1. COATING PROCESSES

A fabric may be coated by the direct application of a compound on its surface. This system is called direct coating. The compound may also be first coated on a release paper and then transferred to the substrate. This technique is known as transfer or indirect coating. There are three coating processes used in the production of coated fabrics for shoe, luggage, garment and upholstery sectors. According to the coating process, the coating material may be in the form of paste, foam or solution.

Coating processes:
- Direct coating
- Transfer coating or Indirect coating
- Coating by coagulation

In this article we describe the transfer coating or indirect coating.

1.1 TRANSFER OR INDIRECT COATING FOR THE PRODUCTION OF SYNTHETIC LEATHER

The transfer coating is widely used in the production of synthetic leather, which finds applications in shoes, leather-like goods, garments, upholstery and automotive industries. The coating is carried out by applying mainly PVC and polyurethane resins on a silicon coated release paper by means of knife-over-roll method. The production speed may vary from 8-40 m/min according to the oven length, the type and quantity of resin applied. A light coating is about 40 g/m2 dry weight whereas for heavier shoe materials, polymer dry weights up to 250 g/m2 are also used. . In such cases intermediate layers are applied as foams. For technical applications, weights of 400 g/m2 are also employed.

A simple transfer coating line is composed of two coating heads; the first one used for the top layer also called “skin” whereas the second head applies an adhesive for fabric lamination. Some of these products are finished successively by printing or spraying.

Modern transfer coating plants employ 3 or even 4 coating heads. Each head is followed by a hot air drying oven and cooling drums. The release paper is fed from a double un-winder having a paper splicing table. The paper passes through an accumulator for a non-stop processing. At the first coating head, the wear resistant skin is spread by a knife-over-roll (steel) system. The gap between the paper and the blade normally range 0,05 to 0,4 mm and a very precise coating head which can maintain constantly the set thickness is absolutely important.

The first layer is pre-gelled at 140-150°C (in case of PVC) in a hot air oven equipped with rolls for supporting release paper. The material is then cooled by passing round the cooling drums to obtain enough mechanical consistency to withstand without damage the next coating layer. The second head applies a higher quantity of polymer with an average thickness of 0.2 mm. This coating shall produce the foam layer in case of expanded PVC after curing and expansion. The wet foam layer is pre-gelled in a second oven and then

cooled. At the third head, an adhesive layer is deposited followed by the lamination of a textile substrate on it. Based on different process experience sometime foaming is made on second oven (considering a 3-head coating line), while sometime in the third oven.

After thorough cooling, the release paper and the coated fabric are separated and wound up on separate winders. The release paper is inspected and reused several times.

Elastic fabrics and majority of knitted fabrics are transfer coated to avoid excessive tensions exerted by knife as happens during direct coating. A transfer coating is also suitable for not very dense fabrics as it helps in avoiding resin penetration and consequent fabric stiffening. **Figure 1** shows a 3-head transfer coating line whereas the photo illustrated in **Figure 2** shows an industrial transfer coating plant.

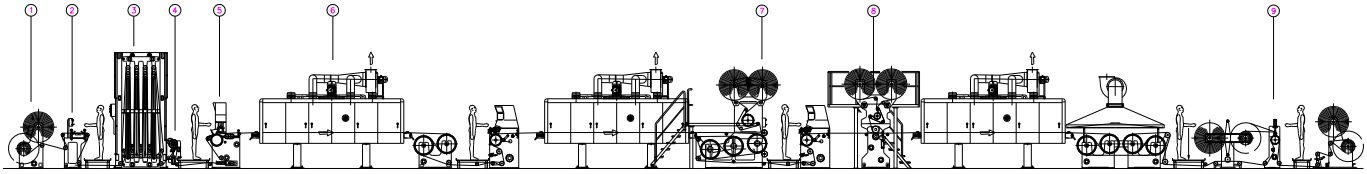

Figure 1: 3-Head transfer coating line

Figure 2: Industrial transfer coating line (Courtesy: m/s Matex Srl – Italy)

1.1.1. ONE-COAT OR PRE-DRIED COATING OF PU

As mentioned above, during bonding the fabric is laid on the wet adhesive **(Figure 3).** In this case, there is a risk that the liquid adhesive may penetrate into the substrate making it stiff after drying.

