Dyeing Technologies for the Future

By:
Dr. N.N. Mahapatra

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(Views expressed in this article are the personal opinion of the author.)

Water scarcity and increased environmental awareness are world-wide concerns which are causing a sharp rise in prices for intake and disposal of water. The textiles industry is also one of the biggest consumers of water with conventional textile dyeing using large amounts of fresh water which is disposed of as waste water containing dyestuff chemicals.

The Pollution Control Board in India has become also very strict. Tirupur Processing units are all closed. Bhilwara process units are also under terrible pressure maintaining the zero discharge notification. Vapi, Ahmedabad, Kolkata, Jetpur, Pali, Surat, Bhiwandi are also under pressure to follow the strict norms.

Most of the discussion in sustainable textiles has centered around the fibres - manufacturers making a switch to organic cotton, or creating fabrics from natural, easily - renewable materials like bamboo or hemp. But very little attention has been paid to the dyeing process, which can be a potentially devastating industry when it comes to chemicals, waste, and water usage. AirDye, a new method created by Colorep for dyeing textiles takes water almost out of the equation, using 90 % less water, but also reducing the emissions and energy used by 85 %, since extreme heat is needed to dry the textiles after they are soaked in dye (and most fabrics then require a post- rinse and yet another dry cycle.

4,000 years ago man used water to carry dye to a piece of fabric. Early water pollution was born. Since then, more and more chemicals have been added to color fabric, producing ongoing and ever worsening water pollution. In the mid 20th century, came new fibers such as nylon and polyester. These new "high tech" fibers were difficult to dye so heavy metals and other toxic compounds were added to water baths to carry the dyes. These toxins end up in the world's lakes, rivers, and oceans causing horrific damage. Today the World Bank estimates that 17-20% of industrial pollution comes from textile coloring and treatment. They've also identified 72 toxic chemicals in our water solely from textile dyeing, 30 of which are permanent.

From experience it is known that estimated 100-150 litres of water are needed to process 1 kg of textile material. Water is also used as a solvent in many pre-treatment and finishing processes, such as washing, scouring, bleaching, dyeing, rinsing and finishing and the contaminated water must then be handled and treated prior to disposal or recycling.

There is going to very huge water scarcity as compared to population growth. After dyeing the disposal of the effluent is also a great problem.

Following are the few options to overcome the above problems in the future.

(1) Salt Free Dyeing of Cotton Fabrics

Textile scientists have developed a more efficient method of dyeing cotton that is not only less harmful to the environment, but also uses significantly smaller amounts of energy, water and salt in the dyeing process. The key to the new process, called cationic fiber modification, is treating the cotton with a chemical that gives it a positive charge that attracts negatively charged dyes.

"The new process is much more efficient and saves about half of the time normally required to dye cotton. It uses one third of the energy and only 20 percent of the water used in traditional methods, and no salt." Traditionally, cotton is dyed using water-soluble dyes, but these compounds don't naturally adhere well to cotton, so large amounts of salt must also be added to the mix to make the dye less soluble and better at adhering. The amount of salt needed sometimes approaches ratios of 1-to-1 by weight of the fabric. Large amounts of water are also needed -- it takes eight gallons of water to dye one pound of fabric.

In cationic fiber modification, a chemical called N-(3chloro-2-hydroxypropyl) trimethylammonium chloride is applied to the cotton before it is dyed. The chemical gives the cotton fiber a permanent positive electrical charge, which strongly attracts the negatively charged dyes. All cotton dyes have negative electrical charges.

As a result of the electrical attraction, less dye is needed; the colors in the fabric appear to be more vivid. There is no noticeable change in the texture of the cotton fiber.

Another benefit of the new process is that it can be done using standard dyeing and finishing machines, so manufacturers don't have to retool their operations.

Textile Scientists are now focusing their research on how to streamline the new process even further. Currently, they say, one drawback is that the fabric has to be taken out of the manufacturing line to have the chemical applied. Then it must be given time to react with the chemical. This extra step significantly slows the process of dyeing and finishing, which are best completed as one uninterrupted process. They are working to overcome that problem, but the biggest hurdle may be convincing industry to embrace the new process.

