Metallic Coatings on Nonwovens for Special Purposes

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ABSTRACT: A special, highly adhesive metallic coating has been developed for nonwovens. The coating process has been developed for various substrata as: polyamid, polyester, glass-fiber cellulose and other natural fibers (or their mixtures), and their nonwoven counterparts. The coating itself is an autocatalytic, finishing process, requiring only dip-technologies (like a standard dyeing) on the finely adjusted textile.

INTRODUCTION

A METALLIC COATING is developed by us for textiles, especially for nonwovens. The coating process is made by an autocatalytic method. The technology is a dip-coating without any galvanic (electric) agitation. The whole process is very similar to a simple textile-dyeing.

Only water solutions have been used in these steps, which can be harmonized with each other by time and by the applied chemicals; the process can be done on a continuous conveyor-like basis.

Despite the fact that the chemical (electroless) deposition was discovered more than fifty years ago [1], the underlying mechanism is still not fully understood [2]. The different views are in agreement with the autocatalytic behavior, but for the details of the real process, several explanations are offered: pure electrochemical mechanism [3], "atomic hydrogen" mechanism [4], "dihydroxyl-nickel" mechanism [5], and "hydride-ion transfer" mechanism [6].

In earlier papers [7–12], we described some special features of electroless NiP layers grown on various substrates. These deposits exhibit layered structures that clearly reflect the various stages of formation [7,8].

THE STEPS OF THE PROCESS

The process consists of basically three different steps: a pretreatment, the coating process itself, and a post-treatment. A rough draft of the coating steps is given in Figure 1. The pretreatment sensitizes and activates the clean textile, for which the metallic coating is fixed with a high adhesion. This process is the clue for a satisfactory product.

The schematic diagram of the whole process is shown in Figure 2, while Figure 3 shows the coating process in more detail. The total process is controlled by special computer-guarded equipment, which functions are schematically shown in Figure 4.

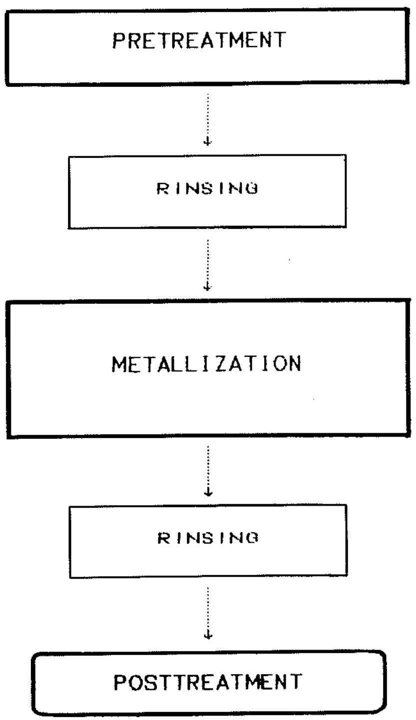

FIGURE 1. Block diagram of the coating process.

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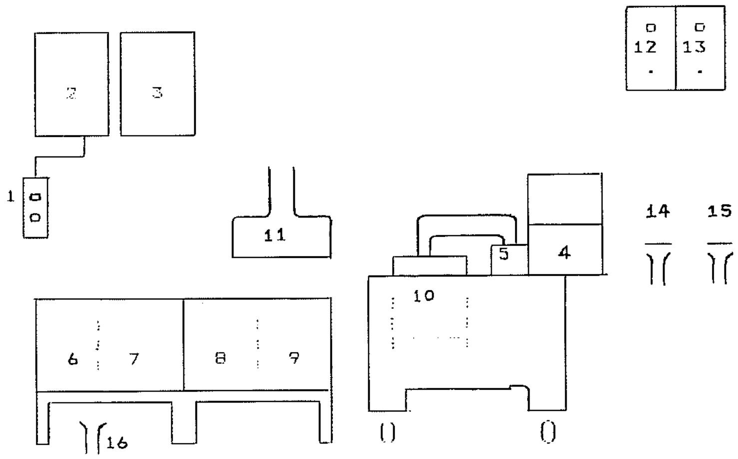

1. mains
2. electric distribution
3. anodic protection
4. control unit
5. heat-exchanger, valves
6–9. pretreatments and rinse
10. coating bath
11. air-conditioner
12–13. regenerators
14. water (heat exchange)
15. water (heat control)
16. water-sink

FIGURE 2. Schematic diagram of the arrangement of the coating equipment.

