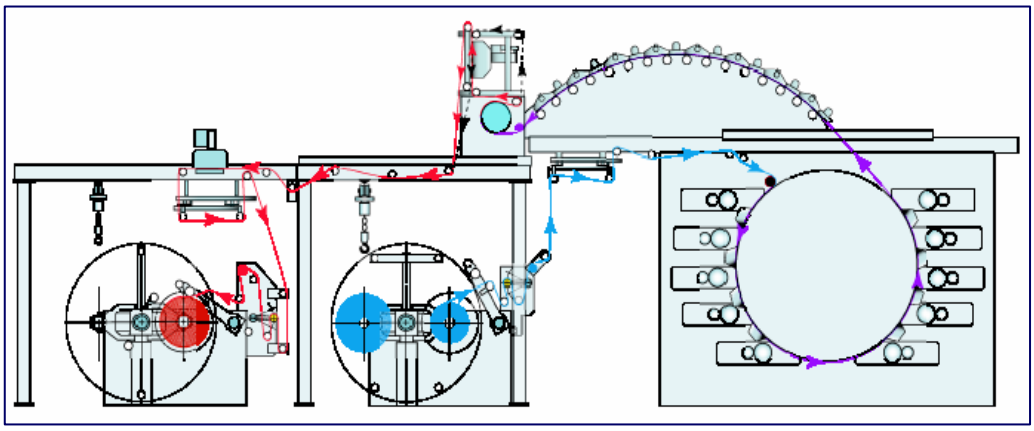
NONWOVEN Enhancements

Printing Aqueous Inks on Nonwovens

Steven J Dalbey
Polytex Environmental Inks

CONTENT



WORLD'S RECOGNIZED SOURCE
POLYTEX
FOR ENVIRONMENTALLY SAFE INKS

1. DEVELOPMETS OF AQUEOUS TECHNOLOGY

The use of water-based inks can be traced to the early 1900's. In the 1940's a few low performance systems were being used by the corrugated board industry where print quality was not important. In the late 1960's acrylic based and styrenated shellac inks began to replace earlier maleic and fumeric rosins but these systems had severe deficiencies including:

- poor gloss
- poor adhesion
- foaming
- poor beat stability
- poor film properties
-

New acrylic polymers became available in the early 1970's for use on gravure and flexo presses but exhibited serious defects such as:

- drying in the engravings and on cylinders
- difficult to clean
- poor print quality
- poor block assistance

As a result, water based systems did not receive serious attention from most converters. However, other factors surfaced to influence increased attention and awareness to aqueous systems. In the mid 1970's there was a world wide crude oil shortage that affected the availability and cost of petroleum based by products such as solvents used for solvent based inks and coatings. This placed increased pressure on finding suitable alternatives and replacement products. The increased attention in environmental issues, plant emissions, air quality and safety received deserved government attention. In the U.S., Congress passed the Clean Air Act requiring states to meet standards established by the Environmental Protection Agency (EPA). A critical part of this act was to set 1imits on emissions of volatile organic compounds (VOC'S). Non compliance meant monetary penalties and in some cases plant closings. Ink companies responded to the challenge with meaningful commitment to the development of user friendly inks and coatings.

During this same period governments also initiated actions to protect the safety and health of employees. In the U.S. the Occupational Safety and Health Act set forth exacting regulations limiting workers to solvent exposure. This human factor became another key for opening the door for safer water based inks. Additional incentive was provided as companies recognized the costs associated with fire protection equipment such as sprinklers, the cost to run incineration units to capture and destroy emissions and the carrying charges for insurance policies.

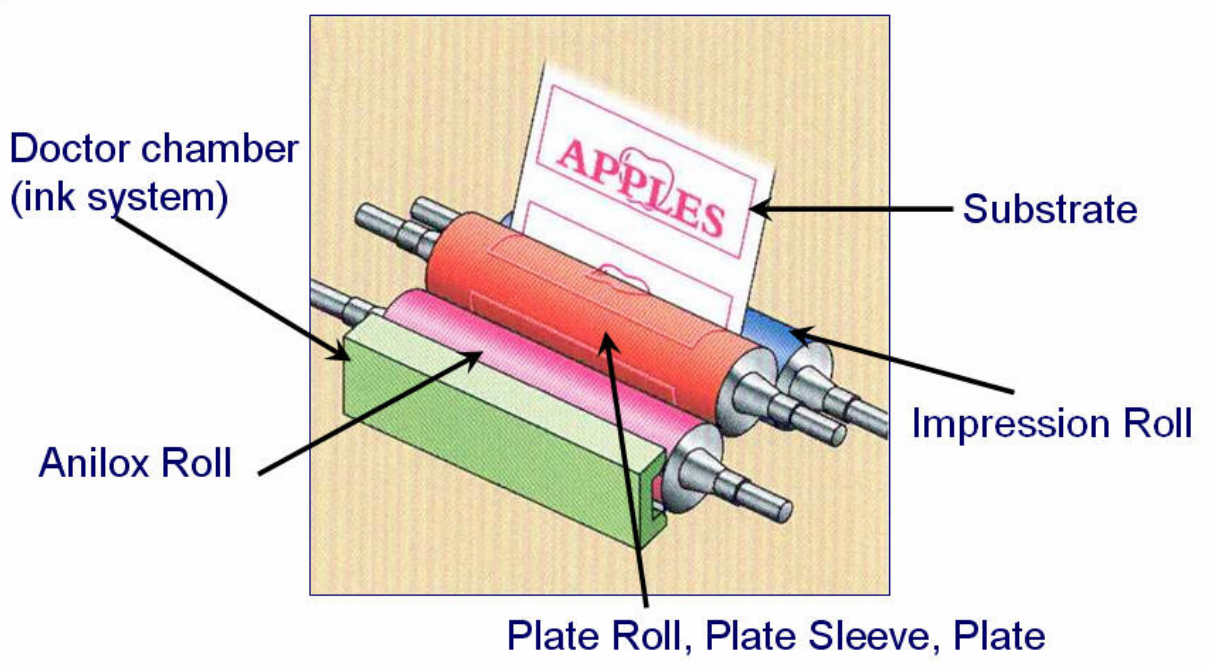
2. TECHNICAL PARAMETERS

Solvent formulation is fairly simple systems of resins dissolved in volatile organic solvent(s) containing pigment and fillers to achieve color and opacity. Film formation occurs as solvent evaporates. In contest aqueous systems are complex mixtures of resins, pH modifiers, coalescent, surfactants, rheology modifiers, defoamers, pigments and fillers to provide specific performance properties. Water is the dominant earner. Resins or polymers can be water soluble or emulsions that are discreet micron size particles suspended in water. Film formation occurs as water evaporates and resin particles combine and coalesce. Since water has higher heat vaporization than most solvents formulations may require heat to evaporate the water drier requirements are generally linked to performance characteristics or properties to be discussed in the section on process variables.

There are several important differences between solvent and aqueous systems that are tied to understanding the performance differences with these products.

- Emulsion resins used in aqueous inks and coating are high molecular weight polymers compared to those used in solvent inks. High molecular weight polymers provide better physical properties and contribute durability.
- Aqueous systems can be formulated to higher solids content to provide improved physical characteristics.
- Solvent systems are limited as the resins must be dissolved to form a solution which limits the use of high molecular weight resins and their solids content.

Controlling rheology or flow properties of these systems is critical to their use in the various print or coating processes and will be discussed in another section.

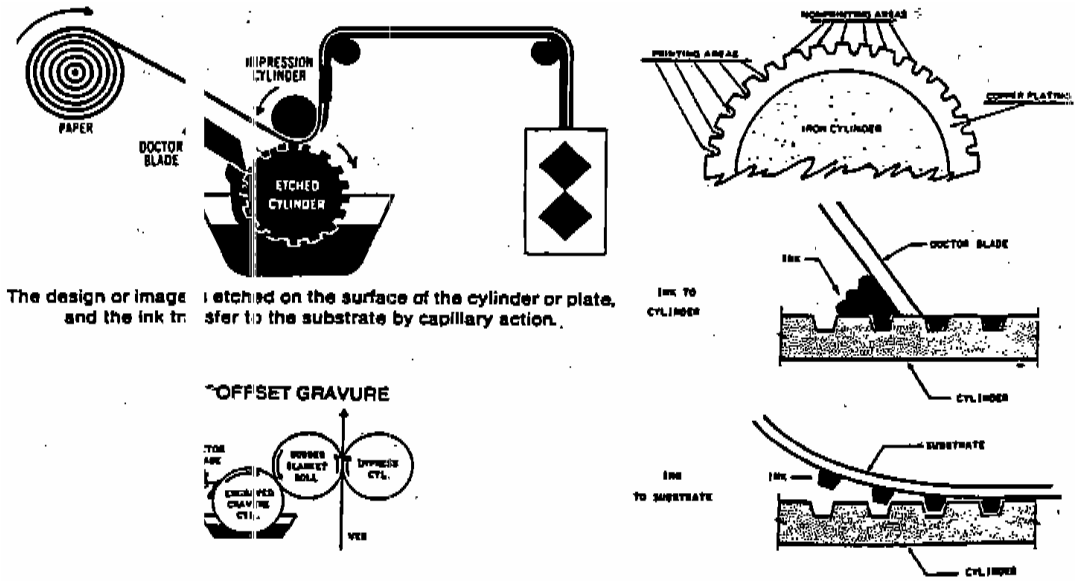


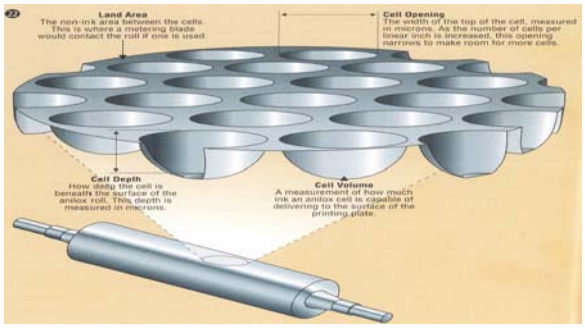
3. PROCESS & PROCESS VALUABLES

Each process makes specific and different demands on printing inks. It is therefore important to understand these requirements if aqueous systems are to be used successfully. The major converting process is used by converters are discussed.

