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Innovative Technologies for Enhancing the Printing Performance of Textile Fabrics: A Review

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Abstract:- The state of the art "Innovative Technologies for Enhancing the Printing Performance of Textile Fabrics" is divided into four sections.

Section 1: Represents the evaluation and innovation of the key ingredients of printing paste. Colorant (dye or pigment), Thickener, Binder (if using pigment), Auxiliaries.

Section 2: Represents some of the developed technologies in textile printing.

Section 3: Represents the modern printing methods,

Section 4: Represents the future out look

Keywords:- *Innovative Technologies. Enhancing, Printing Performance, Textile Fabrics.*

I. INTRODUCTION

The printing of textiles is one of the most used methods and varies in the presentation of colors and designs on woven fabrics. An analytical look, it is a process that combines the idea of design, one or more colorings, and using a technique to apply colorants to each other accurately. Many techniques have been used and the available color doubled [1].

Printing is the method of applying the dye to the fabric in the prevailing positioning method of printing about 65% of publications [2, 3]. Therefore, the widely used printing has become applicable to all kinds of fiber or mixture, the ability to avoid any washing after fixation [4]. Printing on colored fabrics is an important area in industrial applications where UV treatment is rarely used or investigated in textile finishing processes such as dyeing, painting and pigment printing.

UV curing is used in many industrial applications, due to its low power consumption, short operating period, fast and reliable treatment, low environmental pollution, room temperature treatment, space saving, etc. [4]. Electron radiation technology has become a well-accepted technique, which has emerged in a very large number of mainly industrial applications such as the fields of painting and printing [5]. Inkjet printing technology is attracting more attention in the textile world. This is mainly due to rapid response [6], the low cost of producing a sample or special custom arrangement [7,8], less waste in printing [9], and much lower skill requirements and operating techniques than those resulting from conventional printing techniques.

However, inkjet printing also has its drawbacks. For example, lack of production, poor color productivity, complex machine maintenance, and limitations in dye choices to improve property.

Such as enhanced color fastness [10-15]. Without improving the current inkjet printing technology, it is difficult to predict its output of more than 30 billion square meters of annual production of printed textiles. The printing and dyeing process carries about 50% of printed textiles. In the United States, the share reaches almost 88%, in England 50%, and in China 60-80% [16].

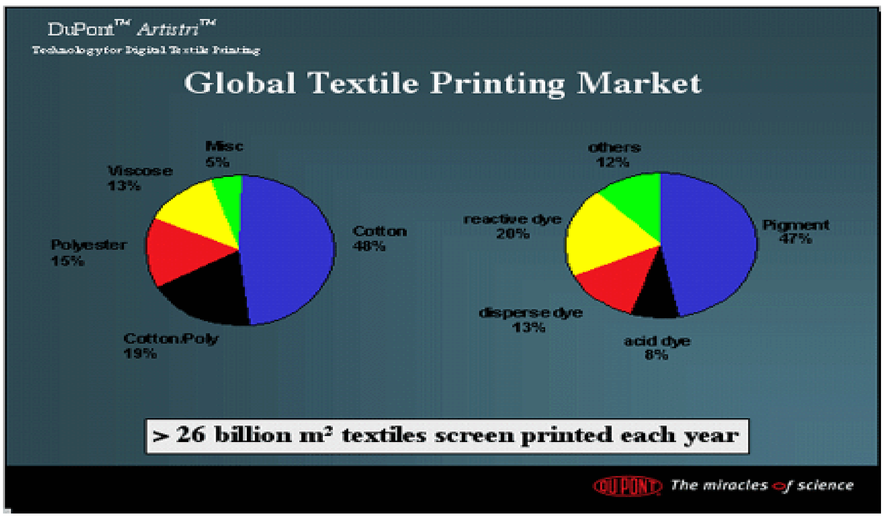

Fig. 1:- The textile printing market, textile types and suppliers [17].

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The goal of this review is to provide a survey about the innovative technologies for enhancing the printing performance of textile fabrics. Taking in mind that these technologies could be considered green technologies.

- *Section 1: The evaluation and innovation of the key ingredients of printing paste*

- *Textile Printing*

Textile printing processes, entirely dependent on the type of fiber (cellulosic, polyester, acrylic, protein ...), the nature of the dye (reactive dye, VAT dye, etc.) and the quality of the finished product, [18].

A. Colorant

It could be either dye (reactive, acid, disperse….etc) or a pigment

- *Reactive dye*

Reducing or eliminating urea in reactive dye printing pastes is of environmental importance. Sodium edetate is presented as a complete substitute for urea in the traditional printing paste of reactive dyes, using a fixed amount of sodium alginate as a thickening agent. Three different printed pastes containing urea / NaHCO3, sodium edetate / NaHCO3 and sodium edetate were searched. Various factors that may affect the printability of cotton were evaluated, such as sodium liberation concentrations, urea, and dye, and the absence or presence of alkali and steam time in publications obtained with respect to dye fixation, color strength, dye penetration, leveling and stability properties. Persistence of colors was obtained from good to excellent for all samples regardless of the printing paste used [19].

Printing traditional and modified nylon fabrics 66 with reactive dyes from various commercial fields, maximum color productivity has been achieved. Production of the color obtained on the modified cloth was higher than that achieved in conventional nylon 66. [20].

- *Acid dyes*

Silk, wool (natural) and nylon 66 (synthetic) fabrics are printed with acid dyes using wet transfer printing technique. The use of urea causes many environmental problems, so printers are forced to reduce the amount of urea in the effluent. Wet transfer printing is an alternative to eliminating the use of urea in acidic printing. [21].

- *Disperse dyes*

Natural fabrics, cellulosic such as cotton, jute or protonic such as wool and silk or refurbished cellulose fabrics such as Fibran and Viscose, are water-loving fibers and do not have any affinity for dispersed dyes and cannot be printed by heat transfer printing technology as such [22]. There are multiple attempts to process these fabrics to converge the dispersion of dyes and make them suitable for transfer printing technology, which has been reviewed by many workers [23-25].

- *Pigments*

Pigment is a colored molecular aggregate, insoluble in water and other components of the print paste. Pigments may belong to any chemical class of colorants but they do not contain any reactive group capable of any reaction with the textile fibers or any other components of the print past. Pigments for use in textile printing are normally supplied in the form of mobile aqueous dispersions.