"The textile industry is very slow to adopt change, (especially on) something like this that mainly reduces pollution and energy consumption... There's been some interest in this, but so far commercialization has been slow". "This is going to be driven by the people who need to reduce pollution from their plant, or want to save energy or double their production capacity without buying more equipment." Dow Chemical Co. is the manufacturer of the chemical that gives the cotton a positive charge.

(2) Waterless dyeing process

The Yeh Group, was established in 1988 and is located on a 40 acre site near to the city of Bangkok in Thailand where it specializes in performance polyester knit fabrics. The group is composed of Tong Siang and Penn Asia and has sales offices located in Europe and North America. Current customers include Adidas, The North Face, Puma, Mammut, Odlo, Mizuno and Victoria Secret. DyeCoo Textile Systems B.V. is based in the

Netherlands and claims to be the world's first supplier of industrial CO_2 dyeing equipment, for which it holds patents. It produces both warp and weft knitted fabrics, says it will be the first textile manufacturer to implement a new waterless dyeing process developed by DyeCoo Textile Systems of the Netherlands which is currently being readied for commercial introduction in the fourth quarter of this year. Elimination of process-water and chemicals are a real breakthrough for the textile dyeing industry. DyeCoo Textile Systems designs and manufactures machines using carbon dioxide (CO_2) for dyeing of textile-materials. It's a complete water free dyeing process with considerable lower operational costs compared to the conventional dyeing processes.

Advantages

- Elimination of water consumption
- Elimination of wastewater discharges
- Wastewater treatment process eliminated
- Elimination of drying and dryer effluent
- Reduction in energy consumption
- Reduction in air emissions
- Reduction in dyeing time
- Surfactants and auxiliary chemicals in dyes eliminated
- Dye utilization is very high with very little residue dye.
- Unused dye can be recaptured
- Approximately 95% of used C02 will be recycled
- Fewer redyes are required
- Color correction is easier compared to aqueous dyeing.

The company says it has exclusive rights to the process and is branding fabrics produced using it, as DryDye fabrics.

Supercritical fluid CO_2

"Elimination of the water process and chemicals is a real and significant breakthrough for the textile dyeing industry. This new process utilizes supercritical fluid carbon dioxide (CO,) for dyeing textile-materials. It is a completely waterless dyeing process using only nominal amounts of CO" nearly all of which is recycled. DryDye fabrics dyed with this unique waterless process will have the same dye qualities and durability as current, conventionally-dyed fabrics," a spokesperson for the Yeh Group said.

The Yeh Group, which claims to be an innovative, environmentally responsible producer of quality knit fabrics and garments, supplies to premium brands in sports and intimate apparel markets. By pioneering and implementing this new waterless dyeing process, the company says it will eliminate the use of millions of litres of fresh water in dyeing fabrics using the new process.

Instead of current aqueous dyeing systems, DryDye fabrics will be dyed using supercritical carbon dioxide in a stainless steel chamber developed and tested by DyeCoo. Yeh Group says, for the past three decades, supercritical fluids have been used in various extraction processes, including the extraction of natural substances for the

production of pharmaceuticals, cosmetics and spices. In addition, leading producers of textiles dyestuffs have attempted to harness the technology for textiles dyeing but none has produced a successful commercial system to date.

Supercritical fluid CO_2 is said to have become a mainstay in extraction processes in the food industry (decaffeination, extraction of hops) and apparel dry cleaning, where it is said to be the best, gentlest, most thorough cleaning method now available. Carbon dioxide is also said to be considered the best supercritical fluid for the dyeing process, is naturally occurring, chemically inert, physiologically compatible, relatively inexpensive and readily available.

Dyeing polyester and other synthetics

"Using supercritical fluid CO" polyester and other synthetics can be dyed with modified disperse dyes. The supercritical fluid CO, causes the polymer fibre to swell allowing the disperse dye to easily diffuse within the polymer, penetrating the pore and capillary structure of the fibres. The viscosity of the dye solution is lower, making the circulation of the dye solutions easier and less energy intensive. This deep penetration provides effective colouration of polymers which are characteristically hydrophobic. Dyeing and removing excess dye are processes that are done in the same vessel. Residue dye is minimal and may be extracted and recycled," the Yeh Group says.