GRAVURE

The rotogravure process is an excellent method for producing quality tonal prints and is the basic method for a technique referred to as process printing. In this procedure four colors are printed in sequence yellow, magenta, cyan (blue) and black to achieve photographic quality prints. The basic element of the gravure process is the gravure print cylinder composed of millions of micron size cells which make up the image area. The cylinder is a steel base with a thin copper covering. The cells are generated via chemical etching or mechanical or laser engraving that are cut into the copper shell. The copper shell is chrome coated to protect the engraving. The engraved cylinder rotates in an ink fountain to cover the entire surface. A blade (doctor knife) positioned of the cylinder surface removes all of the ink except for the ink contained in the individual cells. New development involves the use of an enclosed blade system where the ink is contained within the blade reservoir and is deposited and wiped at the same time. This method has the advantage for minimizing the amount ink required by eliminating the fountain. Finally, the ink is opposite onto the substrate (web) with pressure (see figure).



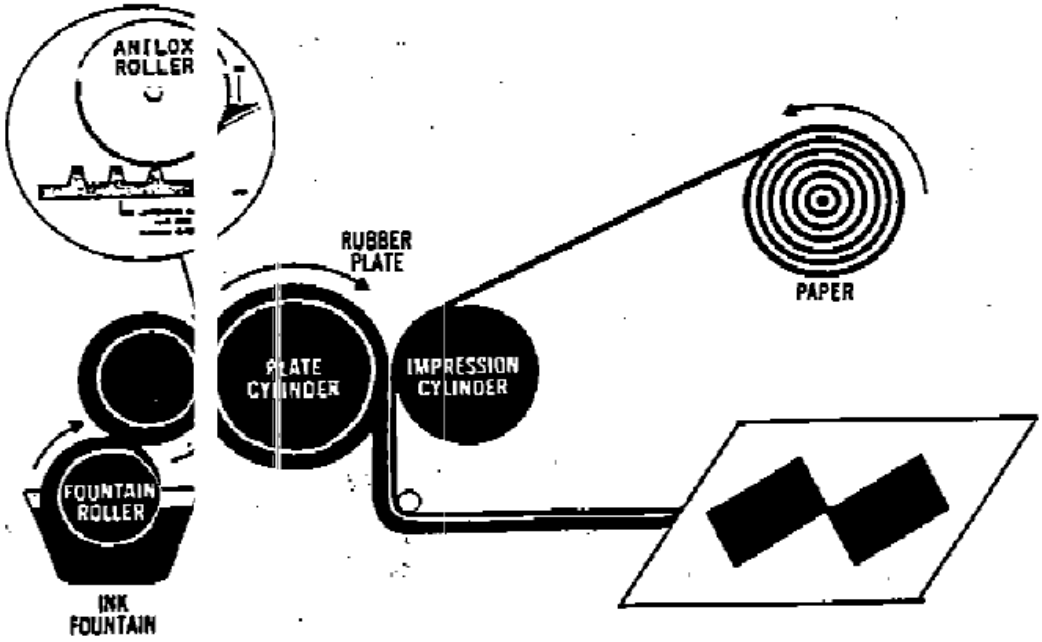


Gravure inks must have excellent wet flow out properties and are usually formulated at low viscosity from 100 to 300 centipoises (15-30 seconds # 3 Zahn Cup). Flow properties and rheology are important factors in achieving quality prints. A review of this topic is provided later. Unlike flexography trapping is not an issue as each color passes through individual stations with driers to dry each color. Drier concepts are covered later in this presentation.

Inks are available or both the sophisticated in-line multi-station presses and older U-Type presses with limited drying capacity. Machines that have been used for solvent inks can usually be modified and converted to handle water-based inks.

FLEXOGRAPHY

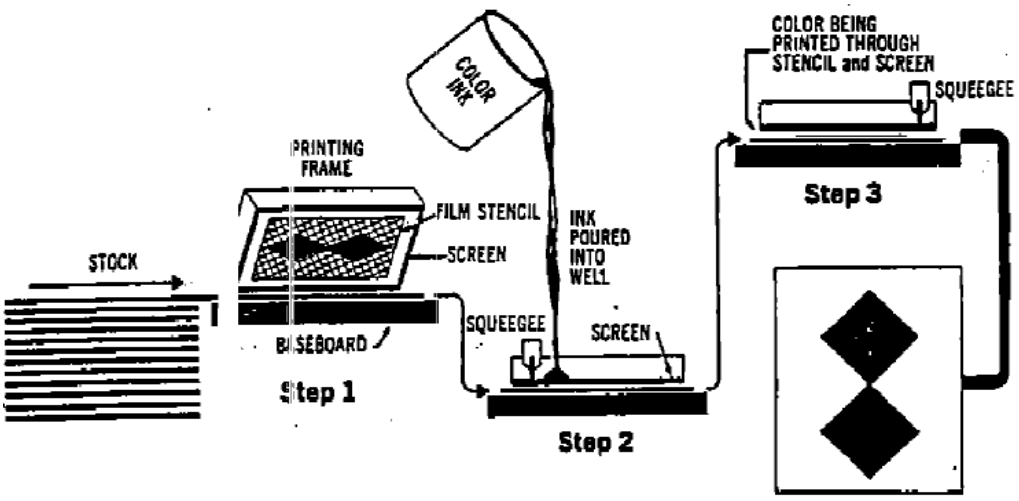
In contrast to gravure printing, flexo printing is accomplished by using rubber plates or cylinders where the image or print areas are above the surface of the cylinder. The ink is delivered from a fountain or closed doctor blade unit on to an engraved roller referred to as the anilox roller and onto the design cylinder. The final transfer is from the rubber cylinder onto the substrate.



Trapping with water-based inks is a critical performance requirement. Trapping occurs when one color prints over a previously printed wet color. It is essential that print definition and color strength be retained Developing inks with thixotropic flow properties give better results and this and other rheology characteristics will be reviewed. Solvent inks do not exhibit this type of flow whereas aqueous inks can be modified to be thixotropic. Flexo printing has become an important more widely used printing process. Print cylinders are less expensive compared to gravure and using laser techniques cylinders can be engraved to provide excellent print quality at very high speeds. This process is used for printing on synthetic film such as polyethylene and polypropylene. Controlling the surface tension is essential to develop ink adhesion and print fidelity. For this reason most presses are equipped with corona discharge units to provide a surface energy (dynes) to the poly films. Best results are achieved with levels of 40 to 45 dynes.

SCREEN PRINTING

Although flat screen printing has lost position as a major process, a large number of smaller companies are still involved. Traditionally slow evaporating solvent inks have been used as the slow solvents minimize join marks as the screen moves down the table. Today, the transition to water-based inks he replaced solvent inks. Water based inks can be retarded to effectively eliminate join mark and provide open time to minimize ink drying in the screen. This is a special process which is capable of laying down a heavy ink deposit compared to gravure or flexo. For this reason screen printing creates vivid, high impact designs with bright opaque colors.



Rotary screen printing for continuous web processing has become an important print process for decorative product such as flooring, wall covering, textiles and non wovens. In rotary screen printing ink is delivered to the inside portion of the round screen. The screen, in contrast to flat screens where the screens are made of synthetic fabric, is a seamless nickel construction containing thousands of small openings. The number of holes or openings per inch is referred to as the screen mesh. Similar to gravure the higher numbers mean finer screens which yield better print quality and lower ink deposits. A squeegee blade positioned inside the screen is used to push ink through the screen holes. For both the flat and rotary processes water-based inks and coatings are formulated to provide the necessary open time to prevent ink drying in the screen openings. Rotary screen printing is a high shear process and the inks must be formulated with appropriate flow properties. Normally, higher viscosity is needed to contain ink within the screen. Under shear of the squeegee blade, screen inks will develop a lower viscosity to provide excellent screen release and flow. A careful blend of ink components are employed to provide open time, screen release and print fidelity even after the press has been stopped and restarted after being down prolonged intervals of time.