Pigment printing is one of the most important ways to print textiles worldwide. [26]. Not only is it the oldest, but the easiest way to print in terms of simplicity. In the dye, the printing of insoluble dyes, which do not converge with the fibers, is installed on the cloth with fastening agents in the desired pattern. Earlier recommendations were based on emulsion print pastes, which utilized white spirit emulsion in water as the thickening systems. During drying and fixation, water and volatile solvents were removed by evaporation and Dye prints can be produced that meet acceptable standards in terms of color, shadow clarity, handle softness and stability characteristics **[27].**

B. Thickener

Viscosity of the printing is sufficient to restrict the printing paste properties to avoid color spread on the surface of the cloth this is depend on the thickener used. Thick tools affect print quality in terms of color depth, brightness, and clarity of prints.

- *Natural Thickener*

Sodium alginate, guar gum and gum Arabic thickener are all the best for reactive dyes. The development of the printing process of active dyes for cellulosic textiles using natural thickness factors and environmentally friendly additives is of great importance. Printing experiments using guar gum have shown that the use of different additives can prevent the hardness of the fabric. These additives have no significant effect on rheology and color strength but they have contributed to handling soft fabrics even when guar gum was used as a thickening agent. The use of additives and gum laurel provides good quality leaflets while minimizing wastewater pollution [28].

Fenugreek gum was isolated from fenugreek seeds and subjected to chemical modification via cyanoethylation, which converts it to water-soluble product that resists fermentation by storing. Furthermore, the results obtained indicate that cyanoethylated fenugreek gum could be used safely as thickeners in printing transfer-printing paper. The latter gives printed goods characterized by soft handle and excellent color fastness properties **[29].**

Treatment of cotton fabrics using reactive cyclodextrin (R-CD) at different concentrations to enhance the printability of cotton fabrics. Reactive and natural dyes were used to print cotton fabrics before and after modification. The effect of incorporating R-CD in unprinted cotton paste was studied. [30].

Screen-printing of silk fabrics with reactive dye using gum Indalca and gum Arabic thickeners was studied and the printed samples were tested for color fastness. Gum Arabic, which is a natural gum used for textile printing, is a high-solid-content thickening agent used especially for silk. The samples were printed with three methods including dry heat fixation, sodium silicate pad batch method, and steaming method **[31].**

➢ *Synthetic Thickener*

The apparent viscosity of the printing paste, as well as both the K / S value and the printing stability characteristics were due to the reactive dye nature and thickener type [32].

A water-based acrylic thickener is a generally high molecular weight copolymer of acrylic acid and their esters. Thickener properties can be customized by a suitable selection of monomers. Acidic common monomers are responsible for the development of a partially neutralized viscosity with a base [33].

Most Alcoprint thickeners are so called liquid dispersion polymers. As the polymerization is as emulsion, they have more uniform particle size, leading to excellent flow properties and cause no problems of screen choking during printing. The manufactures has two ways to control the volatile emissions in synthetic thickeners to use better quality of oils or to increase the efficiency of thickeners by increasing the polymer content. Both these ways have been followed for Alco print thickeners **[34]**.

➢ *Oil in Water Emulsions*

For pigment printing because of the relatively high solid content of thickener that remains enclosed in the binder film, causing a firm handle and poor fastness of prints. On the other hand, the use of emulsion thickeners (o/w type) results in good fastness properties, high degree of brilliance, sharp outlines, and soft handle in the printed fabric. However, the presence of white spirit in large proportions has three major disadvantages that limit its use in many countries: 1) Risk of explosion during drying of fabric if ventilation is inadequate 2) Environmental pollution 3) Increased cost due to increasing prices and declining availability of oil products **[33].**

C. Binder

The binder is a film-forming material consisting of long-chain molecules and when applied to the fabric, in addition to the dye, produces a three-dimensional continuous mesh, during proper stabilization. Binders used in pigment printing on textiles are copolymers or copolymers of unsaturated monomers such as ethyl acrylate, butyl acryl, styrene, acrylonitrile, vinyl acetate, butadiene, etc.

However, pigment printing has problems such as relatively high temperature, harsh hand, and poor pottery stability of printed goods. Formaldehyde emission and clogging on screens should also be considered during the actual printing process. These disadvantages are related to the folders used. Thus, to improve the quality of pigment printed goods, the overall characteristics of the document need to be improved [35].

Some kind of low temperature curable binder were synthesized from a mixture of polyacrylates and other vinyl monomers by pre-crosslinking technique through emulsion co-polymerization. The results show that a non-formaldehyde releasing binder with low temperature curable property was developed by precrosslinking technique. The emulsion has good storage stability [36, 37].

Shah et al., Also invented a type of binder, a polymer of dicarboxylic acid, a functional monomer, such as alkyl hydroxyl alkyl, a neuromonomer or monomer, and an emulsifier of phosphate esters, producing a printing media that improves performance and excellent redispersibility. The binder-printing tool is useful in producing pigment prints with good wet and dry amount, soft hand, and good stability for washing. The link of this invention does not require the presence of formaldehyde interlocking agents containing or generating such as N-methylol acrylamide [35].

➢ *Chitosan in Printing*

Bahmani et al. Use chitosan as a thickener and a binder built into pigment printing. The chitosan printing paste was prepared and the dye was added and stirred to give a uniform dispersion of the pigment. Polyester and cotton fabrics were printed using a printing paste. Chitosan printed fabrics are characterized by high color stability with weak color strength (K / S) and stiffness of fabrics. [38]. Because chitosan-based thickeners do not lend themselves to prolonged storage, they must be used within 24 hr. Using chitosan enables printing to be carried out in weakly alkaline, neutral and weakly acid media, which helps to save textile chemicals compared to the traditional method. It is found that chitosan forms an adequately strong bond with both the dye and the fiber, which is confirmed by the high colour fastness (wet and dry crocking and washfastness) **[39]**.

A high viscosity chitosan has been also developed and used as thickener in printing 100% cotton with pigment. In addition, chitosan has biomedical applications such as membranes, artificial skin, wound dressings and drug delivery systems. Chitosan has been widely used in dyes for various fibers such as cotton and wool **[40, 41]**.