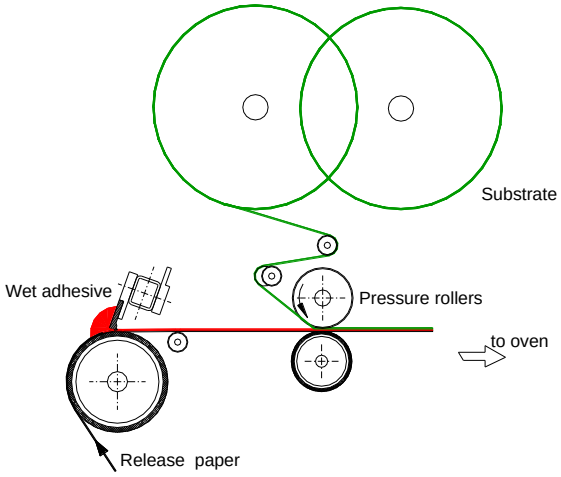

Figure 3: Wet lamination

To avoid it, a dry lamination method is also commonly used. According to this system, a polyurethane adhesive is coated (40-60 g/m2) on the release paper at the second coating head, and then partially dried at low temperature. At the oven exit, a strong pressing roll is installed. The release paper coated with adhesive and the substrate fed from an independent roll, pass through the pressing roll **(Figure 4)**. After lamination, the adhesive is cured in the last oven. The sandwich is cooled at the oven exit and the release paper is separated. Since there is no adhesive penetration, the coated fabric remains soft and flexible and is suitable for garment end-uses.

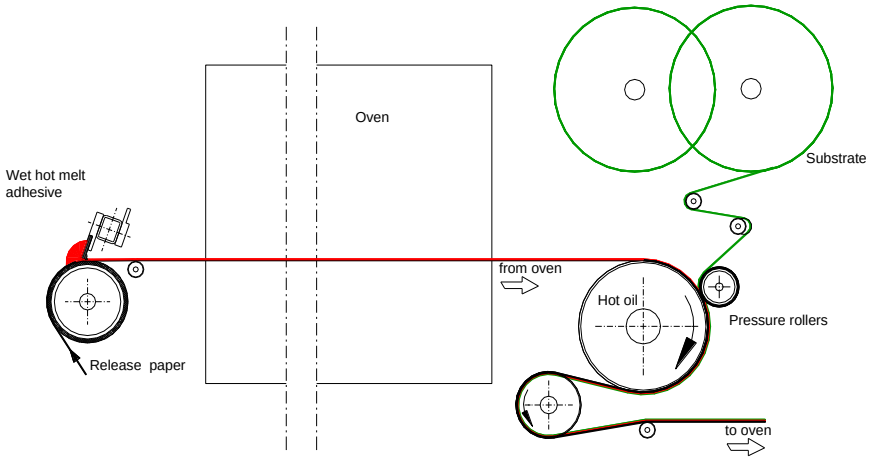

Figure 4: One-coat lamination

1.1.2 TRANSFER COATING WITH PVC

PVC was firstly used just after the Second World War and marked the beginning of synthetic materials in footwear. This development had led to the construction of more and more sophisticated shoes and other high end-products like automotive interior or luxury articles . The present structure of coated PVC materials consists of a multi-layer PVC coating with a particular finish depending on the type of application **(Figure 5)**.