COATING APPLICATIONS

Aqueous systems are available for the important range of coating techniques including air knife, rod, knife, roller, certain and spray coating. Each process requires specific rheology properties as most coating processes are high shear applications. Rod coating is one example where low viscosity to provide smooth lay down of color is essential. High speed applications such as air knife coaters are susceptible to foaming and formulations are provided to avoid this problem. For all processes especially spray applications particle size distribution must be controlled to provide

defect free coatings such as streaks and other surface problems. For these reasons, water based coatings are formulated for:

- Low foam generation
- Excellent transfer and flow
- Easy clean up
- Excellent particle size distribution

DIGITAL PRINTING

Digital printing is a form of non-impact, printing as there is no contact between the print unit and the substrate. The two most important techniques are continuous and drop on demand. Ink jet inks are very low viscosity systems preferably in the 1-10 centipoise range compared to gravure of 100-300 and flexo inks 100-200 centipoise. This process is excellent for delicate substrates and rough surfaces.

In the continuous process, a high frequency voltage is applied to a special piezo crystal that is in contact with the ink. The crystal pulses to from a stream of droplets directed at the web. To control the dots there are electrically charged and pass through oppositely charged plates and some of the dots and deflected away and others reach the web to form the image.

In the drop on demand process, pressure is applied to the ink as needed. There are several nozzles each controlled to deposit droplets of color as required. This system is simpler since no electrostatic charge as generated and deflection is not required.

PROCESS VARIABLES

Effective processing of inks with any of the printing or coating techniques cannot be accomplished without the appropriate selection of the ink or coating delivery method, the choice of the preferred drying technique. A basic understanding of how films are formed and rheology or viscosity characteristics is important.

Pumps are required to deliver inks to the press fountain or to the enclosed doctor blade units. To handle aqueous inks effectively low shear pumps are recommend such as diaphragm or peristaltic pumps. These units do not generate foam or excessive shear that may cause viscosity problems. The pumps can be fitted with stainless steel filters to remove contaminants. For optimum quality and control of defects inks should be filtered before they are introduced into the print unit. Controlled mixing of inks is important and low shear mixers are suggested. Mixers should be positioned to eliminate the formation of a vortex to avoid foam.

Desired performance properties are achieved when the inks or coatings are dried and film formation has taken place. The terms drying and curing are often used interchangeably. The term drying is used to describe the removal of the volatile portion of the formulation either solvent or water. The development of optimum properties occurs when the ink is set (cured) to from a cohesive film. Inks are designed and formulated to have specific curing or film forming characteristics. Some of the factors that affect curing are humidity, moisture and temperature and substrate porosity. Inks formation is accomplished by certain physical or chemical mechanisms.

Absorption is accomplished by penetration of the ink into the pores of the substrate and the Diffusion of the ink through the material.

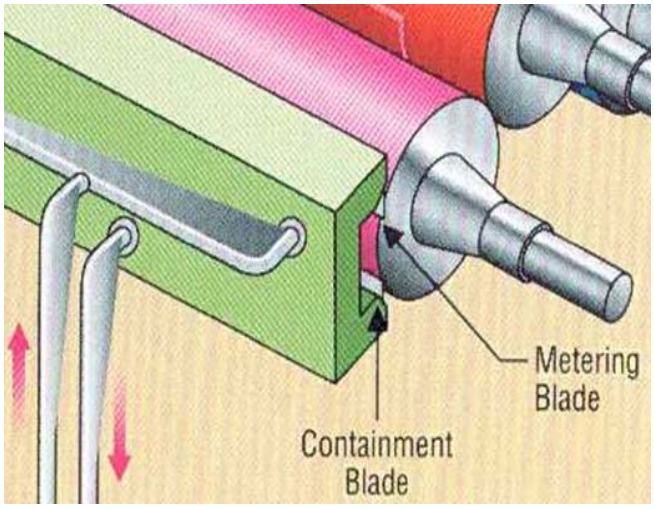
Evaporation of solvent or water based inks is dependent upon the vapor pressure of the carrier. Evaporation can be accelerated by adding an external heat source.

Curing can occur be chemical reactions within the ink often through a cross linking mechanism. In this case specific ink components are selected that react with each other as evaporation and drying takes place inks from a component different from each of the individual components. UV inks are unique systems as the curing mechanism is initiated by exposing the ink to an ultra violet energy source to provide cross linking.

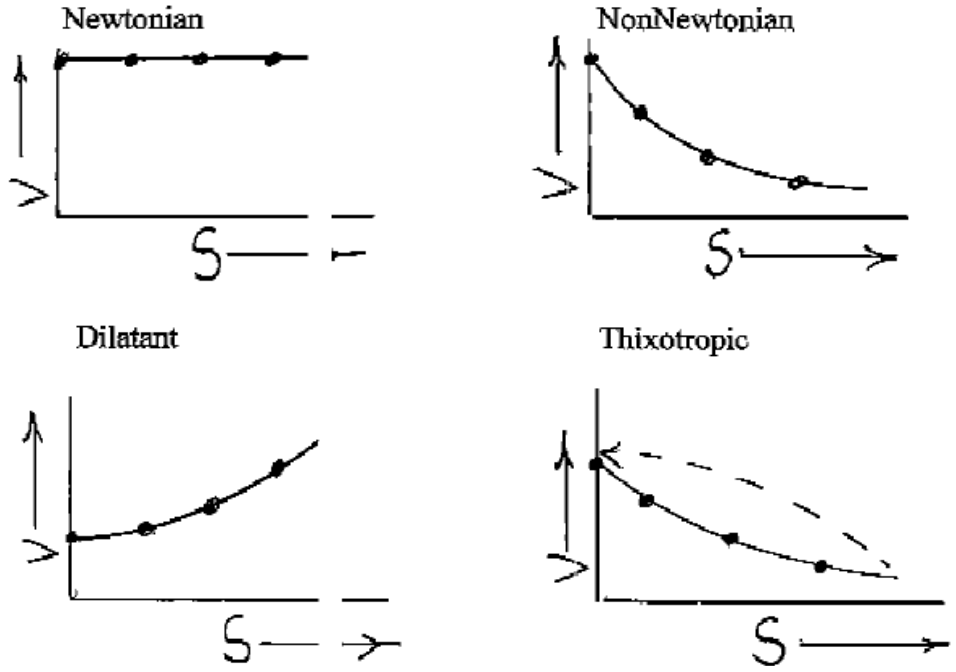
Drying of inks can be accelerated with the use of an external heat source and modern print presses are fitted with units to affect the rate of film formation and provide the high line speeds required for product on efficiency. The most efficient and widely used drying techniques are high velocity hot air, impingement units, infra red units or combination of each of these methods. These systems are need between print stations or used in vertical ovens for coating applications. To achieve effective removal of volatile components with hot air, nozzles are positioned to create a narrow air flow to remove vapor from the wet surface and expose a new layer of wet ink. Saturated warn air must be exhausted simultaneously for effective drying. The use of infra red energy provides an effective way to achieve drying in compact spaces. They can be designed to provide a specific wave length range for optimum effectiveness. Heat generated by the IR is delivered through the wet ink to accelerate the drying process. IR driers are also designed so that air is passed through the IR heating sections to add hot air impingement.

RHEOLOGY/VISCOSITY

Since considerable reference has been made as to importance of rheology on the on the performance it is worthwhile to briefly discuss this topic.
Rheology or flow properties can be categorized in four ways and is defined by the relationship between viscosity and shear force. Viscosity is the measurement of how a material flows under pressure or how an ink will resist flowing. In other words, inks with low viscosity will flow more readily then those with high viscosity. Inks and coatings will behave differently and the flow properties will vary as shear forces are applied as for example during the printing process.
Results from each of the print and coating processes can be optimized when inks and coatings are formulated with the preferred rheology.



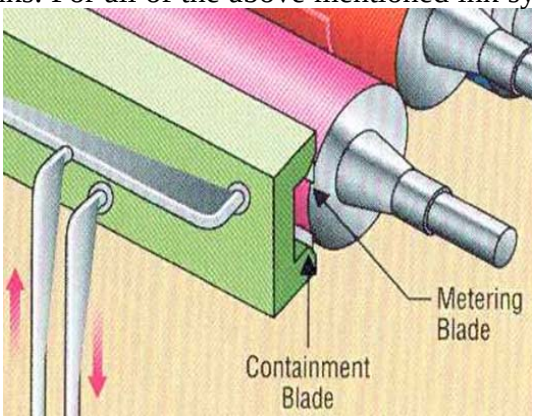
The following descriptive definitions apply:
Newtonian Flow: Viscosity remains constant as shear increases.
Non-Newtonian Flow (pseudoplastic flow): Viscosity decreases as shear increases.
Dilatant Flow: Viscosity increases as shear increases.
Thixotropic Flow: Similar to pseudoplastic flow except that these materials have a time dependent characteristic. As shear force is removed the inks return from their low viscosity state to a higher viscosity. These characteristics are described in the following diagrams.