D. Auxiliaries

➢ *Emulsifiers:*

Printing and installing on fabrics, improve printing like leveling to ensure better operating characteristics on the printing machine **[27].**

➢ *Fixing agents:*

It is Work by the same chemical principle as binders. In combination, they improve the abrasion of the pigment binder film from the fabric surface, thus resulting in better fastness properties to crocking and washing [27].

➢ *Softeners:*

In pigment printing systems, particularly when printing on fine, raised or knitted materials. They could be silicones, which are used as handle modifiers, giving a dry and pleasing handle to the pigment prints **[27].**

➢ *Defoamers:*

It is better to prevent the formation of foam in the pastes, which can lead to uneven prints with operating strips in rotary screen-printing [27].

Section 2: Some of the Innovative Technologies in Textile Printing

A. UV - Technology

UV- technology is an excellent fit for the wide format market due to the near instantaneous cure rates and low volatile organic compound (VOC's). This technique has been improved by the recent emergence of new UV curable raw materials, and we can develop inks that have improved handling and compatibility with a wide range of substrates [42].

➢ *Radiation Curing of Pigment Prints on Textiles*

Printing fabrics using a combination of pigment, oligomers, and monomers using UV or electron beam saves between 3000 and 5000 BTU per pound of cloth compared with conventional techniques [43]. UV curing and ink jet printing technologies have developed in parallel. The use of UV-curable ink with analog printing methods, including flexography, gravure, offset and screen process is growing at a rate that exceeds the growth rates for the use of these processes**.** The US Environmental Protection Agency views UV-curable inks as a green technology that it seems preferable to conventional solvent-based ink systems **[44].**

➢ *Synthesis of Eco Friendly Aqueous UV-curable Binder*

Some novel aqueous UV-curable binder of polyurethane acrylate oligomers based on polyethylene glycol with different molecular weights and having low viscosity were developed. These binders are used for preparing ink jet inks for printing and/or dyeing of cotton, viscose, wool, polyester and nylon 66 fabrics, as well as for preparing printing paste for screen-printing of all types of textile fabrics using pigment dyes. The printed fabrics and/or dyed fabrics are characterized by soft handling and from good to excellent of the overall fastness properties **[45-50].** Aqueous UV- curable binders offer safety from an environmental standpoint.

UV curing for pigment printing has been studied. Problems associated with the process include low crock fastness, stiff fabric hand and low curing efficiency of the resin when pigment is involved. The research was developed at solving these problems by developing a simple, quick, low energy consuming, cost-effective, high quality, and environmentally friendly curing method for textile pigment coloration **[51].**

➢ *UV Curable Binders for Fabric Pigment Coloration*

Shiqi et al. [52] studied the use of UV curable binders for fabric pigment coloration of cotton, polyester/cotton and polyester**.** The UV resin types include aliphatic urethane acrylate, polyester acrylate, and epoxy acrylate. The pigment and UV resin were applied to the textiles using pad, spray, and screen-printing methods.

It was reported that water-based UV resins could be applied on fabrics with traditional wet process equipment such as padder. The curing process is simple an easy to control. However, pigments in a UV resin will reduce curing efficiency. Therefore, the selection of pigments, UV resin components (photoinitiators, oligomers, and monomers), and a suitable UV light source will be the keys to produce high quality UV cured pigment colored products **[52].**

Mercury UV light is a powerful UV source and can efficiently cure pigment colored fabrics. UV resin colored cotton and polyester/cotton fabrics showed high colorfastness with good fabric flexibility. Although there was some difference in applying the technology on polyester, the coloration results on cotton and blend fabrics showed great potential for use of the UV curing process in the textile industry **[52].**

B. Electron Beam Technology.

Electron beam radiation therapy has become a well-accepted technique, and has a large number of industrial applications mainly in the field of coating and printing. Allows rapid conversion of multifunctional liquid monomers and oligomers into solid polymer layers **[53].**

➢ *Advantages of Electron Beam*

The main advantages of electron beam irradiation technology in conventional chemical coating treatment are the use of fewer solvents, 100% polymerization and less serious environmental pollution.

The formula to be treated or linked by electron beam radiation usually contains unsaturated monomers (double bonds), oliguria and other additives depending on the desired properties [54].

➢ *Electron Beam in Pigment Printing of Cotton Fabrics*

Electronic beam irradiation can be used as an alternative to heat treatment in printing dyes of cotton fabrics and using adhesives-free formulations and capacitors. These formulations contain reactive oligomers, monomers and pigment color [55].

➢ *Electron beam Irradiation Compared with the Conventional Thermal of Pigment Printing*

There is a comparison of the results of pigment printing by electron beam irradiation with the traditional thermal printing method with the same pigment colors involving the use of pastes containing binder and thickener systems. It was found that cotton fabrics printed with pigment colors under the influence of the electron beam showed a higher color strength than those printed by conventional thermal stabilization in equal colors to the pigment. The results showed that pigment printing by electron beam or heat treatment improves wrinkle recovery and mechanical properties of cotton fabrics and exhibited similar durability properties in terms of washing, rubbing and handling [55].

C. Laser Technology

It is well known that lasers are a source of energy and can be directed to desirable objects whose strength and intensity can be easily controlled. By directing the laser to the material at a low density, a particular design can be transferred to the surface of the textile material by altering the dye molecules in the tissue and making changes in color quality values [56].Using the new laser technology, the visible properties of denim (blue jeans) can be changed. [57].

Fig. 2 :- Laser surface design machine

D. Plasma Technologies

Plasma Can Be tough of as a partially ionized gas consistant of neural ions, électrons and molécules. Plasma techniques Can replace some wet chemical applications as an environmentally friendly process. It modifies the surface of the fibers and leaves loose properties unaffected [59-61].