THE PHYSICS OF THE PROCESS

The different steps of the coating process were widely investigated, and various theories have been developed.

The proposed mixed-potential theories [13,14] point to the interdependence of the anodic and cathodic reactions in the electroless autocatalytic process. Therefore, the main point of the chemical mechanism is that the catalytic reactions due to the subsurface hydrogen states ("excitonic-like") [15–17] are determining the processes.

The P—Ni bonds are randomly situated in the Ni-deposit and remain on the same site because of the released hydrogen. The random P—Ni is immobile because the rate of phosphorus diffusion is small at this temperature. In the first few atomic layers, the phosphorus is barely bound to Ni [8], due partly to the low solubility of P in Ni and partly to the stronger covalent-like P—H bond [18] against the metallic-like Ni—H one [18]. The existence of Ni—P—H species also has been proposed in intermediate reactions. An increase of phosphorus concentration causes the lowering of $N(E_F)$ [19–21], and thereby, causes the activity of the "excitonic-like states" [15–17], too. The phosphorus content can grow up to 25% (the stable intermetallic compound Ni_3P), whereas the "excitonic-like states" have disappeared and the catalytic activity decreased to zero.

The growth of the coating is controlled by microphysical processes which are basically similar in all stages and centered on autocatalytic behavior. This means that the growth geometry is similar, therefore, the fractal-growth picture can be applied [12]. Detailed investigation of this fractal-growth process shows that the randomness given by the non-homogeneous chemical circumstances on the surfaces do not disturb the basic growth behavior. This is the origin of the industrial coating process' large dependence on the purity of chemicals and in the wide scale of additive chemicals and agitations.

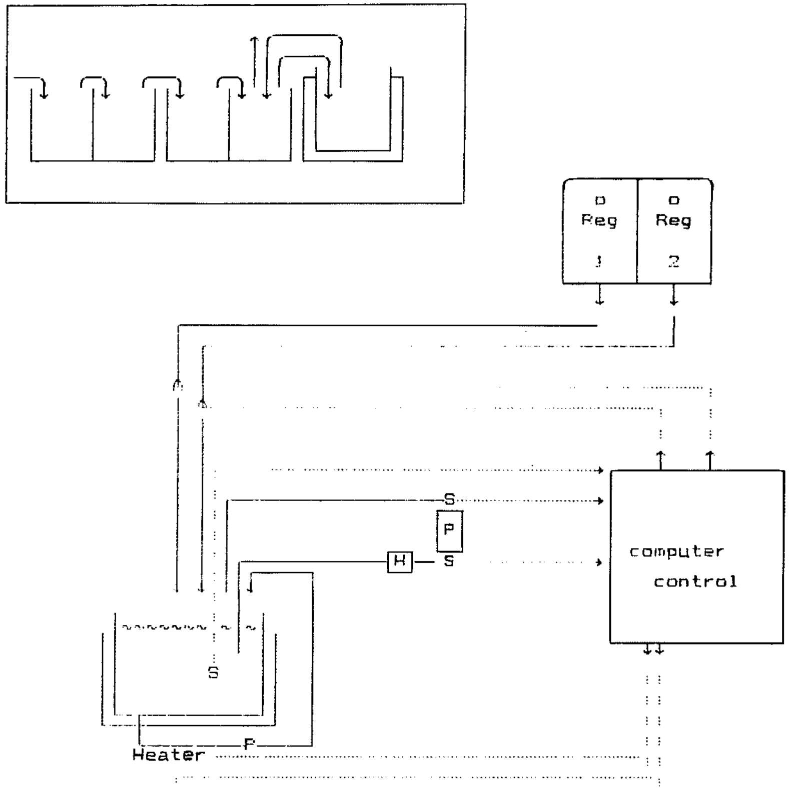

FIGURE 3. Setup of the coating step (the total process is indicated in the insert).