4 SUBSTRATES

Water based inks and successfully used for a variety of common and uncommon substrates and applied with all of the processes described. Paper constructions include ground wood stocks, free sheets, matte and gloss surface papers and coated stocks. Coated stocks include clay based acrylic and PVA coatings and PVC plastisol coatings. Aqueous systems have been developed for calendared and extruded plasticized vinyl films and rigid and semi rigid vinyl. Synthetic films used in packaging applications to include polyolefin and polyester types including metallizd polyester films can be printed with aqueous inks. For all of the above mentioned ink systems are available to provide:

- print fidelity
- adhesion
- crock resistance
- washabilty
- alkali and alcohol resistance
- stain resistance
- emboss ability
- light and heat fastness
- functionality



With the growing importance of non woven substrates a new range of aqueous products have been developed. Nonwovens are finding applications in wall coverings, window treatments, disposable hospital products, wipes, personal care products and table and picnic covers and protective clothing to list a few. Inks are formulated to provide the required hold out properties, adhesion, flexibility, functionality and opacity for these light weight porous structures.

5. ADVANTAGES OF WATER BASED INKS & COATINGS

The performance advantages water based inks and coating systems have been documented with extensive plant testing and long-term plant experience. Advantages have been proven in three concerned areas:

- Performance
- Economics
- Versatility

PERFORMANCE ADVANTAGES

The concern for environmental issues worldwide was the driving force to create interest in using water systems to replace solvents. Government regulations were issued requiring the control of hazardous substances and the emissions of volatile organic compounds found in solvent inks. It was imperative that new water-based inks provide the necessary performance to qualify as an alternative technology. Experience has proven that Polytex systems not only met specifications but in fact exceed standards. Most important for each print process they provide print fidelity, color uniformity and consistency during the production run optimum line speeds.

Performance advantages for water-based systems have been established in the following areas:

- Chemic, Resistance- Aqueous inks are formulated to provide alkali and alcohol resistance and are not affected by soap and commonly used cleaning agents.
- Scrub and Wash Properties- Aqueous inks withstand harsh cleaning tests using standard- scrub testers.
- Adhesion - Aqueous inks adhere to a complete range of substrates including papers, plastic films, coated papers, non-wovens, foil, vinyl, etc.
- Block Resistance- Aqueous inks are used on vinyl constructions and resist plasticized migration. They can be processed at high temperatures without sticking to machine components or sticking within the bundle of finished goods.
- Light Resistance -Aqueous inks will not discolor when exposed to prolonged periods of UV radiation.
- Heat Resistance- Aqueous inks will not discolor during high temperature processing.
- Color Consistency- Evaporation problems usually encountered with solvent inks is eliminated with aqueous inks. Loss of solvents during production is a major reason for poor color consistency with solvent inks.
- Opacity-Aqueous inks can be formulated at higher solids to provide opacity and color strength.
- Film Strength- Aqueous inks contain high molecular weight high solids emulsion polymer systems that contribute to improved film integrity.

ECONOMIC ADVANTAGES

Economics are an important factor for companies considering the conversion to water based inks. It has been demonstrated that these inks not only contribute to improved processing and performance characteristics but also provide savings when compared to solvent systems Favorable economics are achieved due to the following factors:

- Insurance cost
- Cost of Environmental compliance
- Ink stability
- Ink consumption
- End product uniformity

Using water eliminates the cost associated with fire insurance, fire protection equipment, special plant construction requirements, the purchase or maintenance of emission control devices, and the energy costs to run control devices.

Costs to control ink viscosity due to solvent evaporation, loss of production time due to color change and lack of color uniformity are eliminated. This has enabled manufacturers to produce extended print runs and virtually eliminate color drift. The costs associated using expensive solvents to wash cylinders, storage containers and ink fountains are of hidden costs. The printer can utilize finer line gravure engravings flexo anilox cylinders with aqueous inks that results in lower ink deposits and substantial ink savings. More production yardage is possible using less ink. The economic advantages discussed are not theoretical but are factual based on actual plant evaluation.

VERSATILTY

As mentioned earlier aqueous inks can be applied to all of the important substrates:

- papers and coated papers
- plastic forms such as polyolefins
- rigid and flexible PVC surfaces
- metallic oils
- non-wovens

Formulations are available to create a variety of special design effects such as:

- process colors
- metallic finishes
- expanded foam finishes
- mica pearl finishes
- opaque and transparent colors
- suede finishes
- soft finishes
- protective topcoats

6. APPLICATION

The development of aqueous inks has evolved to a range of diverse products that are available to provide performance, color, and functionality and special effect properties for almost any substrate. A partial listing includes:

- Wall covering
- Flooring
- Window molding and blinds
- Vinyl siding
- Furniture edge banding
- High pressure laminates
- Upholstery
- Decorative paper
- Packaging products
- Personal care products
- Surgical protective gowns
- Disposable sheets
- Household pipes
- Napkins/Table covers

8.NEW APPLICATIONS

Inks today are being used for color (Brand Management) and also for functional attributes. There are many characteristics that can be implemented into an ink and/or coating that adds value to the printed product. Below is a list of other functions that can be incorporated in an ink formula:

- Increased absorbency
- Odor masking
- Stiffness / Softness
- Abrasiveness
- 3-dimentional
- Strength
- Stretch
- and many other relating to the purpose of the product

The array of potential applications is only limited by the scope of our imagination.

Steven J Dalbey has been in the ink manufacturing and printing industry for over 20 years, A graduate of Temple University he has secured employment with companies such as Ciba, Sun Chemical, and Polytex Environmental Inks encompassing diverse markets for Nonwovens, Packaging, Corrugated, Home Furnishings, Flooring, etc. with applications using Flexo, Gravure, Silk Screen, etc. with different ink systems - UV EB Water-based, Solvent-based, and Digital Printing.

Steven J Dalbey
Polytex Environmental Inks

NONWOVEN Enhancements

Printing Aqueous Inks on Nonwovens

Colorants in Nonwovens

NONWOVEN Enhancements

Topics

Introduction to Printing

Water Inks on Nonwovens

Characteristics / Functions

Brand Management

NONWOVEN Enhancements

Introduction to Print

- **Gravure**
- **Flexography**

- *Offset Lithography*
- *Silk Screen*

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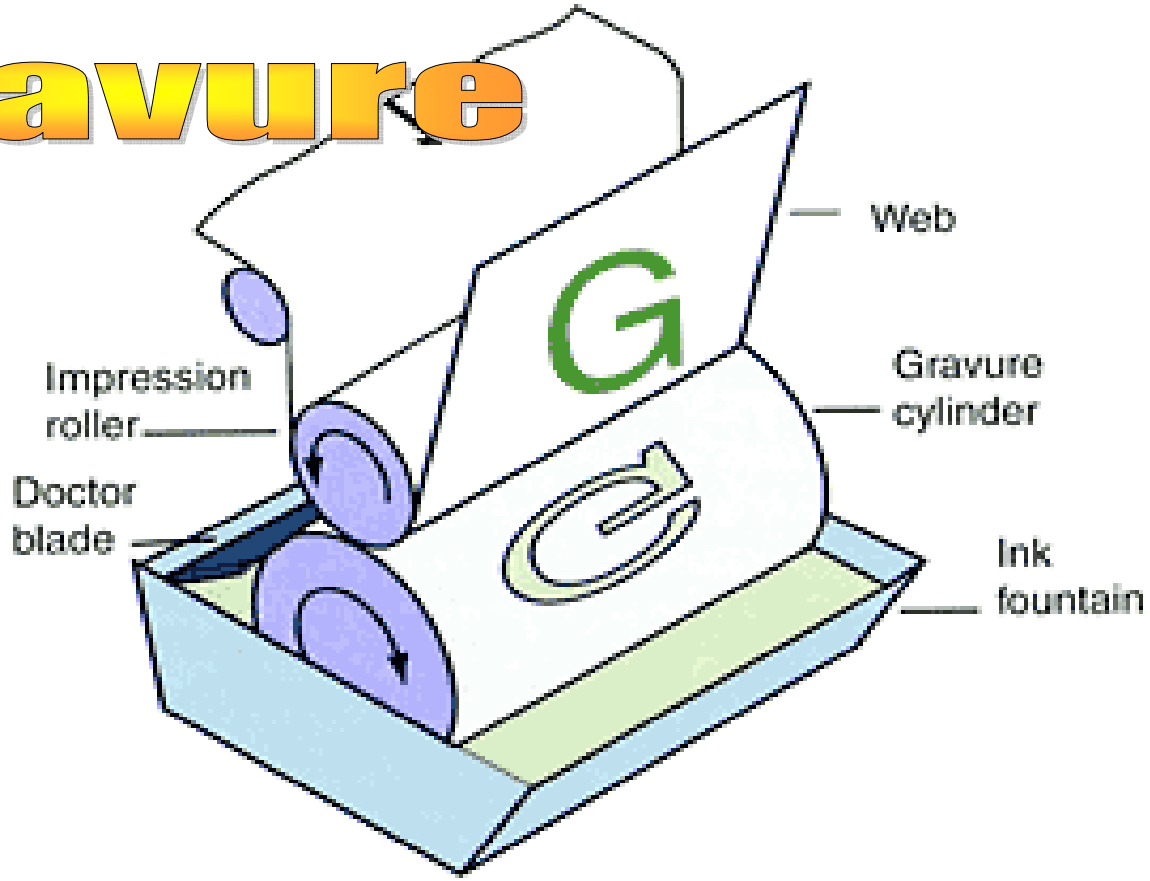
Introduction to Print