More attention is being given to improving many characteristics such as wetness, water expulsion, pollution, soil release, printability, printability and other finishing processes for textile fibers and fabrics by plasma technology [62]. By controlling its variables, such as the nature of the gas, it can improve the discharge strength, pressure and exposure time, and a large variety of surface properties [63]. Plasma technology applied to textile manufacturing has evolved considerably over the past decade, due to its potential benefits in environmental and energy conservation, in the development of high-performance materials for the global market [64]. The surface properties of natural or synthetic fibers or filaments can be modified using plasma treatment. This can lead to processes such as polymerization, grafting, cross-linking, etc., with concomitant effects on wetting, wicking, dyeing, printing, surface adhesion, electrical conductivity and other characteristics of interest to the textile industry [65].

➢ *Application of Low Temperature Plasma and a High – Frequency Technology in Pigment Printing*

Owing to inadequate adhesion of the pigment and binder film to synthetic textile materials and blends thereof, prints and dyeing with pigments often do not meet the quality requirements. One of the possible ways of solving this problem is a suitable modification of the fiber substrate **[66].** Besides laser technology, methods based on gas discharge processes known as low temperature plasma processes can also be used for this purpose. These methods permit the modification of the fiber surface by physical means without the use of chemical auxiliaries.

The pigment printing of cotton fabrics in a high-frequency field is studied**,** where one of the thickeners is methylcellulose. Using the high-frequency method for fixing the pigments, it is possible to eliminate the drying stage. The use of solvitose as a thickener is found to be preferable more than using methylcellulose **[67].**

E. Enzymatic Technologies

It could be integrated into almost every wet processing step of natural fabric. Enzymes treatments can be improve the appearance, handle, performance and durability of the fabric **[68].**

Cellulases have been applied in a biopolishing process in order to: (I) improve the appearance of cotton fabrics by removing fuzz fibers and pills from the fabric surface, reducing pilling propensity and improving fabric handle **[69].** In addition, (II) produce the old-look surface effect of denim garments (i.e. jeans) by the non-homogeneous removal of the indigo dye trapped inside the fibers by the cooperative action of enzymatic hydrolysis and mechanical stress **[69].** A number of enzymatic treatments have been developed to improve the comfort and appearance of wool, as well as to reduce its felting and shrinking tendencies **[68].**

➢ *Textile Printing using Different Enzymes*

Enzymes could be used in natural and synthetic thickener systems, since they might produce good effect on color and surface structure for the printing of cotton, and fabrics. The efficiency depends on their activity and stability within different thickener systems such as polysaccharide, acrylic polymer and their mixtures **[70].**

➢ *Enzymatic Treatment of Pigment Prints*

The enzymatic attack on the performance properties of pigment-printed cellulosic fabrics is determined by the nature of the cellulase enzyme. In addition, enzymatic treatment has a great effect on the fastness properties of the treated pigment prints **[71].**

F. Nanoscale Technology

This technique can be used to prepare binders, for example, a suitable dye binder for inkjet printing. From the polymer, the partial emulsion was synthesized with a high percentage of fine monomer of butyl acrylate (BA) via a modified emulsion polymerization method.

Pigment-based inks formulated using the optimal partial emulsion as a skin aggregation and commercial pigment dispersion have a significant impact on the application of inkjet printing from cloth. They showed excellent printability, good fastness properties and smoothness of printed fabrics **[72].**

- *Route to Prepare Nanoscale Polymer*

Pigments must form firm bonding with fibrous substrates with the aid of water-dispersed binder. How to make a good binder suitable for inkjet.

inks remain a great challenge so far due to a lot of strict (sometimes contradictory) requirements for particle size, surface tension, size distribution, viscosity, stability, compatibility with the components of the inks and the printer, and wettability with the printed cloth, etc.

Micro emulsion polymerization is one of the widely used routes to prepare nanoscale polymer latex **[73].** However, the polymer micro emulsions reported before had a high content (>40 wt %) of hard monomer **[74, 75],** which would inevitably lead to a layer of rigid film formed on the printed fabrics.

This as-synthesized micro emulsion met almost perfectly all aforementioned requirements, and thus could be used to directly make up the inks for fabric inkjet printing. The fabrics obtained in this way showed excellent color fastness and minor change in hand feeling after printing**[74,75].**

G. Microwave Technology

- *Application of an Electro Conductive Polymeric Pigment with Microwave Absorption Properties*

A new method **[76],** for obtaining an electroconductive polymeric pigment with microwave absorption properties has been developed. The method is based on the chemical modification of a powdered polyacrylonitrile PAN by treatment with a water solution, containing cupric sulphate, sodium thiosulphate, and glyoxal. The characterization of the modified PAN, achieved on the basis of crosslink density determination, infrared spectroscopy, and element composition analysis performed by atomic absorption spectroscopy, shows that the polymer pigment is a polyacrylonitrile crosslinked by Cu and S atoms and CN groups of polymer matrice in the form of cuprous sulphide - Diginit. The polymer pigment possesses electro conductive and microwave absorption properties, as determined by measurements of the electromagnetic wave damping, the standing wave coefficient, and bulk electrical resistance .The polymer pigment has been used for obtaining textile materials with special properties: antistatic with microwave absorption, electro conductive with microwave absorption, and electroconductive with microwave reflection, depending on the pigment content in the printing paste.

H. Chemical pretreatment of fabric

- *Cationization*

Cotton is one of the most important fibers in the textile industry and its coloration is achieved with dyes, by either dyeing or printing in aqueous solution, or with pigments using a print paste. Printed cellulosics are considered to account for more than 70% of all printed substrates and pigment printing is a major method. The surface charge of cotton fabric was modified to positive charge by using a reagent that is a non-polymeric cationic reactant. Ionic bonds formed between the paste and the modified cotton fabric, thus improving the wash fastness of the printed fabric **[77, 78].**

The printability of cotton with pigment was improved after simple cationisation of cotton fabrics with Solfix E, polyaminochlorohydrin quaternary ammonium salt with epoxide functionality. The prints obtained on cationised cotton showed better overall fastness properties than prints obtained on untreated cotton. After repeated washings, the prints on cationised cotton showed a much smaller percentage color loss than the prints on untreated cotton fabric **[79]**. Tabba, Hauser, showed that the wash fastness and crock fastness of pigment prints can be improved, and fixation time reduced by the cationization of cotton fabrics **[80]**.