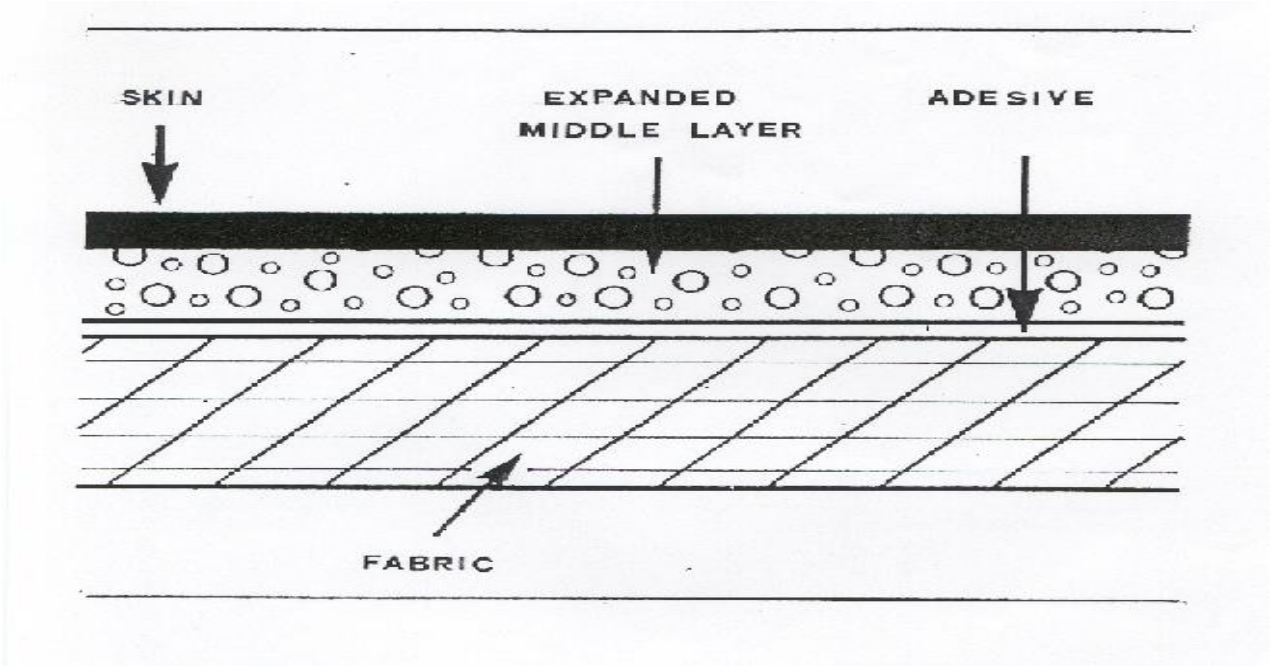

Figure 5. Cross-section of a PVC coated material

The structure consists of:

- top compact PVC layer (skin), which guarantees flex and abrasion resistance.
- second foamed PVC layer that permits to obtain a high thickness material having lower density. The advantage is represented by a “lighter” footwear.
- adhesive layer, which is used to bond PVC to the fabric.

The textile backing gives mechanical characteristics to the entire product. The strength of the finished product depends on the substrate’s resistance while flex and abrasion resistances are influenced by the thickness of the top compact layer. For example, a top coat made of PVC with a particular plasticizer, will give a better low temperature resistance to the footwear suitable for cold countries and for skiing, hockey on ice etc.

1.1.3 TRANSFER COATING WITH POLYURETHANES

Polyurethane polymers were born for a simple transfer coating on cotton or polyester/cotton substrates. Polyurethane uppers have gone through a remarkable technological evolution during the seventies, thanks to the polyurethane polymer characteristics. The coating process is similar to PVC but employs 3 layers of

different types of PU. The advent of polyurethanes also gave rise to the development of the “wet process” to produce coagulated fabrics. With a simple finishing application and using a coagulated base, a lining product may be produced and with several layers of finishes, it is possible to create a shoe upper material. The most complete structure of coagulated coated PU materials is represented in **Figure 6**. Such a coated fabric is definitely the most popular in the production of every day’s shoe uppers or fashionable shoes