Gravure



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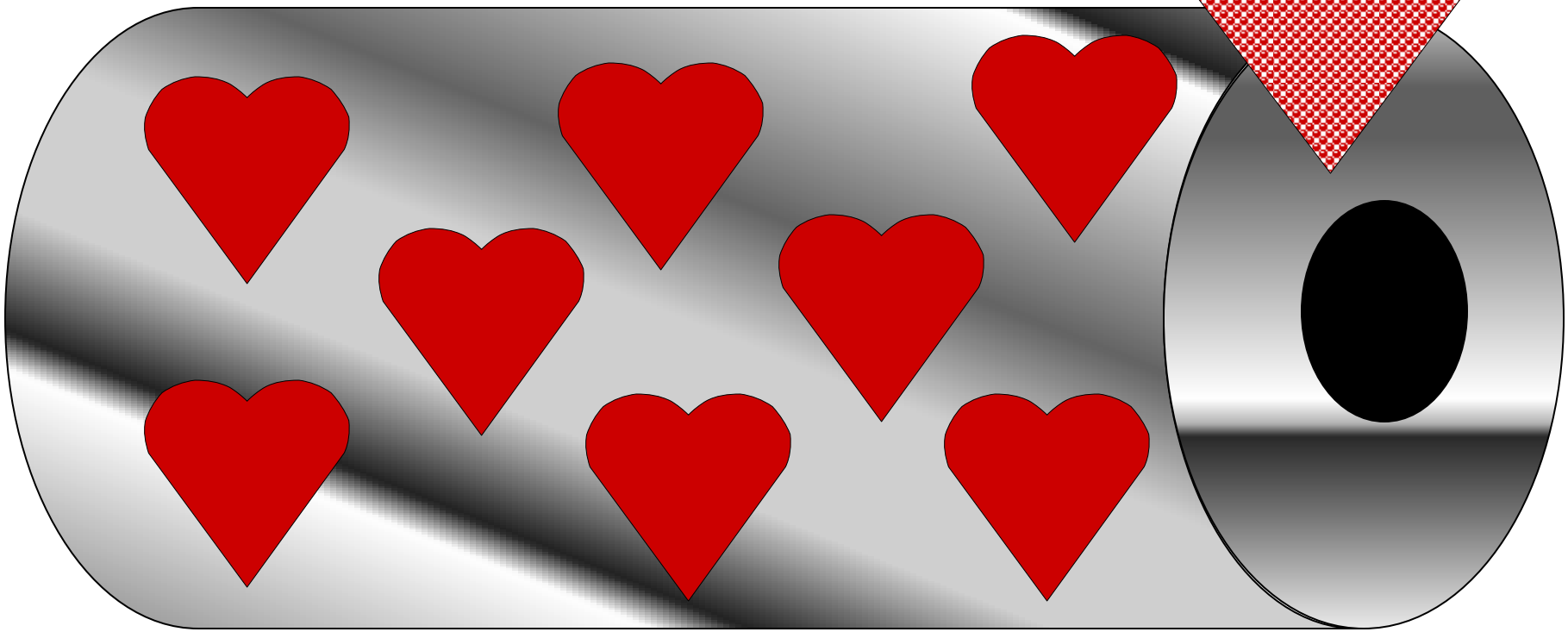
Gravure



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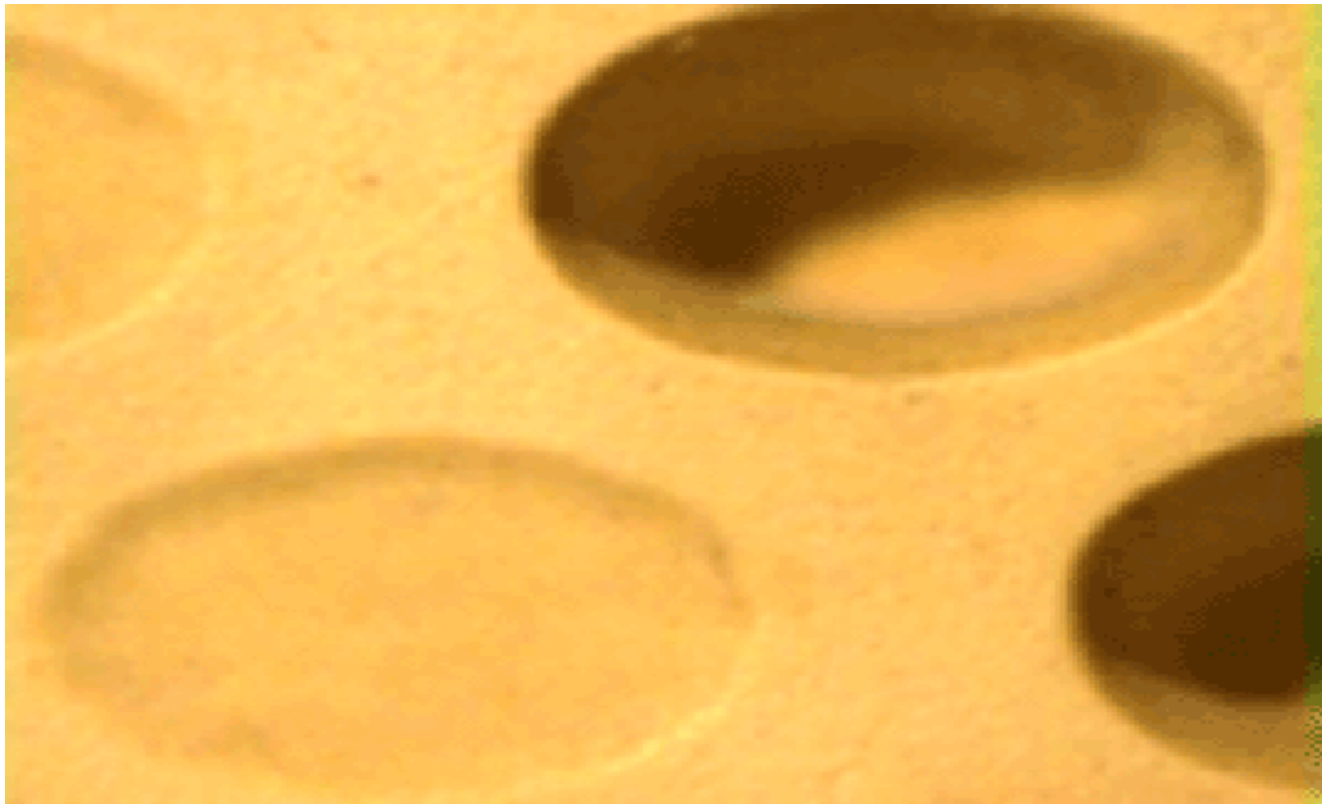
Gravure



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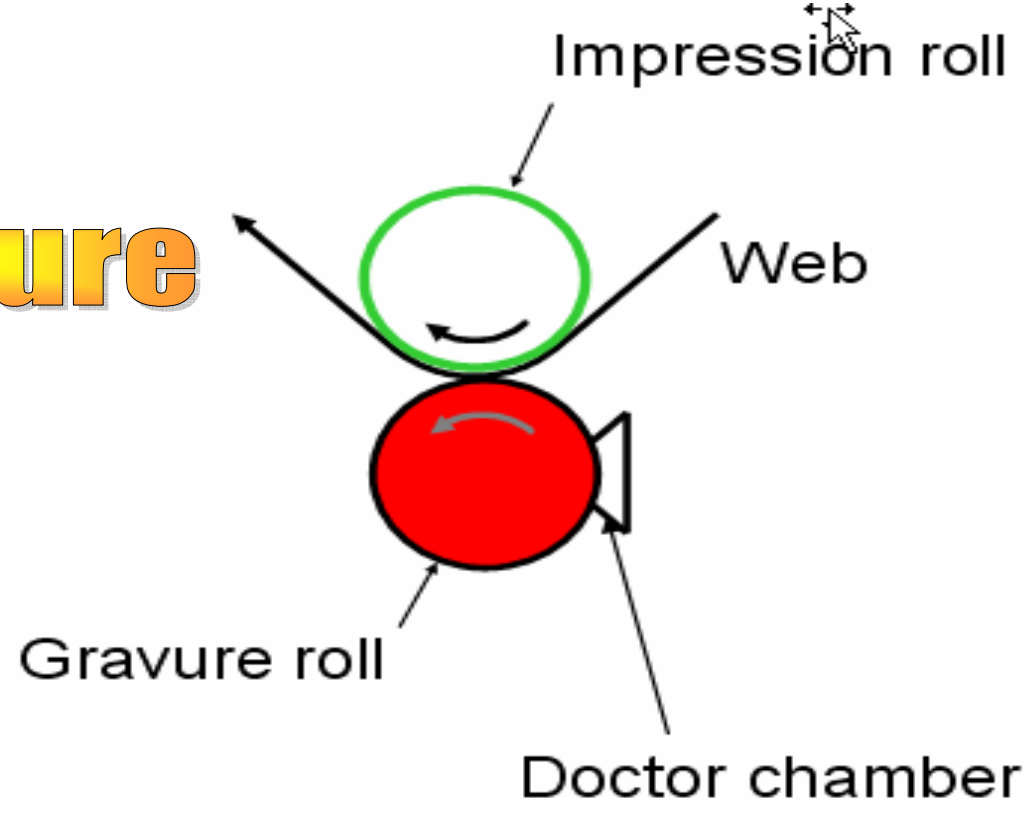
Gravure