- *Amination*

Fabrics made from acrylic were treated with hydroxylamine hydrochloride using aqueous solutions of ammonium acetate. Samples treated with reactive, acidic and direct dyes can be printed using sodium alginate and Meypro gum condensate. The processed prints obtained have high color strength and good stability characteristics, while the blank samples appeared almost colorless **[81].**

- *Section 3: Modern Printing Methods*

A. Automatic or Semiautomatic Flat Screen (flat bed) printing [82]

Printing on flat or semi-automatic screens (flatbed) for many designs that require very accurate images, using polyester, polypropylene or monofilament as screen materials **[83]**. In automatic printing on the flat screen, the cloth is grasped on the printing table and advances sporadically, one design is repeated at a time, after the screens are lowered, printed and raised, to print all colors sequentially, using a fabric-paste wiper system.

B. Rotary Screen-Printing [82]

Rotary screen-printing is the dominant printing method now used from 60 to 70% of printed fabric production [84]. Machines capable of continuously printing up to 24-36 colors are available , although most designs involve less than eight colors, and rotary screen printing on textile materials up o 5m in width can be carried out, at speeds up to 80m min^{-1}, but typically at 40m min^{-1}.

C. Modern Rotary and Flat Screen-Printing Machines [82]

Modern rotary and flat screen printing machines may be supplied with enough color for each screen, with all the operations of weighing, metering, dispersing and mixing of dyes and auxiliaries with stock thickener (suitably diluted), or of pigments with binders and softeners controlled by a robotized color kitchen based upon a computed print recipe.

D. Transfer Printing [82]

Sublimation transfer, melting transfer or film release methods can complete the printing process. In sublimation (or dry heat), printing, volatile dyes (usually dispersed dyes) are printed on a base layer of paper and heated when in contact with textile materials, usually polyester. Luxury dyes are transferred and transferred from the steam stage to the fabric using a dry heat transfer printing method.

Wet printing of cotton with reactive dyes is achieved using color films containing selected different thickeners (sodium alginate, acetylcycline and cyan ethyl gum) [86].

In the film release system, an attempt was made to transport cotton fabrics and printed wool with a dispersed dye through the polyethylene film used. Good results were obtained in color strength, fastness properties as well as mechanical properties **[87]**.

E. Ink Jet Printing

The latest technology in textile printing is the introduction of digital inkjet printing machines, which can print fabrics up to two meters wide using acid, reactive, or dispersed dye inks [88, 89].

➢ *Ink Jet-Printing Technologies*

Ink jet printing is an advanced technology where small droplets of liquid are taken out to affect any substrate in a specific location. The concept is very simple but leads to many applications [90].

The process steps of ink jet printing as shown in Figure 3 can be divided into 4 steps beginning by fabric pretreatment, followed by fabric printing, then fixation and finally washing-off.

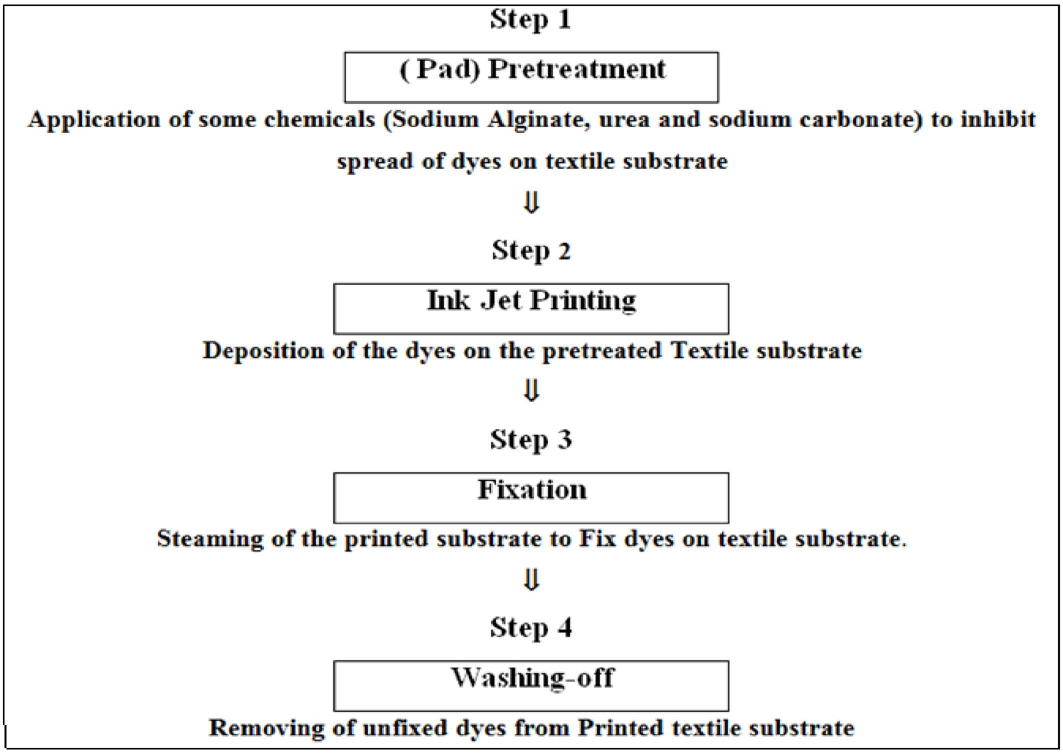

Fig 3:- Process steps of textile jet printing

➢ *Inks for Ink Jet Printing*

The ink used in any jet printing system must meet very strict physical and chemical standards. They must also be formulated to get specific features that enable optimal projection and compatibility with the particular printer, while providing excellent image and color quality. Typical ink formulation will consist of a dye (colorant), suitable solvent, thickener, bactericide, pH buffer and sometimes an anti-oxidant. Clogging of the nozzles with impurities can e avoided by installation of a comprehensive filtration system [91, 92].

Water constitutes the best solvent for jet inks because of its low viscosity, electrical conductivity, odor and cost. The main disadvantage with water-based inks is evaporation. As water evaporates from the ink, salts and organic dyes may precipitate in some nozzles causing its clogging. To reduce evaporation and prevent drying at the jet orifice, ethylene glycol is normally added as humectants. Other humectants like methanol and isopropanol have also been used [91, 93].

The ink must be able to dry quickly after printing but not during the printing process itself. In order to obtain a well-defined print, ink rheology (density, surface tension and viscosity), must be monitored.

