Printing

Contemporary wool dyeing and finishing

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1. Introduction

What is printing?

- Printing of textiles is the production of coloured designs by the application of colourants, or other substances which modify the uptake of colour, to localised areas of textiles (fabrics, yarns, carpet).
- The colorants or other substances (solvent, adhesive, discharge paste, resist) are deposited onto the fabric or yarn in a paste form.
- The yarns or fabric are usually treated with steam, heat, or chemicals for fixation of the colourants.

History of printing

- **Printing of fabrics** has **extremely ancient** roots originating in the Far East. **Early designs** were crude and were produced by **block printing or stencil printing**.
- In **block printing**, a wooden block is carved to form raised pattern areas, the carved surface is placed on a dye paste, and the block is pressed against a fabric surface.
- In **stencil printing**, a design is cut from paper, the paper is placed on the fabric surface, and dye paste is brushed over the open design areas. The paper protects the remaining areas of the fabric surface from the paste.
- In the 16th and 17th centuries, block-printed cotton and silk fabrics were imported in such great quantities into Europe that British home producers of woollen cloths induced Parliament to pass an act in 1621 banning their import.
- Block and stencil printing are still done by artisans throughout the world, and their motifs and patterns are simulated on modern printing equipment.

History of printing

- In the 1780s, mechanisation of printing, with the introduction of roller printing, revolutionised the printed-fabric market.
- The prints produced by roller printing were distinguished by delicacy of design, fine lines, and good fit (registration), in sharp contrast to the crude, wide-line designs with ill fit between pattern repeats produced by block and stencil printing.
- During the 19th and 20th centuries, new printing methods were developed with advances in technology:
  - flat screen
  - rotary screen
  - transfer
  - digital (ink jet).

Uses of printing

- 80-90 billion meters of fabric is produced each year. About 17 billion meters, or about one-fourth, are prints. About 56% of prints are made on apparel and 33% on home furnishings.
- The largest portion of printed apparel fabric is used for women's and children's wear, but each year, more printed fabrics appear in men's garments—a market that traditionally has not used prints.
- Upholstery and drapery fabrics are often printed, as well as many household items, especially sheets and pillowcases, bedspreads, and some towels. In recent years, there has been an interest in printing warp and weft knits.
- Wool has only about 1% of the total printing market. Most wool is printed in Italy and Japan.

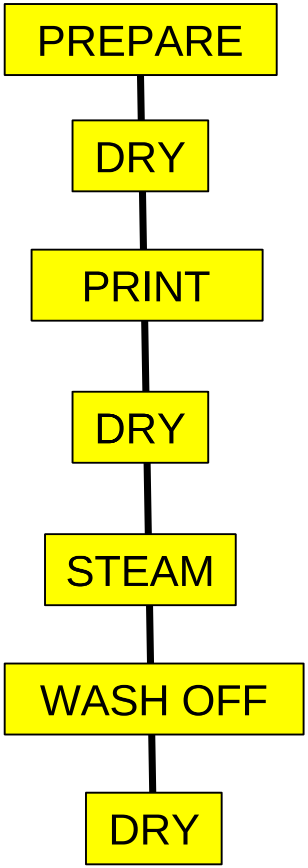
2. Direct printing

Direct printing on wool

Wool is usually printed by applying a thickened dye paste containing conventional wool dyes (acid, premetallised and reactive dyes) directly on a pretreated fabric surface.

The sequence of steps in direct printing is shown here.

Printing of wool consists of more steps than for other fibres.



2.a Preparation of fabric

The need for surface modification of wool before printing

Wool is a particularly difficult fabric to print, since each fibre is coated with a thin layer of hydrophobic lipid making the wetability of untreated wool similar to Teflon.

Therefore, to obtain the deepest and sharpest prints, wool is usually prepared for printing by oxidising the surfaces of the fibres.

Wool fabrics are usually oxidised with chlorine to:

1. improve wetability of the fabric by the print paste
2. increase colour yield
3. prevent felting during washing off.

Preparation methods

- Chlorination with 2-4% of active chlorine is most widely used. Methods are:
  - batch DCCA and
  - continuous DCCA treatments and
  - Kroy chlorination.
- Other pretreatment methods include:
  - soft lustre treatments
  - vacuum plasma
  - UV radiation (e.g. Siroflash).

Fabric chlorination with DCCA

Batch treatment

Fabric is run for 20 minutes cold with:

- 1-2% Leophen M (BASF) and
- 3% acetic acid (60%) at
- pH 3.5-4.5.

Then treated for 20-45 minutes cold in the same bath with up to:

- 4.0% Basolan DC at pH 4 to 4.5 with
- 2 ml/l formic acid.

Unreacted chlorine is removed from the fabric by treating for 10 minutes cold in the same bath with:

- 1-5 g/l Blankit D or DA (sodium metabisulphite)
- 0.5% Kieralon OL
- pH 2.5–3, heat to 80ºC for 20 minutes
- Adjust to pH 5 with sodium carbonate
- 5 min at pH 5 and 80ºC.