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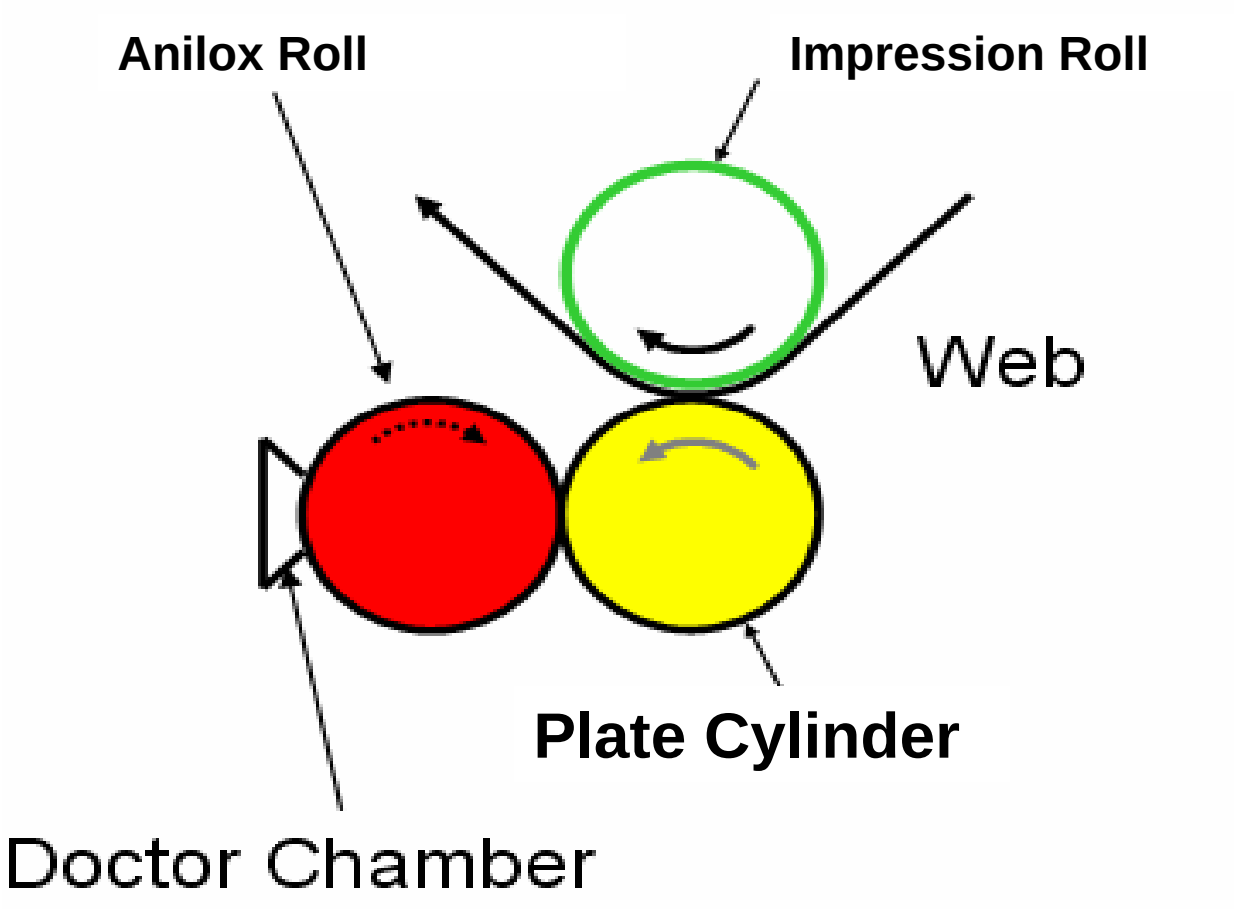
Flexo



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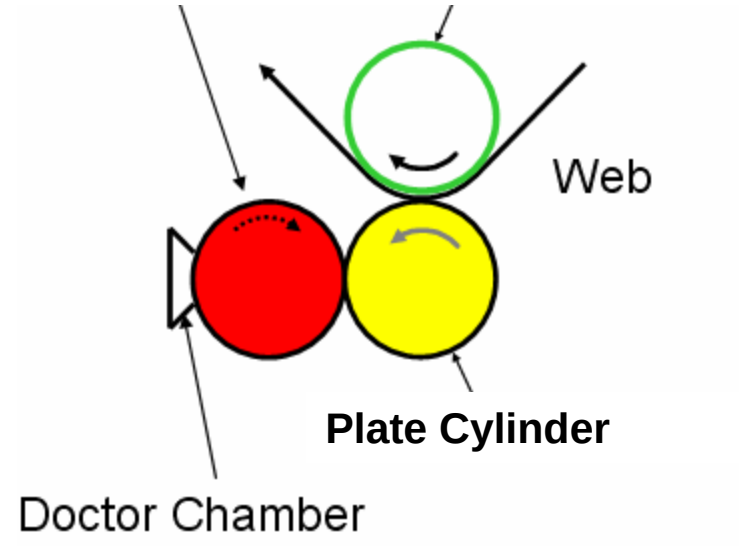
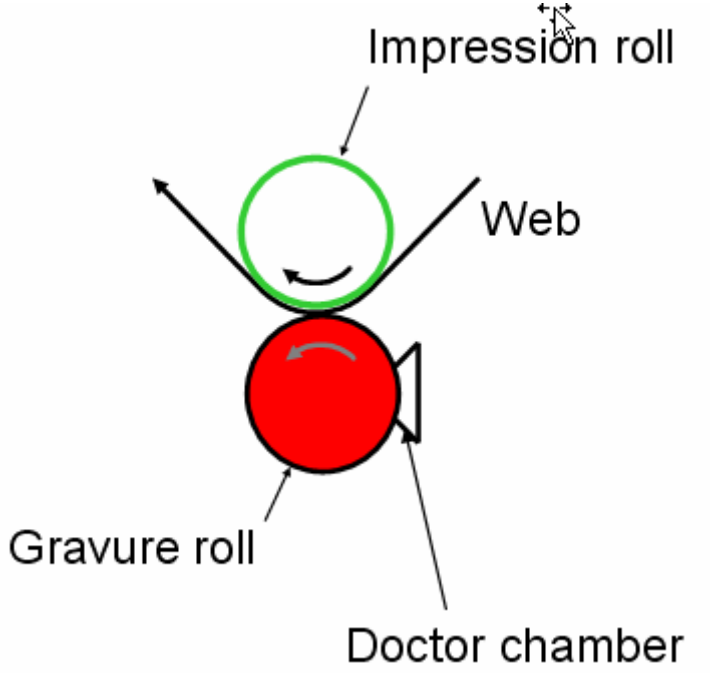
Flexo