A wide range of high performance inks for different fabrics was patented [94], these were reactive inks for cotton, wool and silk; acid inks for wool, silk and polyamide; finally disperse inks for polyester.

- *Reactive Dyes*

In inkjet, printing inks, reactive inks are also one of the most common inks due to their excellent water solubility, relatively, low prices, high washing stability and pottery, and beautiful brightness. Efforts to improve the quality of interactive inkjet publications include a study on the printing of adjuvant chemicals, the printing process, and the conditions of the printing house [95-97]. These dyes can be used to print cotton, viscose and up to some extent wool and silk. These dyes give very good around fastness properties due to their covalent bond formation. For their fixation alkali and heat is necessary. Alkali must be applied by a pre-treatment process as it interferes with reactive dyes and nozzle components if put in the ink itself. The fixation is done by steam or hot air fixation process. A substrate wash-off is also necessary [98].

Moreover, there are two ways to improve the color fastness on the fabric, first choose the dyes with better fastness, and / or use a UV absorber. The use of UV absorbers in inks and post-printing treatment was examined and the effect of these treatments on the stability of print light. The results obtained showed an improvement in the light fastness of interactive inkjet prints [99].

- *Acid Dyes*

Acid dyes are used to print wool, silk and polyamide fibers. This is a small segment but has proved its importance in high quality fabrics of wool and silk. The trend for unique design on swimsuits have high demand for ink jet printing on polyamide fabric. Steaming is necessary for the fixation and a separate wash off is essential for the removal of unfixed dye **[98].** Cotton fabric inkjet printing with acid dyes is investigated using quaternary ammonium (Choline Chloride (CC)) and two cross-linking agents (DMDHEU and BTCA) to examine dye uptake. The concentration of chemicals, the finishing condition, and the inkjet printing processes are explored **[100].**

- *Disperse dyes*

Disperse dyes are considered the base of heat transfer printing technique for polyester. Inks are based on a special type of disperse dyes that can be printed onto paper and then transferred to textile using a heat press. The same class of inks with selection of fastness properties fulfilling the requirements of particular needs. They are applied directly onto the substrate and fixed by high temperature steaming, after which washing may or may not be necessary **[98].**

➢ *Advantages of Inkjet Printing [98].*

- No screens are required. * Unlimited colors can be used in a design.
- No or little pretreatment required. *Significantly reduces time to market
- No repeat size limitation Low cost of change over
- Photographic images can be printed.
- Environmentally friendly - reduces use of water, dyes & solutions

➢ *Disadvantages*

- Low speed 2 - 20 yds /hour.
- Less production.

Section 4: Future Outlook

The great advances of recent decades in textile and textile science, and in information technology, are now ready to enter the textile industry, and it is already possible to imagine that in the next ten years, our way of looking at the textile industry will change dramatically. Moreover, the environmental issues will lead to big changes in the textile process. As it happens with all revolutions, this big change will cause many problems to the industries of textile chains, but it may also represent a big chance for those, which will be able to ride this wave of change.

- ➢ Today, the technologies involving the use of UV- curing and/or the electron beam radiation means e.g. in pigment printing techniques using the UV curable binders, might be favorable in future as they are energy conservation, and considered as clean technology and cost saving techniques.
- ➢ As plasma treatment of textile fibers is fast growing and find some potential applications since it does not involve handling of hazardous chemicals and thus there are no problems of effluents compared with the chemical treatments.
- ➢ Digital textile printing has proven to be tremendously cost saving in sampling only, so far. At this stage in the technological development of digital ink-jet systems for textile printing, it is impossible to forecast the level of market penetration they will reach in the immediate future. Speed limitations compared to other existing techniques, and the industry's built-in resistance to change, so far, have blocked the wide spread acceptance of ink jets in most production applications.
- ➢ However, the commitment to digital printing now shown by many important machines, technology, chemicals, and software suppliers as well as the R&D projects going on internationally suggest that ink jet should definitely have an increasing future. In addition, the economics of the ink jet technology are expected to improve for longer production runs.
- ➢ Natural thickener extracted from seeds such as fenugreek, guar, cassia…etc is considered eco friendly thickeners where they have low COD & BO D. As well as the hull of these seeds can be used for extracting natural dyes and the biodegradable hull(spent hull) remove hazardous metals as Cr and Cu from textile effluent.

- Due to the good thickening properties of chitosan, it could be used in pigment printing alone and saving of both thickener and binder.

II. CONCLUSION

- Inkjet printing technology had been attracted more attention in the textile world.
- -UV curing had been used in many industrial applications, due to its low power consumption, short operating period, fast and reliable treatment, low environmental pollution, room temperature treatment, space saving, etc.
- Electron radiation technology had been become a well-accepted technique, which has emerged in a very large number of mainly industrial applications such as the fields of painting and printing
- Plasma treatment of textile fibers had been fast growing and find some potential applications