Then the bath is dropped and the fabric rinsed warm and cold.

Aftertreatment can be carried out with:

- 1–2 ml/l hydrogen peroxide 35%
- 1 g/l Kieralon OL or Leophen RA
- 10 minutes at 40ºC
- no rinse.

Fabric chlorination with DCCA

Continuous treatment

Fabric is padded with a liquor containing:

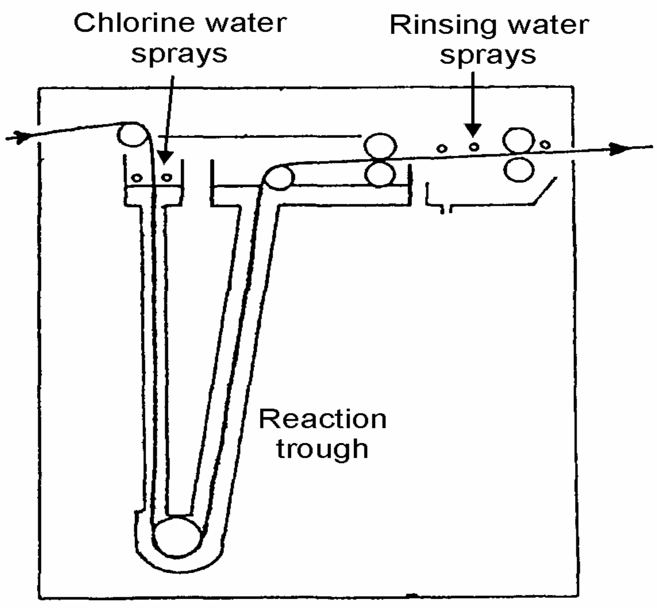
    - 35-50 g/l Basolan DC and
    - 5 g/l Laventin CW (BASF) (any nonionic wetting agent which is stable to chlorine) at
    - 80% pick-up.
- Hold for dwell time of 2-10 minutes in a scray.
- The fabric then passes to anti-chlorination and rinsing stages:
    - 5 g/l Blankit D or DA
    - 1 g/l Kieralon OL
    - 5 g/l formic acid 85%
    - total 3–10 minutes at 80–90^{o}C.
- Efficient ventilation is required to exhaust chlorine gas emitted during the process.

MSDS chemical data for Basolan DC

- ***Chemical:* Basolan* DC.**
- *Other names:* Sodium Dichloroisocyanurate.
- *Formula:* $C_3Cl_2N_3NaO_3$.
- *CAS#:* 2893-78-9.
- *Database ID:* 8257*Last updated:* 12/8/2005 10:27:50
- AM *Risk Phrases* RISK LEVEL 4 ALERT.
  - This chemical will require a risk assessment prior to laboratory use.
  - Contact with combustible material may cause fire.
  - Harmful if swallowed.
  - Contact with acids liberates toxic gas.
  - Irritating to eyes and respiratory system.
  - Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
- *MSDS* Basolan DC.pdf *MSDS expiry date*13/03/2004

Chlorination of fabric using a Kroy machine

- An aqueous acidic solution of chlorine is sprayed onto fabric at the start of its passage into a very deep, narrow trough and reaction occurs very rapidly as the fabric passes through the machine.
- After chlorination, the fabric is passed to an open-width washer where it receives anti-chlorination, neutralisation and rinsing treatments.
- Efficient extraction and scrubbing systems are required to remove chlorine gas from the vicinity if the chlorinator.
- Fabric for printing can be made from treated loose stock, top, or yarn treated in a suitably modified machine.



Disadvantages of chlorination

- Fabric yellowing.
- Harsh handle.
- Difficulty in achieving level treatment.
- Absorbable organohalogens (AOX) in the effluent.

Preparation for printing with UV

- The Siroflash process involves continuous UV exposure of wool, followed by a mild wet oxidative treatment with hydrogen peroxide in a winch.
- This treatment produces a similar improvement in colour yields to chlorination but with less yellowing and a softer handle.

Vacuum plasma

- This treatment is a ‘roll to roll’ process carried out inside a chamber at a vacuum between 50 and 150 pascals, at a speed ranging from 10 to 40 m/min. The fabric is interlaced amongst a number of electrodes (rollers) connected to a medium-frequency generator which creates an electrical field where a gas (air, oxygen, nitrogen etc.) is transformed into a cold-glow discharge plasma consisting of ions, electrons, UV radiation and free radicals. The plasma acts on the surface of the fabrics removing first the organic contaminants and then modifying the chemical structure.

- Colour yields can be equivalent to those obtained with chlorination treatments.

