com/
- **Skin Leather** - is engineered in the laboratory from skin cells is marketed as having the same quality of traditional leather without the waste and harm to animals. Modern Meadow Leather www.modernmeadow.com/

Fig. 4: MYLO Leather. Source: www.dezeen.com/2020/10/08/mylo-consortium-adidas-stella-mccartney-lululemon-kering-mycelium/

2.3 Textiles

Textile fabrics are made from yarns and are available in a wide array of colours, varieties, styles and designs. Textiles are made from natural or man-made fibres and can be woven, knitted, non-woven. Natural fibres are cellulosic or protein and man-made fibres are made from various chemicals (synthetic) or are regenerated from natural sources (natural polymers). **Woven** fabrics are manufactured by interlacing two or more threads in a pattern that holds them together and creates the fabric. **Knitted** fabrics consist of a series of interlaced loops. In the footwear industry warp-knitted fabrics like tricot, locknit and satin are mainly used. **Non-woven** fabrics are made from fibres bonded together by chemical, mechanical, heat or solvent treatment.

2.4 New textile fibres, yarns and fabrics

The textile industry is a major contributor to harmful environmental effects and waste generation in the eco-system therefore the majority of new textiles are developed as innovative solutions to address the need for more sustainable systems.

Examples of new textiles fibres yarns and fabrics are listed below:

- **Polylana Fiber** - offers an eco-friendly alternative for acrylic fibres and is made from a mix of innovative polyester chips and recycled polyester. https://polylana-fiber.com/
- **Meryl nylon -** offer an eco-friendly alternative to cotton and address recycling options https://www.nylstar.com/
- **Seaqual -** is a fibre made entirely from recycled marine plastic. https://www.seaqual.org/
- **MATRYX fabric -** is made from recycled polyester and is light, breathable and abrasion-resistant. https://www.matryx-textile.com/en/
- **Tectec Performance** - are advanced coated and laminated fabrics that have enhanced properties. https://tectex.pt/
- **REMEANT** - is a sustainable textile fabric made from upcycled plastic used in packaging materials

Fig. 5: REMEANT textile fabric. Source: https://nat-2.eu/nat-2-reduceusecycle-line/

3 New materials for bottom components

The bottom part of the footwear supports and connects the bottom of the foot with the ground and has the main role of protecting the foot from mechanical actions and environmental agents, thus ensuring comfort.

Bottom complexity depends on the footwear type, model and characteristics. The main bottom components are the insole and insock on the interior, the midsole as an intermediate layer and the sole and outsole in the exterior.

Fig. 6: Cork insole. Source: https://yoursole.com/blog/us/cork-footbed-collection

3.1 Natural materials for bottom components

Natural materials that are used for bottom components are leather, wood, cork and natural rubber.

- Leather is mainly used for insocks and formal footwear soles.
- Wood soles are mainly used by designers and fashion labels but they are also popular in some professions providing protection.
- Cork is a versatile natural material with many applications. For soles, as durability is required it is usually mixed with various synthetic materials like PU and PVC.
- Soles made from natural rubber are soft and have high slip resistance on wet surfaces but have a low resistance to mechanical actions therefore natural rubber is usually mixed with other synthetic materials to improve its properties.

3.2 Synthetic materials for bottom components

Synthetic materials used for soles fall into the category of rubbers, plastics, thermoplastic rubbers and polyurethane mixtures:

Rubber is processed through vulcanization and consists of mixtures of plasticizers, antioxidants, active batches, fillers, colouring agents, activators, accelerators, crosslinking agents and specific additives:

- Styrene-butadiene (SBR) - high elasticity, good tensile and abrasion resistance, high resistance to light and weathering, but lower resistance to tearing and repeated bending;
- Polybutadiene (BR) - very good resistance to low temperatures, high abrasion resistance, good resistance to wear and repeated bending and high elasticity;
- Nitrile - NR - good tensile strength and resistance to ageing;

Thermoplastic Rubber has similar physical-mechanical properties to those of vulcanized rubber:

- Styrene-Butadiene-Styrene (SBS) - exceptional stability to water, alkalis, sulfuric, nitric and hydrochloric acids, ammonia, alcohols, low temperature but limited resistance to mineral and vegetable oils.