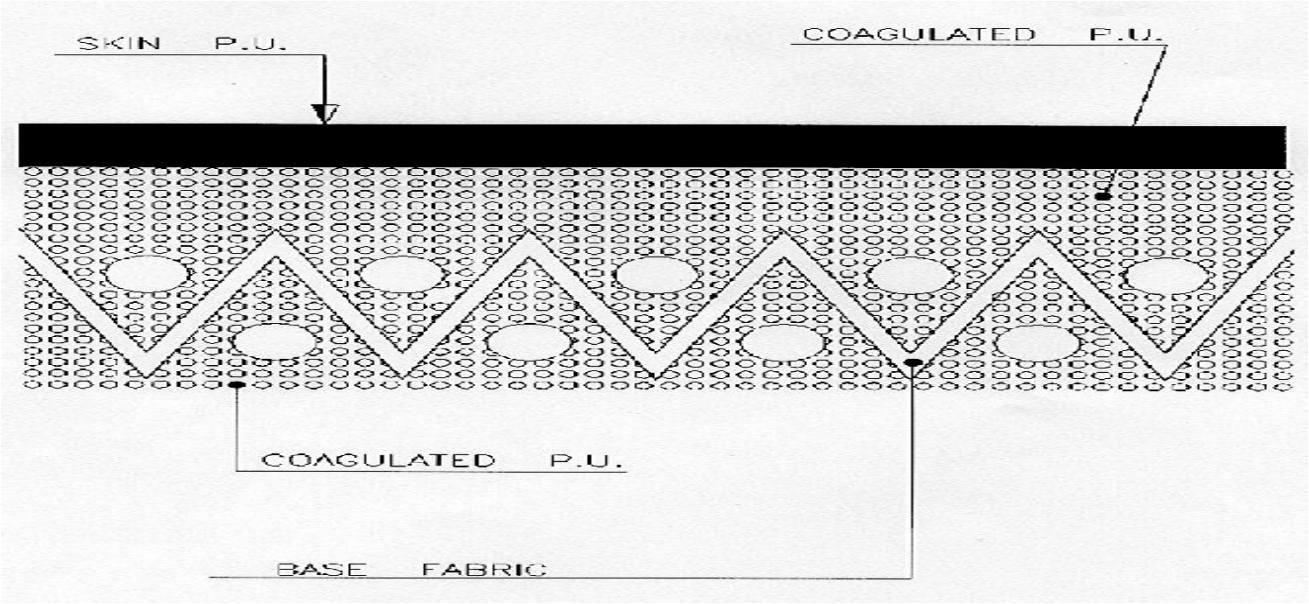

Figure 6. Cross-section of polyurethane coated fabric

The sketch shows PU skin obtained by transfer coating. The skin coat is in polyurethane with the look and feel of the required finished product. This last finish often consists of various PU coated layers. The skin, though reduces breathability, improves abrasion and flex performance, which are important for shoe uppers. The coagulated bases as such have an excellent breathability but a lower abrasion resistance. Hence, they are recommended for shoe linings. The mechanical resistance of a coated product is an important feature because during wearing they have to withstand stretching without tearing. It is, therefore, necessary to use polyester/cotton blend fabrics because polyester offers a greater resistance and a better elasticity, while cotton provides softness and guarantees a good PU adhesion.

1.1.4 TRANSFER COATING WITH PVC/PU RESINS

This is a particular type of coating procedure based on first coating in polyurethane (preskin) and then coating PVC on the successive heads. The objective is to confer a pleasant and warm hand of polyurethane combined with the body of PVC. Such coated fabrics are used almost exclusively for the small leather-like goods and cheap shoe linings.

1.1.5 RELEASE PAPER

Release papers are used only in transfer or indirect coating. The more coated polymers on release paper are PVC and polyurethanes.

The release papers can be smooth or embossed and function: (a) as a conveying element for what is coated and laminated on it, and (b) for transferring its own engraving or finishing pattern onto the end product. They may be opaque, bright, plain or embossed. There are basically two categories of release papers:

a) Silicon coated release papers

These papers have a silicone coating in order to confer anti-adhesive property. They can be used for high temperatures, are very versatile and have been used for a long time. Their main disadvantage is the difficulty in obtaining fine and well-defined embossing patterns.

b) Polypropylene papers

These papers have an anti-adhesive polypropylene coating. Their advantage lies in offering fine, well-defined and exact grains. They, however, cannot be used for temperatures higher than 150°C.
The standard specifications of a silicone coated release paper, used in the coating sector are:

- width from 150 to 160 cm
- weight from 150 to 300 g/sqm
- roll weight from 400 to 600 kg
- roll length from 1000 to 2000 m

After each coating operation, release paper is inspected on a special inspection machine. All defective or torn areas are removed and joints are made with special adhesive tapes. The paper is re-used from 6 to10 times according to the processing conditions.

1.2. OTHER FINISHING OF SYNTHETIC LEATHER: EMBOSSING AND LACQUERING

Whatever type of synthetic leather it is produced (100% PVC, 100% PU or Semi-PU) quite often article need to be finished with two more technologies: **Embossing** and **Lacquering.**

The embossing equipment are used for deep mechanic compression of the substrate in order to give special surface pattern effect (release paper used in synthetic leather process in fact doesn't have engraving so deep). Quite often, embossing line are supplied with paper of transfer film device in order to print special design or special effect on the surface.

The Lacquering line (normally two or three head) which allow to create special surface visual effect on the product as well as apply a final top protective coating which can change external surface specification (resistance to abrasion, UV light, dust…) or feeling (smoother hand, oily touch…)