Plasma treatment machine
Unitex HTP/ KPR 180

2.b Print pastes and dyes

Print paste composition

A typical printing paste for direct printing on wool includes:

- *water*
- *thickener* (2-5%) (e.g. locust bean gum or alginate)
- *urea* (0-20%), as humectant and to assist dye dissolution
- *diethylene glycol or thiodiglycol (Glyezin A, BASF)* (0-3%), also to assist dye dissolution
- *wetting agent*, used sparingly, otherwise the print will become too diffuse (e.g. Glyezin BC, BASF, a nonionic ethoxylated alcohol)
- *acid or acid donor* (e.g. formic acid, acetic acid, ammonium sulphate depending on the dye)
- *sodium chlorate*, an oxidising agent, to prevent reduction of dyes during steaming.

Colourants for wool printing

In principle, any types of wool dyes could be used, but in practice, the choice of dye is determined by the shade and the substrate to be printed.

The main requirement is that the dye should be soluble or well dispersed in the print paste.

Acid dyes - can be used for bright shades, depending on wet fastness requirements.

Premetallised dyes are used for deep, duller shades of good fastness and are applied to wool in much the same way as acid dyes, except that an acid donor is not used.

Reactive dyes are used for deep, bright shades, they are printed at pH 3-5 with formic acid in place of ammonium sulphate. Reactive dye prints on wool can be steamed for a shorter time than acid and premetallised dyes, but intensive washing off under mild alkaline conditions is required if their high wet-fastness is to be achieved.

Pigment printing

- Pigments are insoluble colourants.
- They are dispersed in fine particulate form in print pastes and are made to adhere to the fabric by means of binders that are cured during drying after printing. The binder forms a resin film coloured by the pigments.
- To date, there are no commercially viable pigment printing methods for high quality wool articles.
- This topic will not be dealt with further in this lecture.

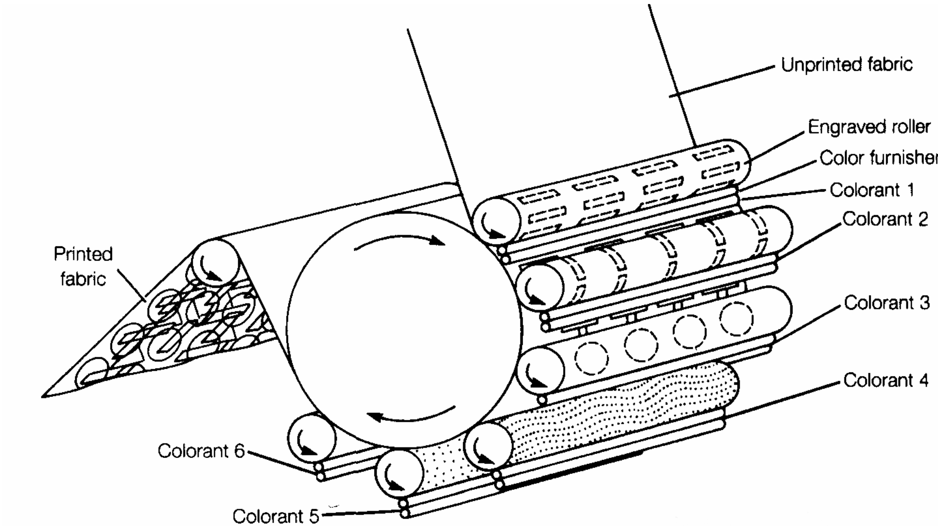
2.c Printing machines:

Gravure (roller)
Flat screen
Rotary screen.

Roller printing

- Roller printing has remained essentially unchanged since its inception in 1783.
- The areas of the design to be printed are etched or ‘carved out’ on a copper roll, with one roll for each colour.
- The etched areas on a print roll are continuously filled with print paste from a smooth-surfaced furnish roll that picks up the paste from the colour box. A doctor blade removes any print paste from the raised surface of the print roll, thus leaving print paste only in the etched areas of the print roll.
- Most roller-printing machines have eight print rolls but some have 16 arranged around a central cylinder.
- Print paste is transferred to the fabric when each engraved roller presses the fabric against the central cylinder. The blanket and back grey cloth absorb excess print paste, so that it does not become deposited on the drum. Fabric moves at rates up to 100-150 metres per minute.