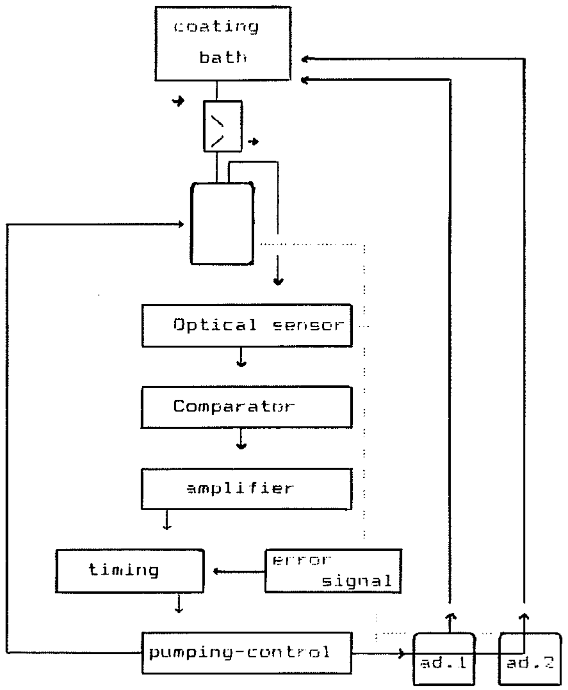

FIGURE 4. Block diagram of the computer-guarded central control unit.

The growth process can be divided into three well-distinguished stages [7–9]:

- The first is the nucleation period which is determined by the initialization process and the Ni-clusters.
- The second is the globular growth period which is determined by the refinement of the growing spheres characterizing the "excitonic-like" process by the P—H interaction. The coalescence of the spheres is hindered by the P-rich precipitations on the globule surface and the hydrogen-gas sorption.
- The third is the smooth-surface growth. When the fine spheres are coalesced, the growth is sheet-like, similar to the Ni—P bond determining the state [22].

The entire electroless deposition process is, in fact, governed by the hydrogen effects.

APPLICATIONS OF THE METALLIZED TEXTILES

The metallized textile materials are applicable in a very wide field of high-tech and conventional technics.

The metallic coatings are very different; their resistivity ranges from pure copper up to the alloys with high electrical resistivity. Special effects (as the negative or zero temperature coefficient of the resistivity, the temperature-limited conductivity, etc.) can be done. These effects give the possibility for self-regulating heaters.

Depending on the properties of the coating, the functional role of the products can be as follows:

1. Decorative coatings (for commercial textile and confection industries, wall-papers, advertisements, packing, etc.)
2. Screening and shielding (for fine electronics, computers, laboratories, low noise circumstances, Faraday-cages, etc.)
3. Medical applications (screening for pacemaker users, humidity control in bed, local electric, magnetic/thermal effects, etc.)
4. Fine printing-painting (network printing for electronic purposes, fine paint distribution, etc.)
5. Mechanical strengthening (functional textile uses for sports and every-day life, etc.)
6. Enhancing wear resistance (functional textile uses, conveyors, etc.)
7. High electric conductivity in flexible material [wiring, sport (fencing or other) indication, security purposes, etc.]
8. Thermo-reflective applications (enhancing the heating efficiency, screening of the thermal-radiation, internal heat reserve for the air balloons, etc.)
9. Antistatic applications (particle filtering in gases and/or liquids, defense of the fine-electronics/computers, etc.)
10. Special heating applications [local heating (in special suits, seats, etc.), heated wall papers, heated carpets/curtains, flexible heating units, etc.]
11. Flame-resistivity (functional textiles, coatings, sandwich layers, etc.)
12. Chemical resistivity (special working suits, textile applications in chemical industries, etc.)
13. Radar-reflectivity [security coating on the non-radar-reflective vehicles (boats, dragon-flights, flight-robots, etc.), security suits for people in trouble (mountain sports, water sports, life jackets, etc.) misleading large metal units, etc.]
14. Antenna applications (telecommunication, etc.)
15. Light reflective applications (enhancement of the sun effectivity in agriculture, etc.)

16. Percolating sensors ("skins" for robots and automats, security applications, mechanical sensors, etc.)
17. Masking applications (shaped porous ceramics, catalysts, specialized porous materials, etc.)