REFERENCES

[1]. T. L. Dawson," *Textile printing*", 2nd Edition, edited by Leslie W C Miles, **Society of Dyers and Colorists, Bradford** 1 (**1994**) 110-113
[2]. W.Kohte, **.Textilveredlung**, 30(**1995**)48.
[3]. W.S. Perkins. **Textile Chemist and Colorist &American Dyestuff Reporter,** 1 (**1999**) 2 5-28.
[4]. R. Eisenlohr and V. Giesen. **International Dyer**, 180 (**1995**)12.
[5]. 5-A.G. Hammands, " *Introduction to Binders, Pigment Printing*". **Handbook**, **(1995**) 5.
[6]. J. Weiser. **International Textile Bulletin** 1(**2001**) 71-74.
[7]. T. Ross, "*A primer in digital textile printing*". **Retrieved** November 2, (**2004**).
[8]. U. Sayed, and S.K. Khobian. **Colourage** 50(2) (**2003**)35-36.
[9]. W. W. Carr, W. C. Tincher, P. Desai, F. L. Cook,and P. H. Pfromm .**National Textile Center Annual Report:** August (**1995**)161-169.
[10]. V. Cahill. **International conference on digital printing technologies** (2002)191-200.
[11]. Y. Yang and V. Naarani. **Coloration Technology,** 120(3) (**2004**) 127-131.
[12]. Yang Y, V. Naarani, and V. Thillainayagam. **Journal of Imaging Science and Technology**, (**2006**).
[13]. T.L. Dawson. **Journal of the Society of Dyers and Colorists** 116(2) (**2000**) 52-59.
[14]. T.L. Dawson and C.J. Hawkyard. **Review of Progression in Coloration** 30 (**2000**)7- 19.
[15]. T.L .Dawson. **Coloration Technology** 117(4) (**2001**) 185-192.
[16]. L.V. Jing, X. Min, and C. Shuilin**. AATCC Rev** June (**2003**)29-32.
[17]. H.P. LE‹. **Journal ISET**, 42, No. 1 (**1998**) 49.
[18]. 18-Miles LWC. In: Miles LWC (Ed) **Society of Dyers and Colorists** (**1994**).
[19]. N.S.E.Ahmed, Y.A Youssef, R.M. El-Shishtawy, and A.A Mousa. **Coloration Technology** Volume 122, Issue 6, December (2006) 324-328.
[20]. S.M. Burkinshaw, S.N. Chevli, and D.J. Marfell. **Dyes and Pigments** 45 (**2000**) 235-242
[21]. M.M. El-Molla. **Journal of the Textile Association**, Volume 65, Issue 2, July (**2004**) 63-68
[22]. Tyronel vigo. **Elsevier Amsterdam,** (**1994**) Chapter 3, 180-185.
[23]. D.P. Chattopadhyag, J.K. Sharma, D.P. Kaushik and S. patni. **Colourage,** July (**1996**) 15-20.
[24]. M.M. El-Molla, A.A. El-Halwagy, H.S. El-Sayad. **Advances in polymers technology**, Vol. 20, No. 4 (**2001**) 1-9.
[25]. M.A. El-Kashouti, A.A. El-halwagy & M.M. El-Molla. **Indian Journal of Fiber & Textile Research** Vol. 25. June (**2000**) 147-151.
[26]. Arshad Chaudhry, *International conference in Recent Advances in Wet Processing of Textiles,***1st-3rd,India**,Febraury, (**1998**) 27.
[27]. V.Giensen, R. Eisenlobr. **Rev.Prog.Coloration**, (**1994**). 29, 26
[28]. R.Schneider, S. Soster. **Dyes and Pigments**, Volume 57, Issue 1, April (**2003)** 7-14
[29]. M.A. El-Kashouti, M.M. El-Molla, T.S. Salem, and A.A .El-Halwagy. **Egyptian Journal of Chemistry**, Volume 47, Issue SPEC. ISS., (**2004**)163-181
[30]. A.A.Hebeish, A.A Ragheb, S.H Nassar, E.E. Allam, and J.I. *Abd El Thalouth,*. **Journal of Applied Polymer Science**, Volume 102, Issue 1, 5 October (**2006**) 338-347
[31]. **M. Gahold and, P. Dubey. International Dyer**, Volume 188, Issue 9, September (**2003**)24-27
[32]. N.A Ibrahim, M.H.Abo-Shosha, and E.M El-Zairy. **Journal of Applied Polymer Science**, Volume 101, Issue 6, 15 September (2006) 4430-4439
[33]. M. Jassal, N. Acharya, P.Bajaj, and, R. B. Chavan. **Journal of Macromolecular Science,** Part C – reviews,1(**2002**) 42.
[34]. W.B.Achwal. **Courage**, October, (**2000**) 28.
[35]. P. K. Shah, and O. H. Westlake, **U.S.Patent No.5,969,018**, **(1999)**.
[36]. L. V. Jing and S.Chen. **Colourage**, July, (**2002**) 41.
[37]. L. V. Jing, and C. shuilin. **AATCC review**,June, (**2003**) 29.
[38]. S. A. Bahmani, G., C.East, and, I. Holme,. **JSDC**, 94(**2000**) 116.
[39]. V.V. Safonov and, I.I. Klochkova. **Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Teknologiya Tekstil'noi Promyshlennosti**, Issue 2, 2004, Pages 48-51
[40]. S. K. Tiwari, K. G. Prajapati, and M. M. Gharia. **Colourage**, September, (**2001**) 17.
[41]. V.R.Giri Dev, R.Neelakandan, S. Sudha, O.L .Shamugasundram, and R.N. Nadaraj, . **Textile Magazine**, Volume 46, Issue 9, July (**2005**) 83-86
[42]. J. A. klang and J. S. Balcerski . **SARTOMER** 8 (**2002)**1-8.
[43]. William K. Walsh and Wadida Oraby . **Radiation Physics and Chemistry**, August (**2002**).
[44]. V.J. Cahill. **Radtech. Report** July/August (**2001**)20-24.
[45]. M.M. EL-Molla, R. Schneider. **Polish Journal of Applied Chemistry**, XLIX, no. 4, (**2005**) 297–313