Roller printing machines



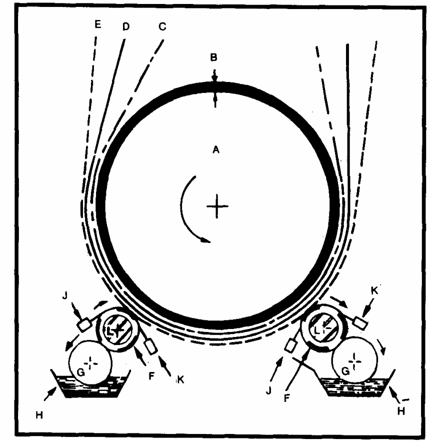
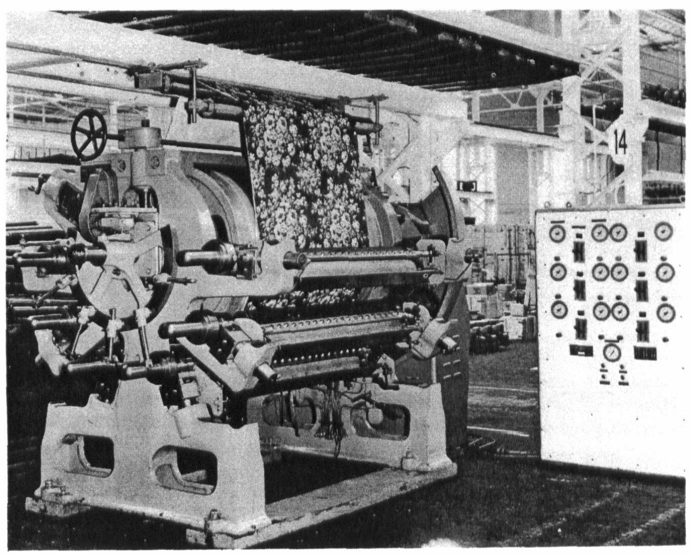


Figure 6.13 *Diagram of a two-colour machine*
A Pressure bowl (impression cylinder), B Lapping,
C Endless printing blanket, D Back grey, E Fabric to be printed,
F Engraved printing cylinder, G Furnishing rollers, H Colour box,
J Colour doctor, K Lint doctor, L Mandrel

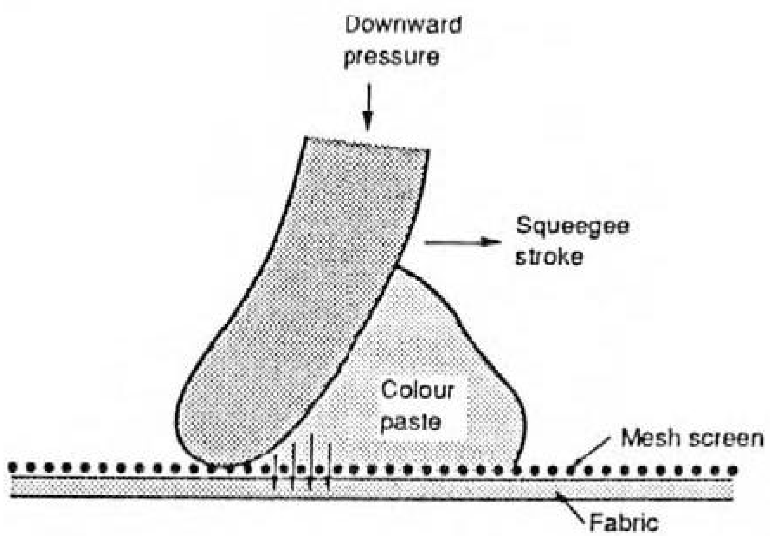


Screen printing

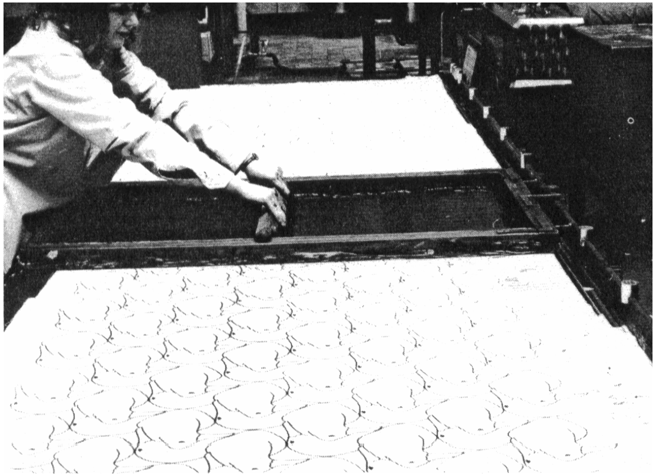
Originally, screens were made from **silk** fabric stretched across a frame and the process was called silk screen printing. Today, screens are made from **nylon, polyester, or metal**.

Each screen is prepared, so that there are open areas and closed areas. The **open areas allow print paste to be pushed through onto the fabric surface**, and the closed areas prevent print paste from reaching the fabric. One screen is required for each colourant applied.

Squeegees can be flexible rubber blades that are drawn across the table.



Manual flat bed screen printing



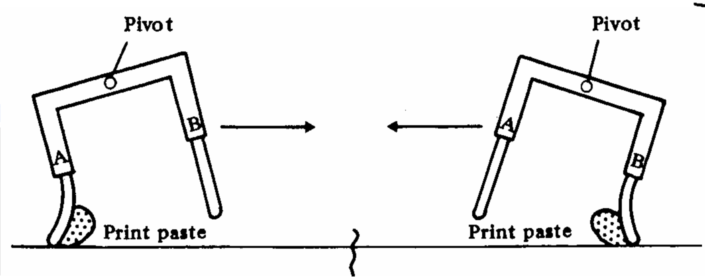
Manual (hand) screen printing began in the United States in the mid-1930s.