Let us discuss one of the above unusual applications, that has a lot of interesting and useful adaptations.

ROBOT/SKIN APPLICATIONS

The history of science and technology is filled with ideas that were applied and later forgotten. However, there is a new renaissance—the resistive (graphite) microphone which we have chosen to construct—a new, interesting, and functional nonwoven application.

The action of the graphite microphone is based on the so-called percolation-resistivity. This means that the resistivity of the graphite-powder depends on pressure (powder conducts much better if the grains touch each other well). This effect changes the sound intensity (pressure "wave" in the air) of the microphone by converting the changes of the resistivity, thereby fitting the electronics level well.

The effect of the above action is converted in nonwovens and causes the random contact effect of independent and conductive (by the coating) fibers. This effect also depends on the mechanical pressure that causes conductivity changes by affecting the ways of continuous conduction through the material. Pressure causes the fibers to touch each other tightly offering more ways for conduction than without the outer mechanical effect.

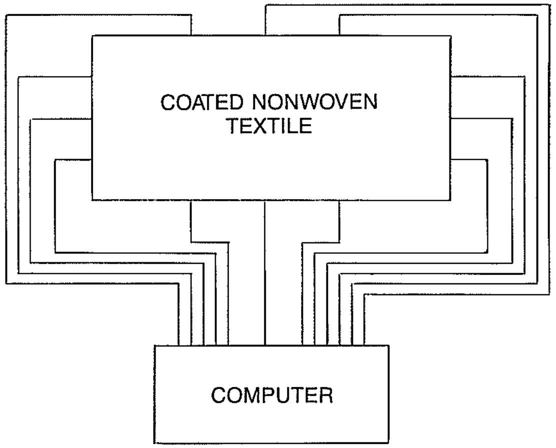

FIGURE 5. Electrode system in a grid arrangement for the position-sensor by the nonwoven sensors.

