Shoe Manufacturing Technology – Today and Tomorrow

Conference: 13th AICLST, Kolkata, 6–8 March 2026

Paper reference: K/TF-112/O

Printed pages: 267–268

Source: *Leather 2050: Challenges & Opportunities*, ILTA (2026)

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Key Note Address

Ref. No. K/TF - 112/O

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Abstract

Leather was once the primary material used in footwear manufacturing. With advances in polymer science and technology, many new materials are now replacing leather. Appearance-wise, these materials are so similar that even an experienced leather technologist may find it difficult to distinguish them from genuine leather. They also exhibit breathability and physical characteristics comparable to those of natural leather. Manufacturing technology has likewise evolved with the introduction of robots and artificial intelligence (AI).

Robots in shoemaking enable high-speed, customized, and automated production, replacing manual labour in tasks such as cutting, stitching, roughing, and gluing. This helps minimize waste, improve material productivity and quality, enhance efficiency, and reduce costs. Technologies now include robotic arms for precise adhesive application, 3D vision systems for scanning, and specialized spray technologies capable of producing shoes in minutes, significantly reducing the labour requirement from dozens of workers to only a few.

1. Robotic Assembly (Stitch- and Glue-Free)

Automated spray bonding is a cutting-edge robotic technology in which a robot sprays ultra-thin, durable polymer threads directly around a shoe mold to construct the upper. This creates a seamless, stitchfree, and glue-free design within minutes, as demonstrated in recent innovations.

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A major leap in manufacturing technology is the move toward reducing or eliminating adhesives altogether through robotic automation. Cut leather components are placed directly on shoe molds, avoiding conventional assembly and lasting operations and thereby saving factory space, capital expenditure, and manpower. The author had the opportunity to experience such technology in Porto, Portugal, where one CNC machine operated by two workers manufactured about 750 pairs of leather safety shoes per shift for a French brand using German technology.

2. Advantages

This process creates a seamless, “sock-like” fit that is faster to produce (about three minutes per pair) and more sustainable, as it is glue-free and generates minimal waste. It also reduces the need for large factory spaces and capital-intensive machinery associated with traditional assembly and lasting operations.

3. Artificial Intelligence in the Footwear Industry

Artificial intelligence is transforming the footwear industry, revolutionizing everything from initial design and material selection to manufacturing, supply chains, and personalized consumer experiences. By utilizing AI-driven tools, brands are enhancing efficiency, reducing waste, and creating more comfortable, tailor-made products.

4. Key Applications of AI in Shoemaking

 Generative Design and Prototyping: AI tools such as Midjourney, Vizcom, and specialized CAD

systems enable designers to rapidly generate diverse shoe concepts, styles, and colour combinations, reducing the need for multiple physical prototypes and saving time and cost.

 Customization and Perfect Fit: AI analyses biometric data—such as 3D foot scans, pressure points, and gait analysis—to create highly personalized footwear that maximizes comfort.

 Production and Quality Control: AI-driven robots can reduce production times and reliance on manual labour, while AI vision systems conduct real-time quality inspections to minimize defects and waste.

 Smart and Adaptive Footwear: AI-enabled footwear can collect data on walking habits and gait, improving comfort and performance over time.

 Supply Chain and Retail: AI predicts fashion trends and optimizes inventory management, reducing overproduction and enabling personalized consumer experiences such as virtual AI-powered try-ons.

 Advanced Manufacturing (Robotics and 3D Printing): AI-powered machines manage cutting, stitching, and assembly with extreme precision, reducing human error and production waste. Some manufacturers use robotic systems to produce shoes in just a few minutes using lightspray technologies.

 Sustainable Material Management: AI supports the development of eco-friendly

materials and lifecycle management, contributing to recyclable and biodegradable footwear initiatives.

5. Key Players and Innovations

Leading brands such as Nike, Adidas, and ECCO are utilizing AI for 3D foot scanning, generative design, and supply-chain optimization. Other innovators focus on custom-fit shoes using extensive biometric analysis, 3Dprinted custom footwear, and AI-generated 3D shoe design platforms.

6. Future Trends

AI is expected to advance further into “smart shoes” capable of collecting data on pressure, temperature, and movement, allowing footwear to adapt dynamically to user behaviour. AI-powered virtual try-ons and interactive 3D modelling are also likely to become more widespread, improving the online shopping experience.

The 22nd International Technical Footwear Congress, organized by UITIC (International Union of Shoe Industry Technicians) and the China Leather Industry Association (CLIA), was held in Shanghai, China, from August 31 to September 3, 2025. The congress, themed “Footwear Industry Competitiveness and Sustainability in the Era of Artificial Intelligence,” focused on how AI is transforming footwear design, manufacturing, and supply chains. Selected international experts were invited by CLIA to gain first-hand insights into AI-driven, sustainable, and automated footwear manufacturing through visits to selected shoe factories in China in the following month.