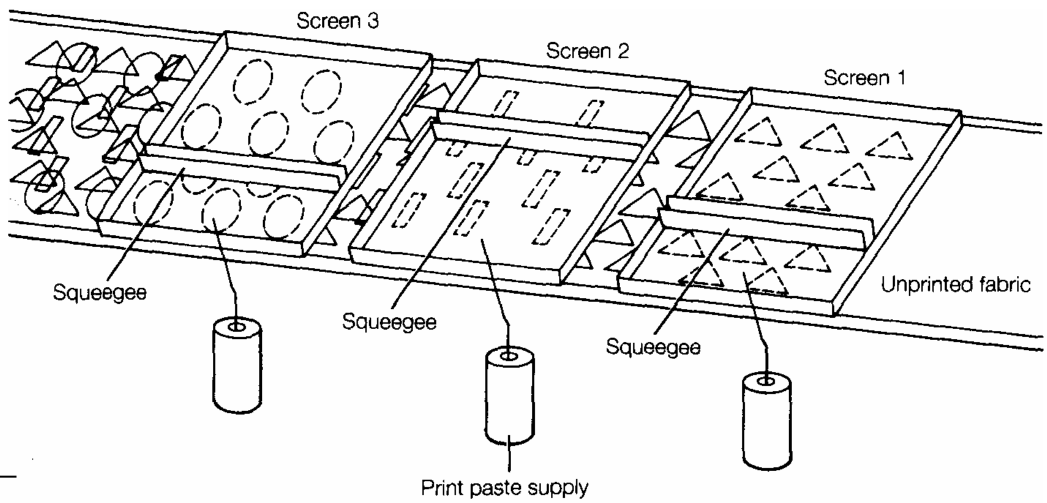
Lengths of fabric up to one piece are stuck to a table with a resilient surface. Screens (usually full width and 64cm wide) are positioned accurately using adjustable lugs. After one or two squeegee strokes, the screen is lifted and moved on two positions. The intervening prints are then filled in after the first set of prints have dried. The process is slow, labour intensive and can suffer from registration and unevenness problems.

Automatic flat bed screen printing

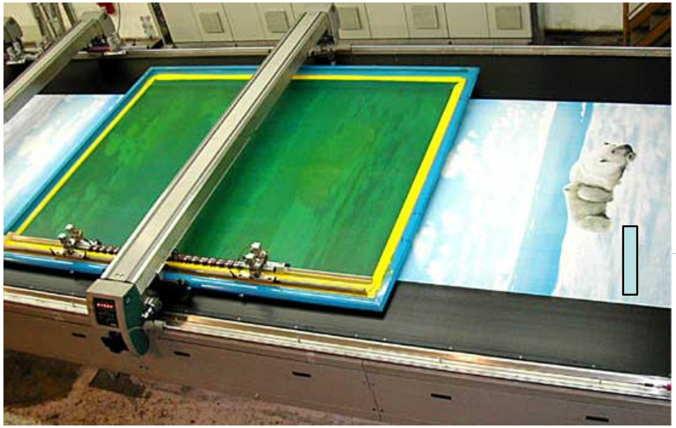
- In the 1940s, flatbed screen printing became mechanised.
- Fabric is stuck with a temporary adhesive to a continuous rubber belt which is advanced intermittently by the screen repeat length between squeegee strokes. Flat screens, one for each colour, are mounted so that that they can be raised and lowered and they are fitted with automatic squeegees and print paste supply systems. After each squeegee stroke, the screens are lifted automatically, the fabric advances one repeat length and the screens are lowered. The fabric is lifted off the blanket at the end of the machine and fed into a dryer. The blanket is washed to remove the adhesive and dried and fresh adhesive applied on the underside of the machine during its return passage.
- Maximum production rates are around 8 m/min.

One type of double-acting automatic squeegee





Automatic flat bed printing



Preparation of screens

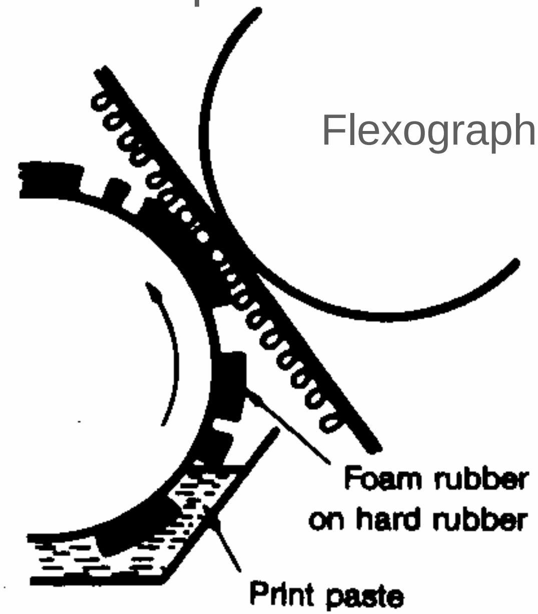
1. Coat with photosensitive activator and crosslinkable binder (e.g. photosensitive dye and acrylic binder or chromic salt and gelatin).
2. Dry in dark.
3. Expose to ultraviolet light using positive film or computer-controlled laser.
4. Wash to remove un-crosslinked binder.
5. Apply lacquer to preserve.