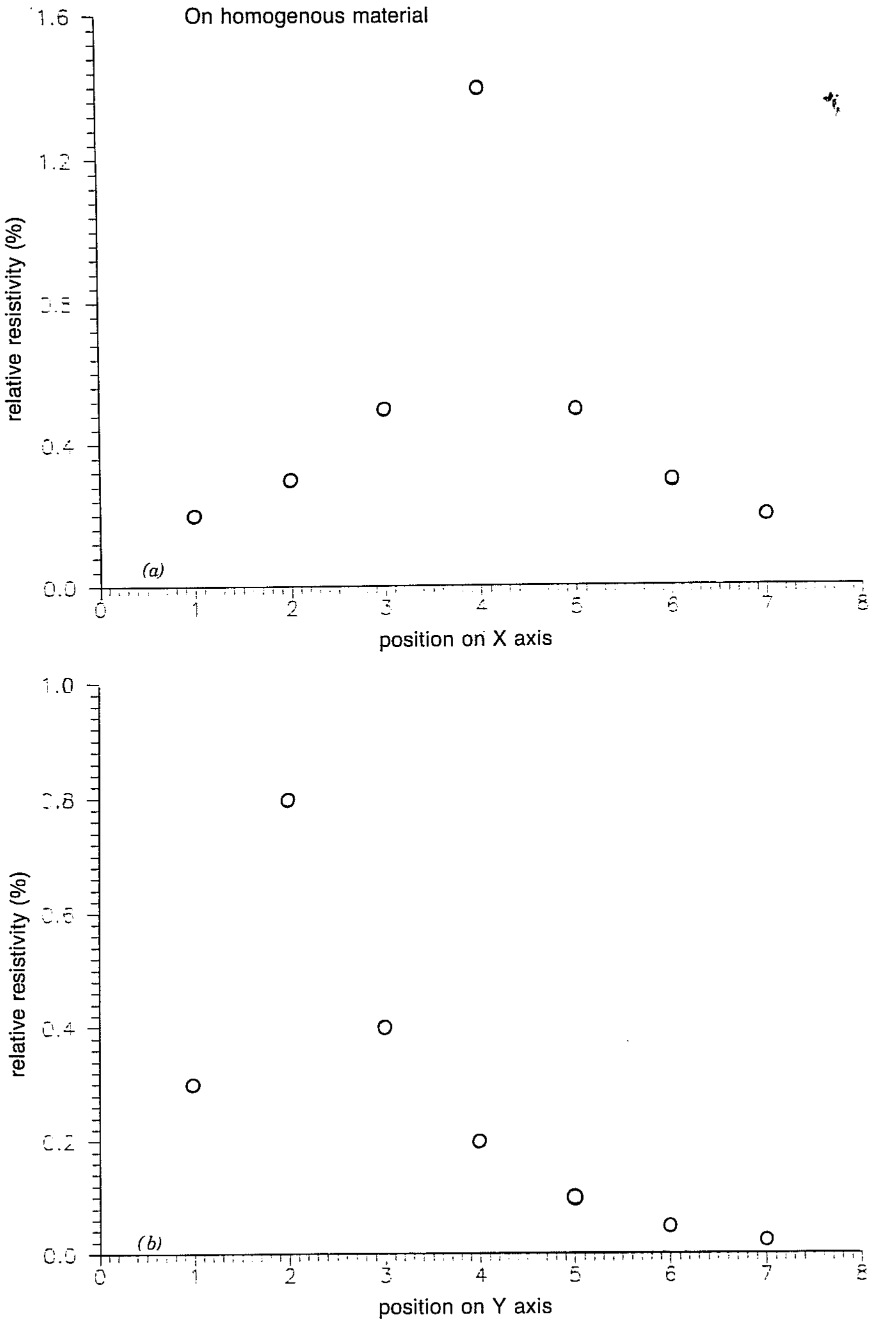

FIGURE 6. Measured relative resistivities in the grid system. The touch was done in position $x = 4$, $y = 2$: (a) measurements in x-direction; (b) measurements in y-direction.