Gravure



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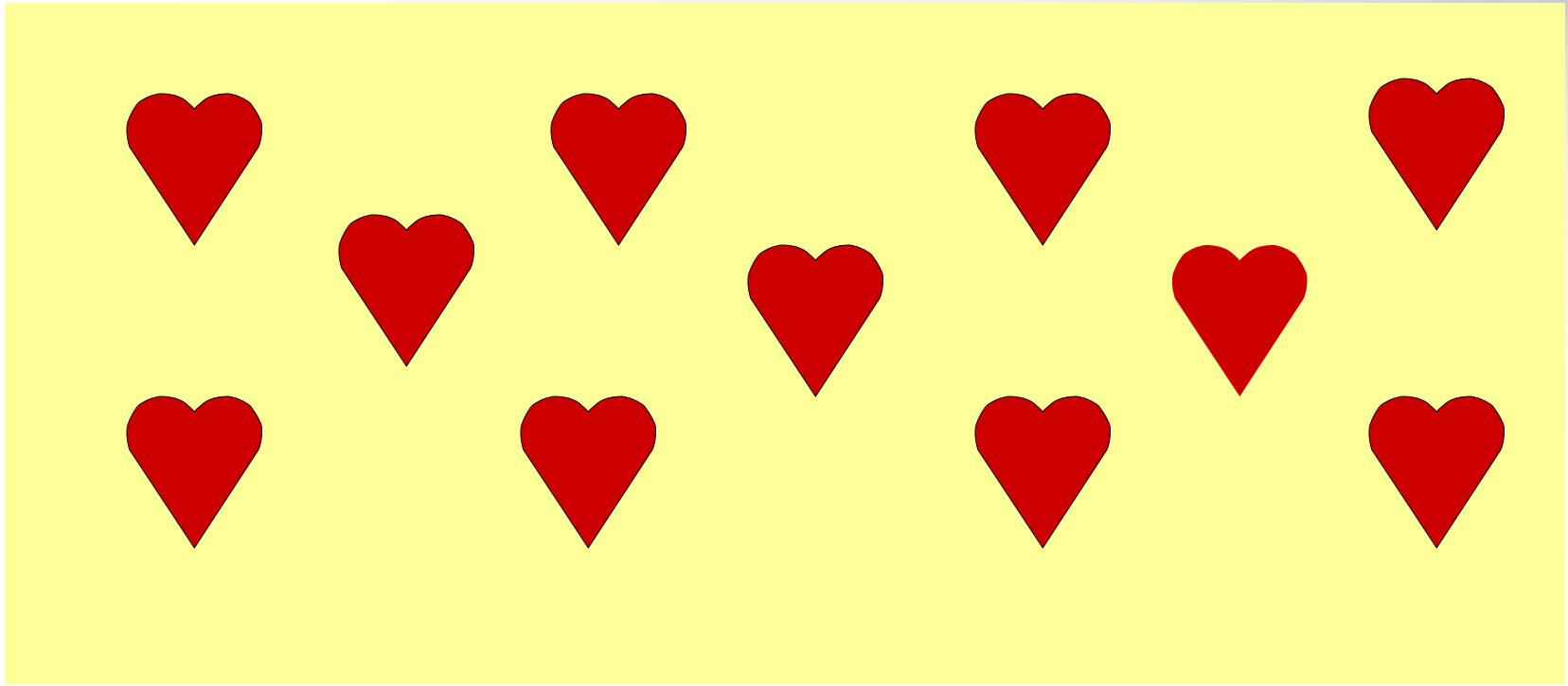
Flexo Printing Plate



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Introduction to Print

Flexo Anilox

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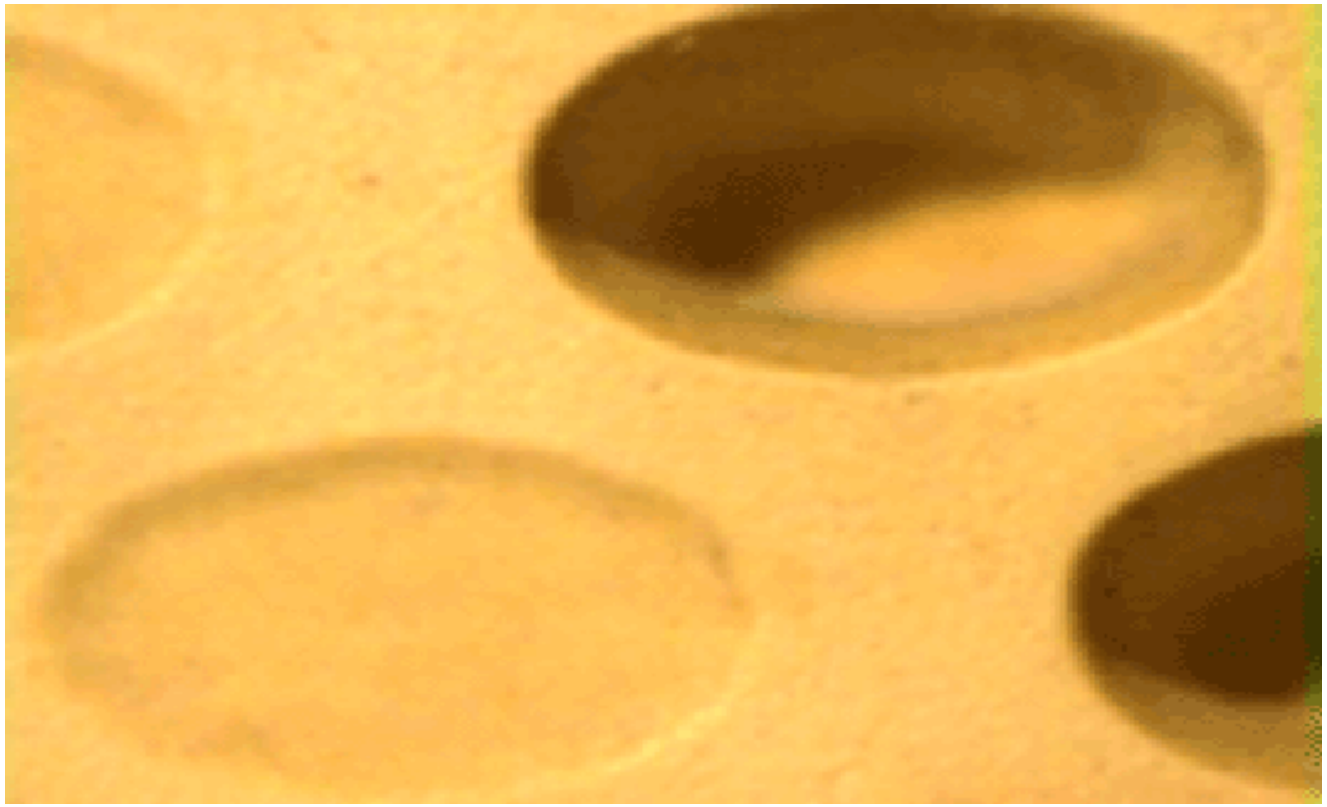
Flexo



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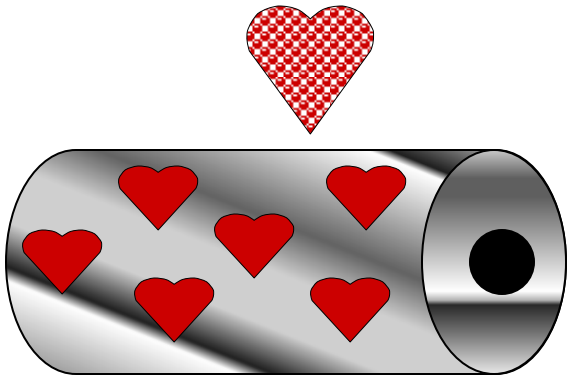
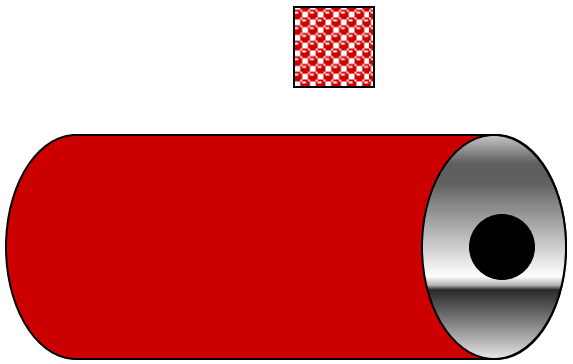
Gravure



Flexo Anilox



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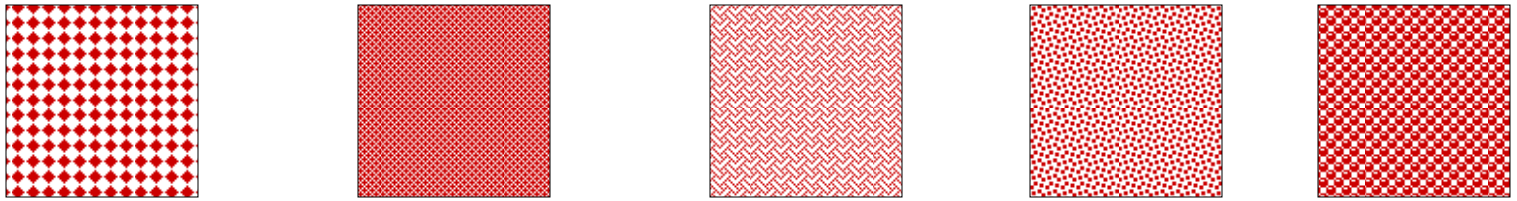
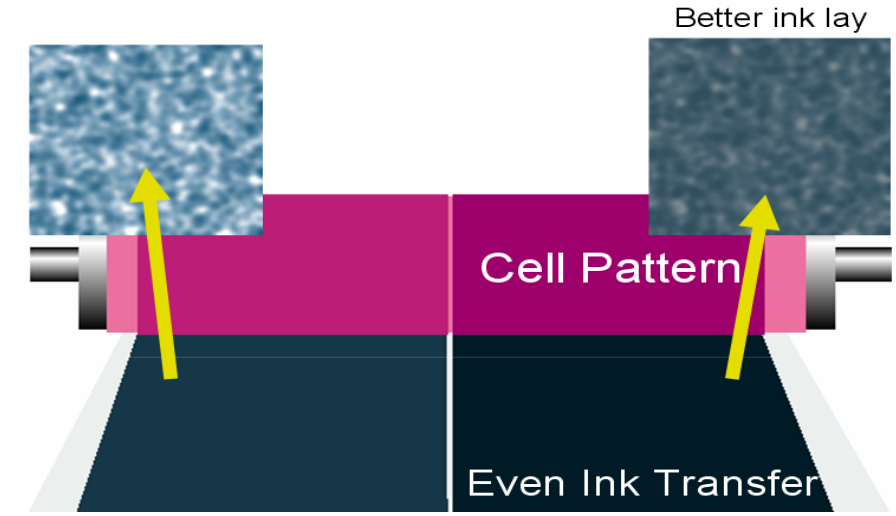
Introduction to Print