Flatbed prints

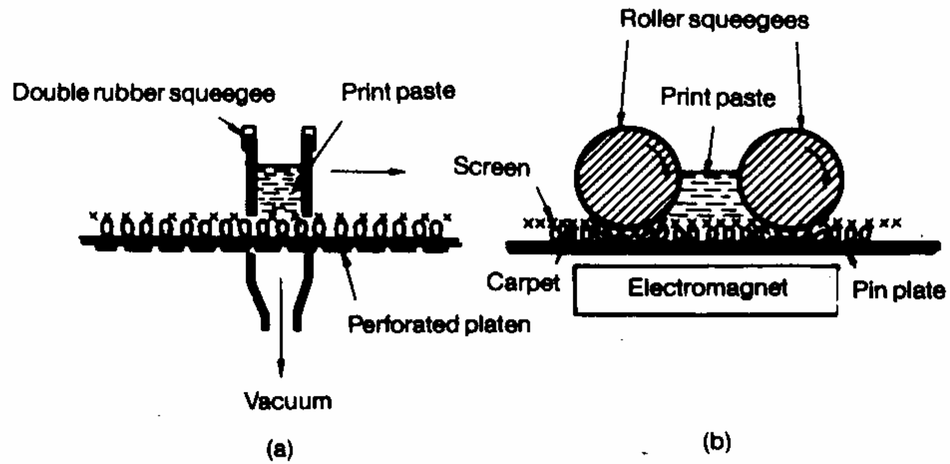
- About **one-tenth** of commercial fabric printing is **flatbed**.
- **All types of fabrics**, including wovens, knits, and nonwovens, can be printed by this method.
- **Typical** flatbed screen printed products have discrete **non-continuous patterns**. These include tablecloths, towels, T-shirts, and scarves. In addition, specialty designs, including those with very large numbers of colours (say over 10) and very long repeats, are often flatbed screen printed.
- Flatbed screen **prints do not have the fine line design** detail that is possible with roller printing, rotary screen printing, and heat-transfer printing. The finest detail is limited by the mesh of the screen fabric to around 200 x 200 holes per inch (80 x 80 holes per centimetrre).
- Patterns with **lengthwise stripes are not flatbed screen printed.**

Conventional carpet printing

Carpet can be printed using conventional flexographic and screen printing methods. The main difference is the relatively large amount of print paste that must be applied compared with fabric.