Plastics used for soles must provide flexibility, dimensional stability, bending resistance, wear-resistance and shock absorption:

- Polyvinyl chloride (PVC) - flexibility and wear resistance;
- Ethylene-vinyl acetate (EVA) - elasticity, reduced rigidity at low temperatures, no resistance to organic solvents and oils;
- Butadiene- Styrene (BS) - durability, flexibility and slip resistance;
- Polyethylene (PE) - low density, good resistance to low temperatures and good resistance to ageing.

Polyurethane blends are composed of polyisocyanates, polyalcohols and polyesters mixed with catalysts, expandants, crosslinking agents, flame retardants, stabilizers and dyes. Soles obtained from these mixtures have good dimensional stability and have the lowest specific density, both compact and porous, compared to vulcanized rubber soles, thermoplastic rubbers or plastics. Also, the soles are resistant to abrasion, bending, ageing, chemicals (hydrocarbons, acids, alcohols), fats and oils, high temperatures and have a high slip coefficient on wet surfaces, therefore having very good anti-slip properties.

A special category of materials is that for rigid soles and heels which are made from compact thermoplastic rubber, polyamide, polypropylene, polyethene, polycarbonate, polyformaldehyde and polyurethane. Soles made from these polymeric mixtures must have good wear resistance, resistance to compression, slip resistance and good shock resistance and absorption.

3.3 New materials for bottom components:

New materials for bottom components enhance footwear characteristics such as plantar pressure distribution, cushioning, shock absorption, balance and stability, slip resistance, softness and flexibility, bending and torsion and durability. Also, these new materials aim to reduce footwear environmental impact by focusing on natural and renewable resources, recycled and/or recyclable polymeric materials, biodegradable polymers and minimization/elimination of hazardous and restricted substances.

- **Graphene foam –** graphene enhances the characteristics such as cushioning, shock absorption, slip resistance and durability. www.manchester.ac.uk/discover/news/graphene-foam-doubles-longevity-of-new-running-shoe/
- **Vibram N-oli** – made with more than 90% natural ingredients originating from plants and biological agricultural by-products without the use of solvents or chemical products. https://eu.vibram.com/en/technology/n-oil/
- **Eco TPU –** made with 60% material from renewable plant origin and having the same features as standard thermoplastic polyurethane. http://resimol.com/en/ecological-shoe-innovations/ecological-shoe-soles-ecotpu/
- **Indosole** – the material is made from recycled tyres and is waterproof and durable. https://www.indosoleeurope.com/
- **Eva Green –** a flexible, light and abrasion-resistant material composed of a resin produced from sugar cane, a renewable source that also contributes to reducing CO2 emissions. https://vapesol.com/eva-green/
- **Algae foam –** made from algae mixed with EVA. Reduces the amount of used synthetic material, cleans lakes of harmful algae, and prevents the release of CO2 into the atmosphere. https://www.bloommaterials.com/

Fig. 7: Bloom algae foam. Source: https://materialdistrict.com/material/algae-foam/bloom-foam-algae-foam-ona774-8/

4 Physical and chemical requirements

Materials have a great influence on footwear, therefore testing footwear materials, footwear components and footwear are essential for understanding footwear behaviour, quality and performance. Materials can be tested and evaluated individually, as part of a system of materials (footwear component) or as part of finished footwear products.

