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Future trends in adhesive technologies

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Joining the upper to the sole is the most critical and demanding bond in footwear construction and solvent-based adhesives are still the ones most commonly used in today's shoe manufacturing process. However, due to environmental and occupational risks, one of the objectives of the footwear industry in the near future is to use non-hazardous and more sustainable adhesives and/or surface treatments. Future trends for adhesive technology in the footwear industry can therefore be based on three main concepts: sustainability, functionalisation and the automatic application of adhesives by robots. These three aspects could all involve

the production of high added value and marketable footwear materials to satisfy the needs and expectations of end users.

Sustainable processes and products are a great challenge for the footwear industry. In this sense, water-based and hot-melt adhesives are both environmentally-friendly and bring about several advantages compared to solvent-based ones. The current trend is towards the elimination or substitution of organic solvents both in adhesives and surface treatments. Among the likely future trends in solvent-free surface treatments for footwear are ultraviolet and/or ozone irradiation, corona discharge or plasma for modification of materials to

obtain good final adhesion results.

Moreover, the functionalisation of adhesives using nanoparticles in order to provide improved properties and new functions is also an emerging technological innovation in the footwear industry. The incorporation of certain additives into the adhesive formulation can be used to reduce or prevent its degradation, achieve flame retardancy, modify the thermal or electrical conductivity and improve mechanical or hydrophobic properties among others.

WATER-BASED ADHESIVES

Water-based adhesives are dispersions or emulsions of a natural or synthetic polymer in water. They

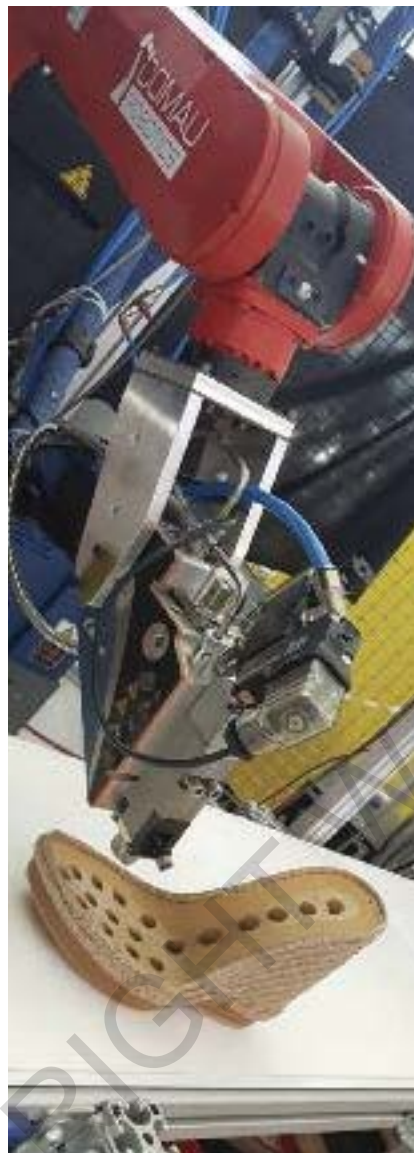
represent an environmentally sustainable alternative and their application procedure in the footwear industry is very similar to that of solvent-based adhesives, with the added advantage that they can be applied not only by brush but also by gun or roller. Their benefits are as follows:

- The absence of organic solvents in their formulation avoids the risk of flammability when stored, transported or applied;
- An improvement in working conditions, as they do not involve environmental hazards. It is also not necessary to use extraction cabins for the application of these adhesives;
- Hazardous waste is not generated so managing this factor is avoided and money saved;
- A higher solids content than in solvent-based adhesives means better performance;
- Strong and durable bonds can be achieved that meet the requirements of any type of footwear, whether children's, men's, women's, leisure, outdoors, etc.

HOT-MELT ADHESIVES

Hot-melt adhesives are 100% solid at room temperature but become fluid at higher temperatures through the use of appropriate application equipment. Unlike water-based and solvent-based adhesives, they do not need a drying phase after they have been applied. Hot-melt adhesives begin bonding straight after application due to the fact that they cool down to their solidification point immediately, offering quick production and reducing the time taken for assembly steps in footwear manufacturing. Although these adhesives are regularly employed in the form of footwear components, such as stiffeners and toe-puffs, they are not used so far for the upper-sole bonding operation, which is a technical challenge on which INESCOP is currently working.

Hot-melt adhesives are applied to one side only and are single-component unlike solvent and water-based adhesives. Furthermore, their versatility, durability and good mechanical properties make hot-melt adhesives good candidates for the



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footwear industry. One of their advantages is their cross-linked structure which offers adequate strength, excellent resistance and also excellent adhesion to a wide range of materials. As a result, there are some compelling reasons for employing hot-melt adhesives in footwear manufacture. These include:

- Their ease of application, handling, storage and transport;
- There is no drying time;
- They form strong, permanent and durable bonds within a few seconds straight after application;
- There is no environmental hazard and minimal wastage as they are 100% solid;

- A complete absence of highly volatile or flammable ingredients;
- They have excellent adhesion properties to a large variety of materials;
- They are cost-effective.

ROBOTIC APPLICATION OF ADHESIVES

The upper-sole bonding operation using water-based or hot-melt adhesives can be automated in the footwear manufacturing process by industrial robotics. The advantage of using robots for adhesive application, apart from the inherent advantages of process automation, is that the amount of adhesive applied is accurately controlled, resulting in a consistent level of quality in upper-sole bonding. Furthermore, the automation of adhesive application leads to an increase in productivity, efficiency and competitiveness.

Taking into account the complex geometry of the sole, the number of sizes prevalent and the huge quantity of different models potentially involved, it is necessary to use intelligent systems that identify the geometry and generate the robot path in an automatic way. Before applying the adhesive automatically, the sole must be digitised in order to define the bonding area. In this regard, INESCOP has developed a complete system that digitises the 3D sole geometry online and generates the paths of the robot in real time which allows any kind of sole to be processed, whether flat, medium- or high-heeled.

Robotic adhesive application also fits into the so-called Industry 4.0 paradigm, the aim of which is the implementation of 'smart factories' with a greater ability to adapt to different needs and production processes, as well as a more efficient allocation of resources, thus opening the way to a fourth industrial revolution. It is a new milestone in industrial development that will certainly involve major social changes in the coming years, making intensive use of the Internet and advanced technologies such as artificial intelligence, advanced robotics, 3D printing, virtual and augmented reality, etc., where adhesives will also play a key role in the future footwear industry. 📌