Flexographic

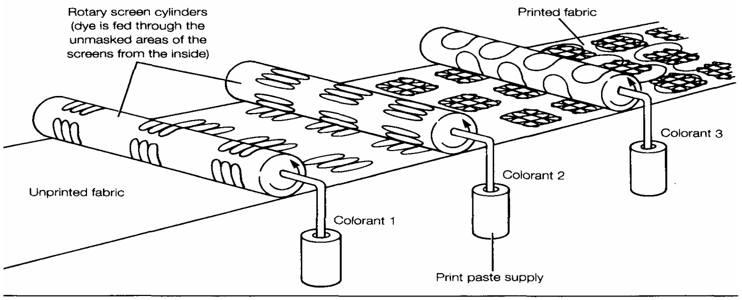


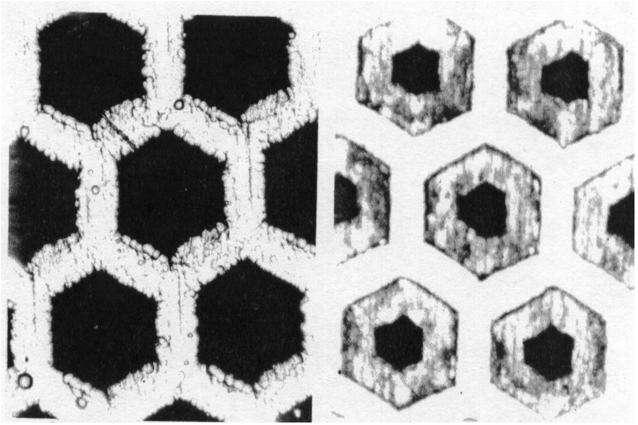
Flat screen

Rotary Screen Printing

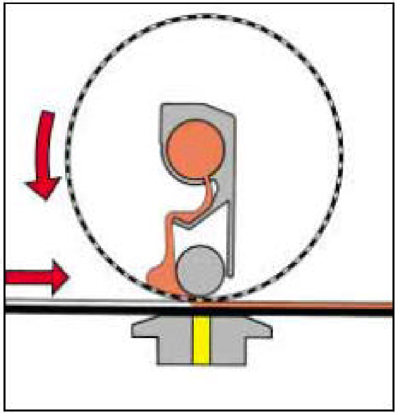
- Rotary screen printing was **introduced in 1963**.
- The fabric is stuck to a rubber belt that moves continuously under rotary screens.
- The **screens are seamless cylinders of metal mesh. Print paste is pumped into the center of a cylindrical screen and pushed through by a squeegee inside the cylinder**.
- The squeegee is stationary while the screen moves, squeegees are usually flexible, stainless steel blades, or rods that rotate while being held in position by an electromagnet.
- Production rates of 25-100 metres per minute are possible on some fabrics.