Reductions in operating costs

According to the Yeh Group, supercritical C02 dyeing gives excellent results as far as dye levelness and shade development are concerned. The physical properties of dyed yarns are also said to be equivalent to conventional methods. Conventional textile dyeing is very water and energy intensive in pre-treatment, dyeing, and post treatment (drying). The supercritical C02 process however, is said to use less energy than conventional processes, resulting in a potential reduction in operating costs of up to 50%. The company says the only overlap is in the pretreatment process, which is essentially the same for both.

(3) Air Dye Technology

What's more, traditional dyeing uses an astonishing amount of water. Estimates vary, but to color just one piece of fabric can take anywhere from seven to 75 gallons of water per pound of fabric (26 to 284 liters per 45 kilo). So traditional dyeing pollutes badly, widely, and ·continues to consume vast amounts of the world's increasingly scarce fresh water.

Why AirDye?

The textile industry is the third largest consumer and polluter of the world's water. The World Bank estimates that 17 to 20 percent of industrial pollution comes from textile coloring and treatment. 72 of the toxic chemicals in our water come solely from textile dyeing - 30 of these cannot be removed, despite purification processes.

AirDye technology prints and dyes without consuming water or emitting pollutants. Brilliant shades, beautiful prints. No harm done.

AirDye® technology manages the application of color to textiles without the use of water. It is today's sustainable alternative to traditional dyeing and printing processes. By using air instead of water to infuse color into fabric, the technology reduces water consumption and pollution. The innovative new process also creates additional opportunities to apply design and color in ways not previously possible. AirDye technology creates new design capabilities while reducing cost:

AirDye technology, from Colorep, Inc., a California-based sustainable technology company, is a solution our planet needs today and for many tomorrows. Business today must achieve high quality, lower costs, competitive practices, and meet customer demand for environmentally responsible products that are attractive.

How is AirDye different?

Conventional dyeing, such as vat dying or cationic dying, can produce good looking results. On the down side, they use polluting heavy metals, a huge amount of precious water and do not provide permanent coloration. Sublimation printing has been used to decorate textiles but is limited in application. AirDye advances both.

Airdye's process begins with using an synthetic fibres for its material, which can be made from recycled PET bottles. Using disperse dyes that are applied to a paper carrier, AirDye uses heat to transfer the dyes from the paper to the surface of the textiles, coloring it at the molecular level. All paper used is recycled, and dyes are inert, meaning that they can go back to their original state and can be reused.

Developed in California by Colorep Inc, AirDye uses proprietary dyes, which are heat transferred from paper to fabric in a one-step process. By bypassing the liquid stage of the dye process, between seven and 75 gallons of water are saved in the dying of a single pound of fabric.

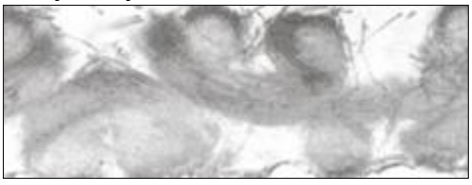
The paper is recycled, as are the remaining dyes, which are turned into tar and asphalt. There are no harmful byproducts and a significant reduction in energy and cost as no screens, boilers, dryers or chemicals are needed.

A wide range of synthetic fabrics from sheer chiffons to performance stretch can be used. Fabrics can be printed one-sided or reversible and feature complementary or contrasting sides of colour or print.

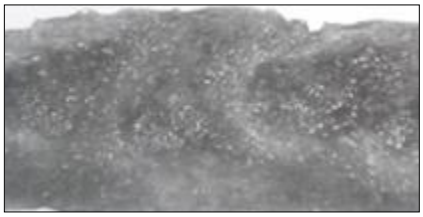
Take a very close look.

Here are four microscopic photos of the neck section of a dyed synthetic T-shirt:

Standard Sublimation & Heat Transfer Printing
The dye does not completely penetrate the fibers; therefore, white fiber may show after cutting or needle penetration.