Gravure, Flexo





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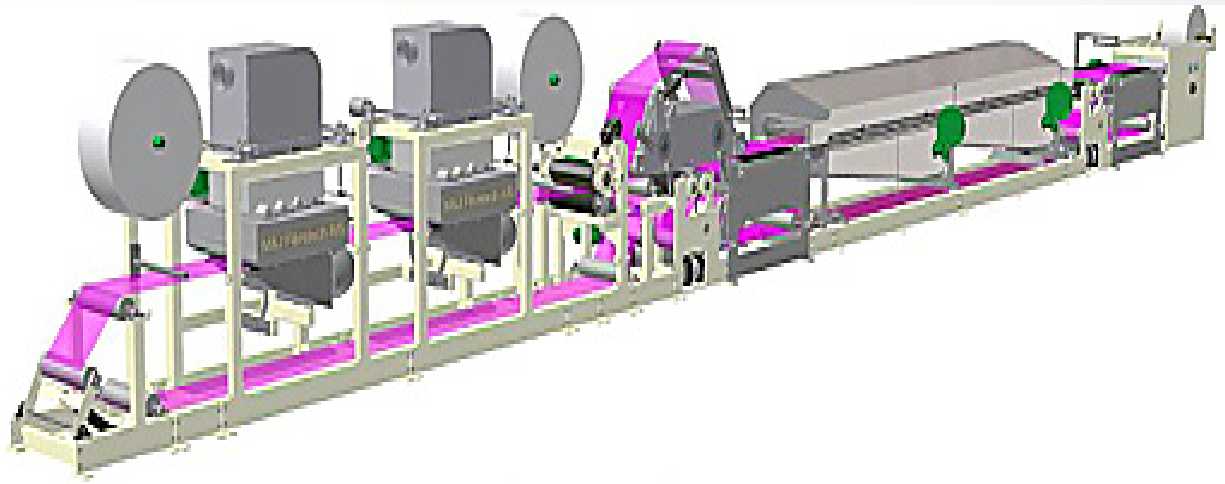
NONWOVEN Enhancements

Introduction to Print



NONWOVEN Enhancements

Water-Based Inks on Nonwovens

- No HAPS - Hazardous Air Pollutants
- Acceptable VOC levels
- Only water required for Clean-up
- Color non-fading
- Low Costs
- Press speeds 1500 – 2500 fpm
- Any Color – Pantone, Corporate, Brand, etc.

NONWOVEN Enhancements

Water-Based Inks on Nonwovens

Medical – **doctors, nurses, and general medical materials**

Baby Infants – **diapers, baby wipes, bibs**

Food service – **table cloths, napkins, place-mates, etc.**

Wipes – **wet, dry, personal, cleaning**

NONWOVEN Enhancements

Water-Based Inks on Nonwovens

Medical

- **Doctors, nurses, and general medical materials**

Enhancements

Water-Based Inks on Nonwovens

Baby Infants

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Enhancements

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Food service

- **Table cloths, napkins, place-mates, etc.**

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Wipes

"A Clean Sweep-is it within reach"?

- ***"Household wipes have registered off-the-chart growth in recent years but now manufacturers will need to innovate even more to compete"***
- *By Ellen Wuagneus Associate Editor "Nonwovens Industry Magazine"*

NONWOVEN Enhancements

Water-Based Inks on Nonwovens

Wipes

- **Wet, dry, personal, cleaning**
  - Specific Rub characteristics
  - Special chemical / cleaner resistance

NONWOVEN Enhancements

Water-Based Inks on Nonwovens

Wipes

- **Bacteria, mold encourage the growth of wipes and will continue to do so**

NONWOVEN Enhancements

Characteristics / Functionality

- **Absorbency**
- **Odor control**
- **Aromatic**
- **Strength**
- **Specialty**
- **Hydrophilic**
- **Hydrophobic {directional}, etc.**

NONWOVEN Enhancements

Brand Management

Product Identification

Value

Comfort Zone

NONWOVEN Enhancements

Brand Management

- Product Identification.
- Color ownership has long been an advantage in brand marketing. We recognize Coke Cola and DHL / FedEx shipping services because of their color and design. Product Identification has proven to assist in providing comfort to the buyer in his purchasing decision.

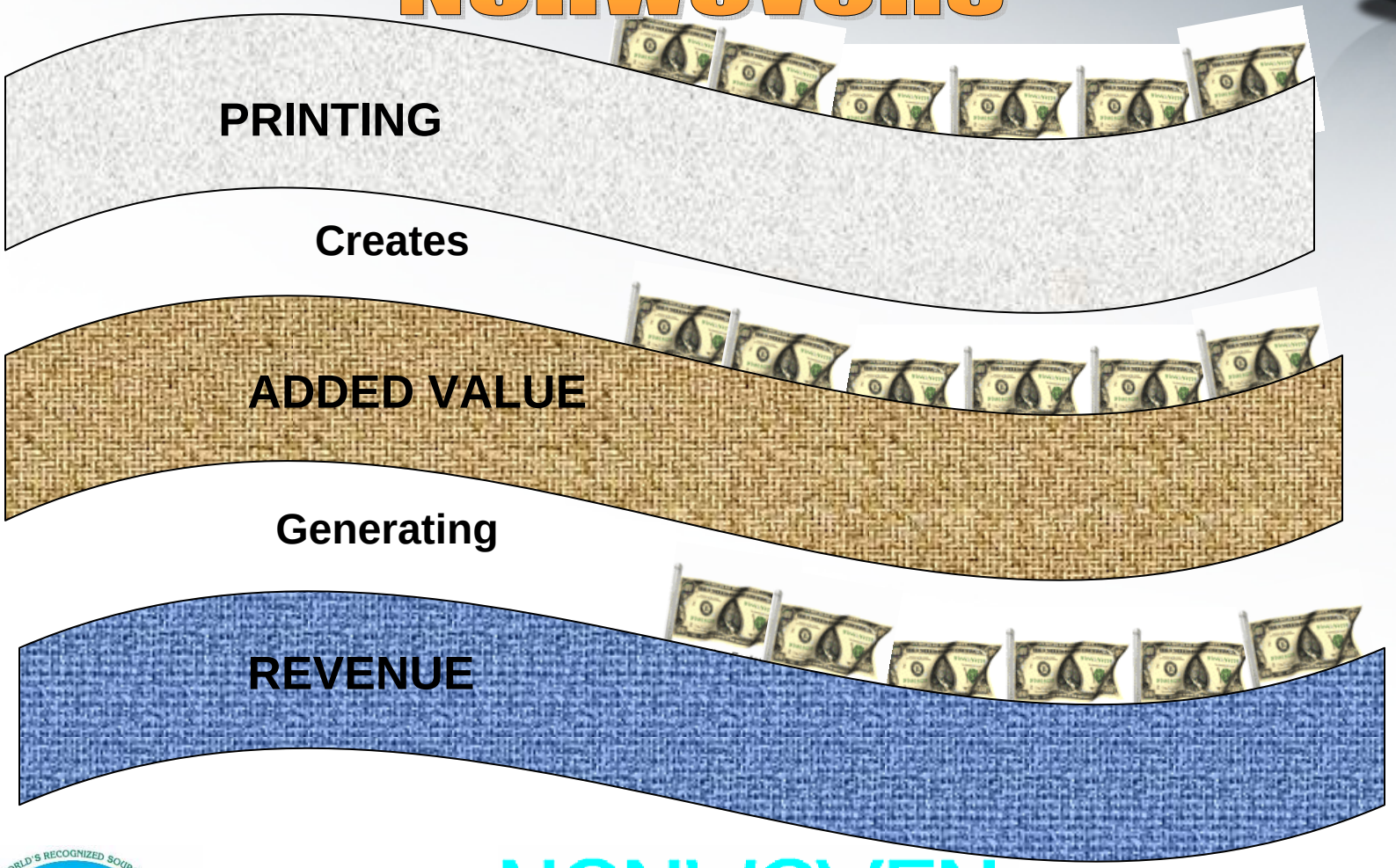
NONWOVEN Enhancements

Benefits of Printing on Nonwovens

"Added-Value"

NONWOVEN Enhancements

Benefits of Printing on Nonwovens



POLYTEX
WORLD'S RECOGNIZED SOURCE
FOR ENVIRONMENTALLY SAFE INKS

NONWOVEN Enhancements

NONWOVEN Enhancements

Thank You

Steven J Dalbey

Polytex Environmental Inks