The main physical tests for footwear materials are the following:

- **Abrasion resistance -** represents the ability to withstand the wear and tear of friction.
- **Adhesion resistance -** is the property that determines the strength of adhesion between two surfaces.
- **Colour Fastness -** is the persistence of material colour under various conditions such as contact with human perspiration or water.
- **Colour migration -** refers to the spreading of dye within the material or from one material to another influenced by temperature, moisture and water.
- **Dimensional stability** - is the method that determines the dimensional stability of materials, for example swelling after immersion in water shrinkage under high temperature.
- **Tear strength -** is a measure of how well a material can withstand the effects of tearing.
- **Tensile strength** - is defined as the ability of a material to resist a pulling force and refers to the breaking strength of the material.
- **Flex resistance -** is the ability of a material to withstand repeated flexing or bending.
- **Water resistance** - is the property of materials related to the penetration of water.
- **Water Vapour Permeability** - refers to materials' breathability and describes the ability to allow water vapour to pass.
- **Slip resistance** - is evaluated by determining its dynamic coefficient of friction between a sole and a surface. Slip resistance is related to a combination of factors including the walkway surface, the footwear sole material and pattern, and the presence of foreign materials between them.
- **Compression energy** - influences the cushioning and shock absorption ability of bottom materials to absorb and to dissipate both the impact and push offloads that occur during walking or running
- **Delamination resistance -** refers to coating resistance to delamination from the substrate.

Fig. 8: Gore-Tex virtual footwear laboratory. Source: widget.gore-tex.com/3d/vlt/index.html?startscene=0&startactions=lookat(399.43,35.93,128.21,0,1)

4.1 Standards that establish footwear performance requirements

Various recognized standardization organizations establish the requirements and tests methods for footwear products. For example, ISO Technical Reports establish the performance requirements for footwear components for various kinds of footwear (not for the finished footwear), irrespective of the material. The standards also establish the test methods to be used to evaluate compliance with the requirements.

ISO standards for general footwear and protective footwear are presented in the following tables:

ISO/TR 20879 Footwear — Performance requirements for components for footwear — Uppers
ISO/TR 20880 Footwear — Performance requirements for components for footwear — Outsole
ISO/TR 20881 Footwear — Performance requirements for components for footwear — Insoles
ISO/TR 20882 Footwear — Performance requirements for components for footwear — Lining and insocks

Tab. 1: ISO standards that establish the performance requirements for general footwear

ISO 20344 – Personal protective equipment — Test methods for footwear
ISO 20345 - Personal protective equipment – Safety Footwear
ISO 20346 – Personal protective equipment – Protective Footwear
ISO 20347 – Personal protective equipment – Occupational Footwear

Tab. 2: ISO standards that establish the performance requirements for protective footwear

The complete list of ISO standards for footwear can be found here www.iso.org/ics/61.060/x/p/1/u/1/w/0/d/0.

4.2 REACH - Registration, Evaluation, Authorisation and Restriction of Chemicals

The use of chemical substances is regulated by REACH which aims to improve the protection of human health and the environment from the risks that can be posed by chemicals while enhancing the competitiveness of the EU chemicals industry. Companies from the footwear industry should ensure that their products do not contain restricted substances. The list of restrictions of the manufacture, placing on the market and use of certain dangerous chemical substances, mixtures and articles is included in REACH Annex XVII which is availed at the following link data.europa.eu/euodp/en/data/dataset/restricted-list-REACH.

4.3 CADS - Cooperation for assuring defined standards for shoe and leather goods

An exclusive list of Restricted Substances for the footwear industry was developed and is constantly updated by CADS which aims to secure the quality of footwear and leather goods, to distinguish footwear and leather goods whose quality is secured with a quality label, and to engage in public relations work for the manufacture and marketing of sustainable, non-toxic, environmentally compatible shoes, shoe materials and leather goods with social responsibility.

CADS list Restricted Substances in Shoes is available at the following link www.cads-shoes.com/en/documents.

The main substance groups regulated by CADS are the following:

- Azo dyes
- Biocides
- Chlorinated Phenols
- Allergenic dyes
- Carcinogenic dyes
- Heavy metals
- Organotin compounds
- Perfluorinated Substances
- Phthalates
- Polycyclic aromatic hydrocarbons
- Volatile Organic Compounds
- Chlorinated benzenes and toluenes
- Flame Retardants

For each restricted substance there are tests designed to identify and quantify their presents in footwear.

5 List of Figures and Tables