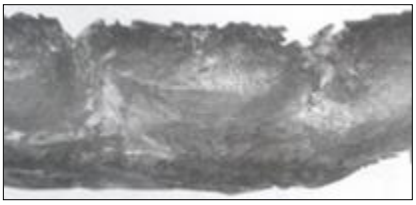


Conventional Dyes
After treatment in a water dye-bath, the fibers show complete dye penetration. However, colorfastness is low to moderate.



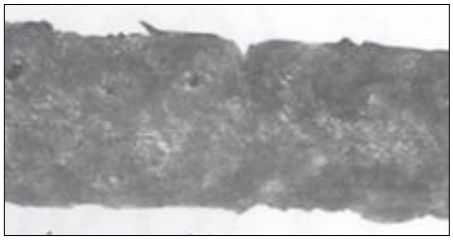
AirDye Controlled Penetration

Using our proprietary Sibius™ Dyes, penetration is deeper. Colors are richer and colorfastness is better. Penetration control is used with Dye Contrast, Print 2 Dye, and Print to Print products, including AirDye wovens.



AirDye® Complete Penetration

AirDye is so advanced that it not only colors the yarn, but also thousands of filaments in each piece of yarn, yielding rich, brilliant colors. Penetration is complete.



Advantages of AirDye Technology

- Does not pollute water in the color application process. By using air instead of water to convey dye, no hazardous waste is emitted and no water wasted.
- Greatly reduces energy requirements, therefore lowering costs, and satisfying the strictest standards of global responsibility.
- Does not use boilers, screen printing machines, drying ovens, or cleaning and scouring chemicals, thereby eliminating major sources of pollution.
- Eliminates water in the color application step and simplifies the process, creating revolutionary possibilities of new industry and employment in unfarmable, arid regions of the world.
- Gives consumers a way to choose style and sustainability at a realistic price at the point of purchase, thereby initiating world change.
- Disperse dyes are used. It is suitable for polyester, nylon, and poly blends as well as certain hard plastics.
- It is similar to transfer printing but more advanced both in the dye formulations and in the transfer methodology.
- Is easy to specify, reduces cost, offers beauty and quality, and reduces environmental impact.
- Offers style without sacrifice. There is no dye-lot variation, no post-dye washing or treatments, and no minimum quantity.
- Offers exciting new options:
- Dye different colors on opposite sides of fabric.
- Dye fabric a sol id color.
- Dye one side a solid color and the opposite side a print.
- Dye one side of fabric with a print and the opposite side with another print.
- Dye opposite sides of fabric with the same print.
- Reducing water consumption by 95%.
- Reduces energy use by 86%.
- Reduces green house gas emissions by 84%.

In an industry that consumes more than 2.4 trillion gallons of water each year to dye synthetic textiles, and more than 2.8 trillion megajoules of energy, while emitting over 568 million metric tons of green house gases.

Textile designs that can feature a look on the front surface of the fabric that differs from what is applied to the back. Fabrics can be printed with a different solid color on each side of the fabric, two different patterns on each side, or combinations of solid colors and patterns.

Conclusion

AirDye technology produces superior results compared to sublimation printing and conventional dyeing, but that is just the beginning of its advantages. AirDye technology also reduces detrimental impacts on the environment. And, because the dye is in the fiber rather than on the fiber, bleach and cleaning agents can't get to it; so colors look richer and last longer. The result is more beautiful colors and maximum color durability, with substantially less water and discharged chemicals.

The result is luxuriously brilliant color and a world-changing impact on our planet's water shortage. Not a bad day's work. AirDye technology is a proprietary process created by parent company Colorep Inc based in California, U.S. As a world innovator, Colorep is passionate about creating new printing and dyeing technologies that improve quality, value, and accessibility while helping to sustain the planet.

The technology works only on synthetic materials and is currently available only in the United States (where only a small fraction of the world's clothing is made, of course). One limitation: "It does not work on cotton or wool or the other fiber types. But Colorep says it plans to extend its use to Europe by the end of summer, and to Central America by late this year.

By next year it will be launched in Surat market keeping in eye the huge synthetic market.

This article was originally published in the Textile Review magazine, May, 2013 issue, published by Saket Projects Limited, Ahmedabad.

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