ISSN No:-2456-2165

[46]. M.M. El-Molla. **Dyes and Pigments** (**2006**) 1- 9
[47]. M. M. El-Molla. ***T*he Egyptian First International Conference in Chemistry, Chemistry for Human Needs in Developing Countries, Sharm El- Sheikh, Egypt** , 11-14 September (**2006**)1-2*6*
[48]. J.A. KLANG and J.S. BALCERSKI, . **SARTOMER**, 1 (**2002**) 9.
[49]. M. M. El-Molla, R. Schneider. **Dyes and Pigments**, 71(**2006**) 258-265
[50]. H.Noguchi and M.Shimomra. **RADTCECH REPORT**, March/April (**2001**)22-25
[51]. T. Kauffman, and M. Mitry. **Adhesives Age**, (**1999**) 42, 27.
[52]. L. Shiqi, H. Boyter, and N. Stewart.**AATCC review**, August, (**2004**) 44
[53]. T. Sherzer, and U. Decker, . **Polymer**, 41 (**2000**) 7681.
[54]. R. Mehnert, S. Naumov, W. Knolle, and I. Janovsky, **Macromol. Chem. Phys.** 201 (**2000**) 2447.
[55]. A.. M. El-Naggar, M. H. Zohdy, H.M Said, M. S. El-din,and D. M. Noval, . **Applied surface science** (**2004**) 30.
[56]. Z. Ondogan, O. Pamuk, E.N. Ondogan, A. Ozguney.**Opt Laser Technol** 37(8)(**2005**) 631–7
[57]. Arif Taner Ozguney.**Optics & Laser Technology** (**2006**)
[58]. H.U. Poll, and S. Schreiter. **Melliand Textilber** 79 (6) (**1998**) 466–468.
[59]. H.U. Poll, U. Schladitz, and S. Schreiter,. **Surf. Coat. Technol**. 142–144 (**2001**) 489–493.
[60]. I.I. Negulescu, S. Despa, J. Chen, B.J. Collier, M. Despa, A. Denes, et al. **Text. Res. J**. 70 (1) (**2000**) 1–7.
[61]. C.D. Radu, P. Kiekens,and J. Verschuren,.**Marcel Dekker, New York,** (**2001**) 203–218.
[62]. N. Sekar, . **Colourage**, June (**2000**) 39-40.
[63]. F. Ferrero, . **Polymer Testing**, 22 (**2003**) 571–578
[64]. A. Perwuelz, M. Casetta, and C. Caze, .**Polym. Test**. 20 **(2001**) 553–561.
[65]. G. Borcia, C.A. Anderson, and N.M.D. Brown, . **Surface & Coatings Technology** (**2006**)
[66]. S. Ruppert, B.Muller, T. Bahners,. and E. Shollmeyer,.**Textilverdlung**, 31(**1996**) 31.
[67]. E.,P Novoselova., O.,G.,Tsirkinal., A.,L Nikiforov,.and B.,N. Melnikov. **Izvestiya Vysshikh chebnykh Zavedenii, seriya Teknologiya Tekstil 'noi Promyshlennosti**, No. 6, (**1999**) 53.
[68]. E. Heine and H. Hoecker,. **Ed. T. Xiaoming** (Boca Raton: CRC Pr LIc,) (**2001**)254
[69]. P.Arkady, A.P.Sinitsyn, A.V.usakov and O.A.Sinitsyna, .**Proc. AATCC Symp., New Orleans, USA** (**1999**)2
[70]. V. Kokol and E.Heine . **Color. Technol**., 121 (**2005**)209-215
[71]. N. A. Ibrahim , M. R. El-Zairy , A. R. El-Gamal , S. A. Tolba ,and T. M. Hussan . **Polymer-Plastics Technology and Engineering** Volume 45, Number 7 **(** **2006**)799 – 807
[72]. Chao-Hua Xue, Min-Min Shi, Hong-Zheng Chen, Gang Wu, and Mang Wang. **Colloids and Surfaces A: Physicochem. Eng. Aspects** 287 (**2006**) 147–152
[73]. S. Roy, and S. Devi. **Polymer** 38 (**1997**) 3325.
[74]. W.H. Ming, F.N. Jones, and S.K. Fu, .**Polym. Bull**. 40 (**1998**) 749.
[75]. F.J. Schork, G.W. Poehlein, S. Wang, J. Reimers, J. Rodrigues, and C. Samer. **Eng. Aspects** 153 (**1999**) 39.
[76]. V. Lekova, C. Popov, B. Ivanoc, and R. Garwanska. **Fibers and Textiles in Eastern Europe,** 6 (**1998**) 52
[77]. A.H. Taba, and p.Houser, .**Textile Chemist and Colorist&American Dyestuff Reporter,** 32 (**2000**) 36.
[78]. S. S. Turk and R. Schneider. **Dyes and pigment**, 47, (**2000**) 269.
[79]. R. M. El-shishtawy and S. H. Nassar. **Color. Technol**., 118 (**2002**) 115.
[80]. P. Hauser, Adham Tabba, .**Textile Chemist and Colorist**, 32, 2,(**2000**)30-33
[81]. Reda M. El-Shishtawy, S.H. Nassar, Nahed S.E. Ahmed. **Dyes and Pigments** (**2006**) 1-8
[82]. I. Holme, "Coloration *of technical textiles*", **Hand book of technical textiles**, Edited by A.R.Horrocks &S.C. Anand (**2000**)187-222
[83]. C.J. Hawkyard," *in textile printing*", 2nd edn, ed. L W C Miles, **The Society of Dyers and Colorists,** Bradford, (**1994**)18-57
[84]. H.A. Ellis, . **Textile Horizons**,5(4)(**1985**)37-38,40
[85]. I.D.Rattee, "in *textile printing*, 2nd edn,ed. L W C Miles, **The Society of Dyers and Colorists,** Bradford, (**1994**)58-98
[86]. I. Holme, . **International Dyer,** Volume 189, Issue 5, May (**2004**) 37-40
[87]. A. A. El-Halgway, H. S. El-Sayad & M. M. El-Molla. **Macromol. Mater. Eng**. 10(**2001**)286
[88]. W.C.Tincher, Q. HU and X. LI, .Textie Chem. Colorist, 30,5,(1998)24-27
[89]. B.Sieei, S.Ervine and K. Siemensmeyer, 18th IFATCC(International Federation of Textile Chemists and Colorists) Conress, Copenhagen, Denmark, (1999) 144-148
[90]. J.Stefanini. Textile Chemist and Colorist, 28 (1996) 19-22.
[91]. S.H. Khamis, Ph.D. Thesis, College of applied arts, Helwan University (2002)
[92]. A. Bohriner, . International Textile Bulletin, 46(2000)16.
[93]. H. Deloach. American Dyestuff Reporter, 83 (1994)110.
[94]. L.Jerome " Principles of non- Impact printing" 2nd Ed., London, Palatino press, (1992)302
[95]. T.L. Dawson. . Colourage 51(10) (2004) 75-82
[96]. R.Schneider. Melliand International 8(2002) 131-134.
[97]. Y .Yang, and S. Li. **Textile Research Journal**, 73(9)(**2003**) 809-814.
[98]. Muhammad Aslam Khan. **Pakistan Textile Journal, April (2004)**
[99]. Yiqi Yang, and Vamshi Naarani.**Dyes and Pigments** (**2006**) 1-7100-Y.Yiqi, and Li. Shiqi, . **Textile Res. J**. 73(9) (**2003)**809-814