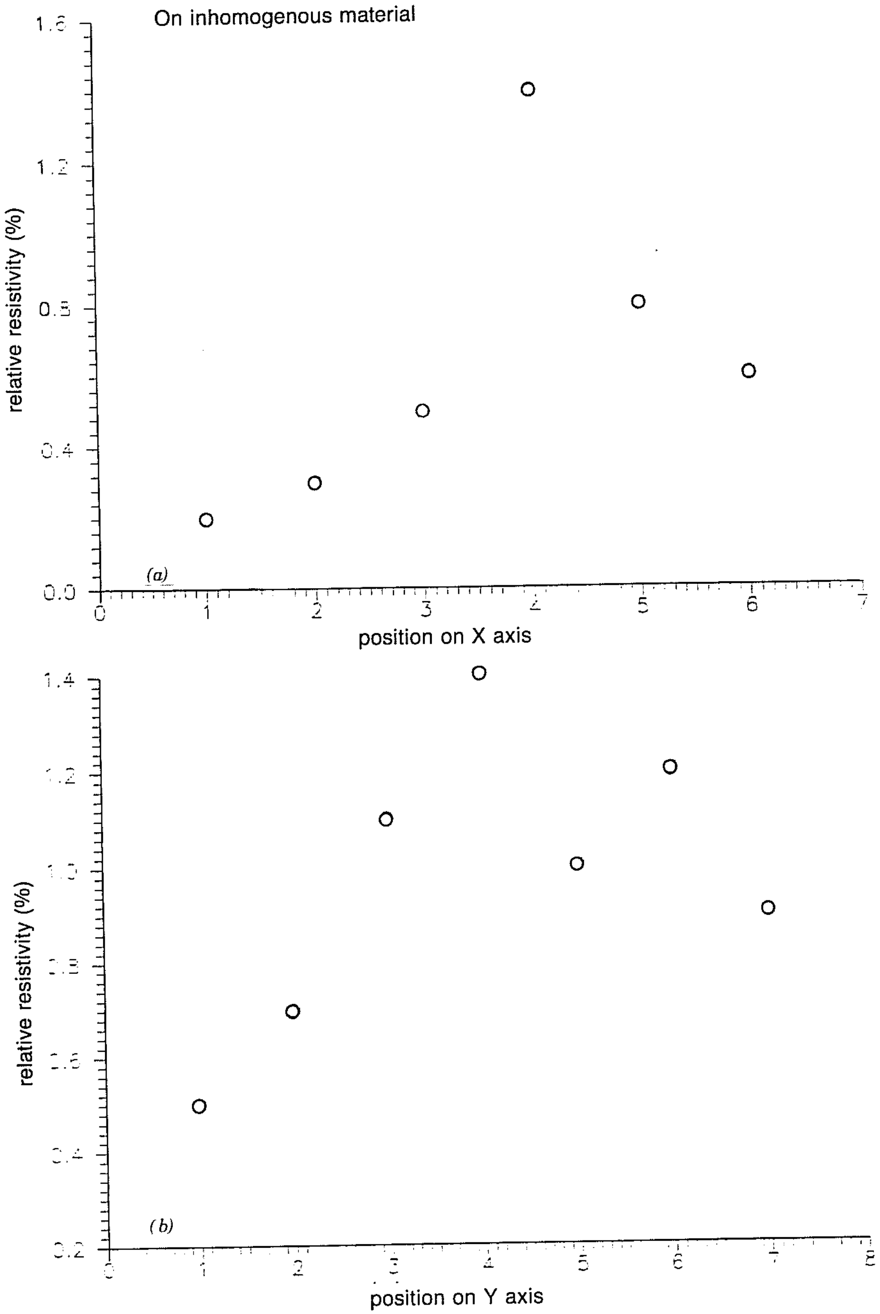

FIGURE 7. Measured relative resistivities in a grid system on non-homogeneous materials. The touch was done in position $x = 4$, $y = 4$: (a) measurements in x-direction; (b) measurements in y-direction.

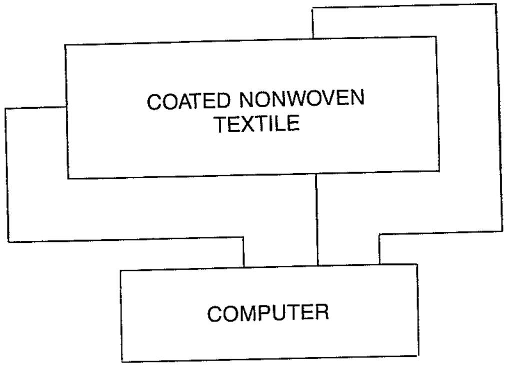

FIGURE 8. Non-symmetric electrode system for computer-controlled position sensors.

Based on this idea, the coated nonwoven becomes a surface sensitive media, ready to develop a new kind of surface sensor. By applying electrodes on the coated materials, the system will be sensitive for any touches, which is useful for different applications. (For example, the guarding of shop windows, exhibitions, museums, etc., without wiring, alarms and security guards at windows, doors, etc.; sensors for different processes, noises, etc.) By constructing an appropriate electrode system on the coated nonwoven (Figure 5), the position-sensor also can be developed. In this arrangement a sense of grids is possible. Some measurements of relative resistivity in these grids (in X and Y perpendicular directions) have been measured and shown in Figure 6. If the material is not homogeneous (Figure 7), the inhomogeneity can be corrected by a computer control. The computer control is able to sense the position without the electrode-grid system; only three electrodes are needed in definite positions (Figure 8).

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Planning Your New Extrusion Coating Line: A Project Engineer's Perspective

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ABSTRACT: Extrusion coating lines are among the most technically complex units found in a converting facility. Issues that impact the execution of projects to install these machines should be thoroughly reviewed by the project team if a successful result is to be obtained. This paper reviews process, facilities, and administrative tasks to be considered when planning a new extrusion coater in an existing manufacturing plant.

KEY WORDS: cost engineering, extrusion coating.

INTRODUCTION

THE DECISION TO proceed with the installation of a major project is an exciting event for any company. These decisions are seldom taken lightly since they involve large capital expenditures. However, events often occur during the course of these projects which lead to cost overruns or the failure of the equipment to meet productivity requirements. These events usually can be anticipated if the project is rigorously defined.

Extrusion coating lines offer the converter the opportunity to manufacture a wide range of products which offer a good rate of return for a reasonable investment. Many of these lines are installed by smaller firms with minimal engineering staffs. These firms can reduce capital cost, im-

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