Rotary screen printing

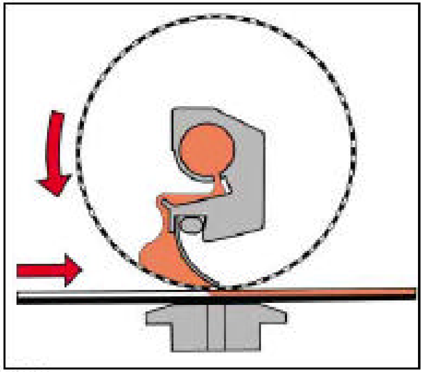




Metal mesh etched screens

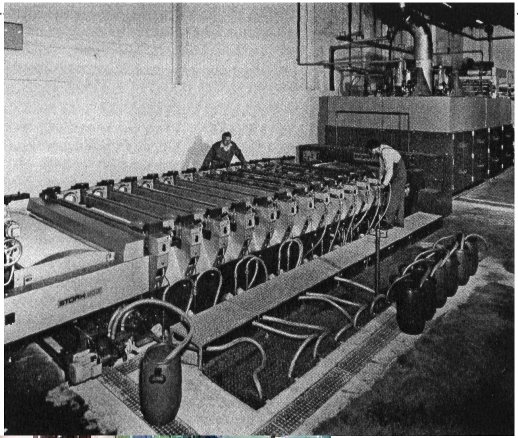


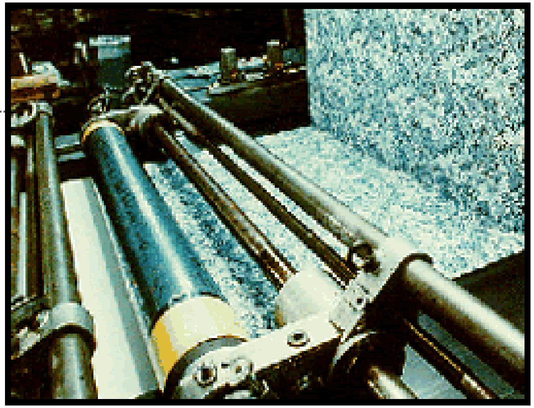
Roller squeegee



Blade squeegee

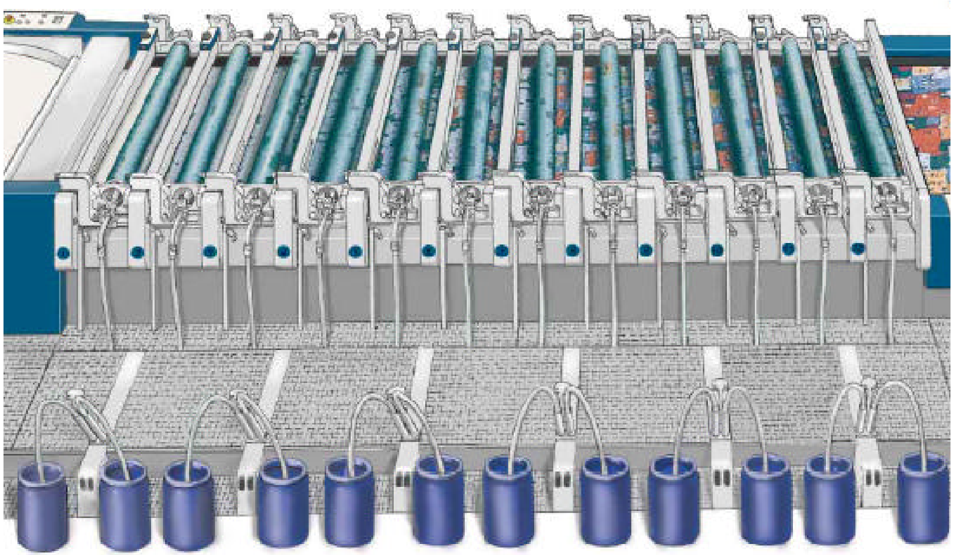
Rotary screen printers



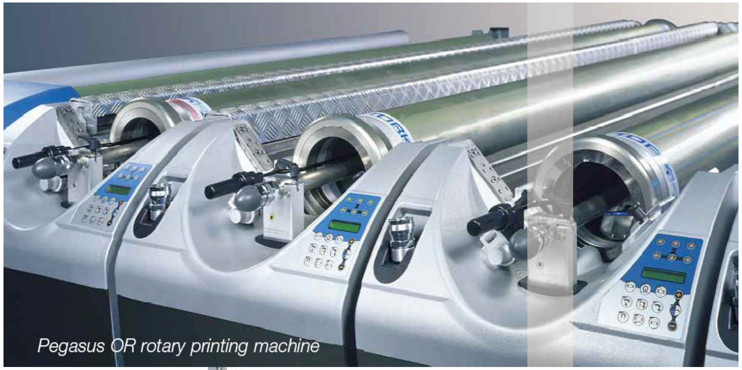


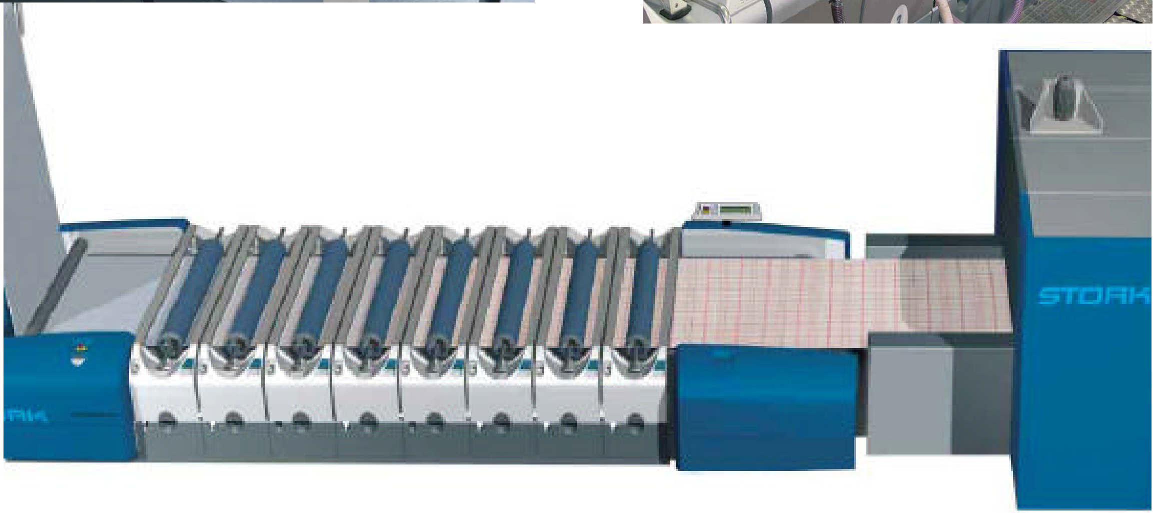
Ichinose Samurai

Stork Pegasus



Stork rotary screen printers





Advantages and disadvantages of rotary screen printing

- Registration is better than with flat screens.
- Changeover times are faster.
- Colour yields are good because the penetration of the print into the fabric is more easily controlled.
- There is less chance for human error.
- Fine lines and half tone effects can be reproduced.
- Set-up for each print run is expensive.
- Maximum standard repeat length is 64 cm.
- Economical only for production runs of around 1000 metres or longer.

2.d Fixation methods

Print fixation

- After printing, the fabric is usually dried and transported to a steamer.
- Prints on wool must be fixed in saturated steam at 100ºC for 15 to 60 minutes (depending on the dye and depth of shade) to achieve maximum colour yields, high levels of fixation and the best washfastness attainable.
- The fabric must then be washed off to remove thickener and unfixed dye.
- Finally the fabric is dried with a stenter.

Steaming of prints

Two types of steamers are commonly used:

- batch steaming with a ‘star’ steamer
- continuous steaming.

Batch steamer

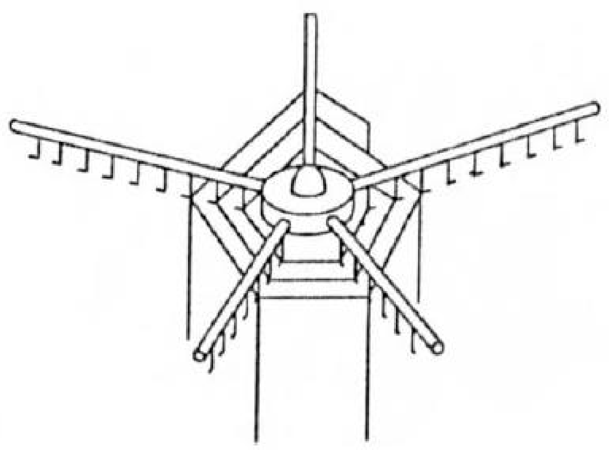
Continuous steamer

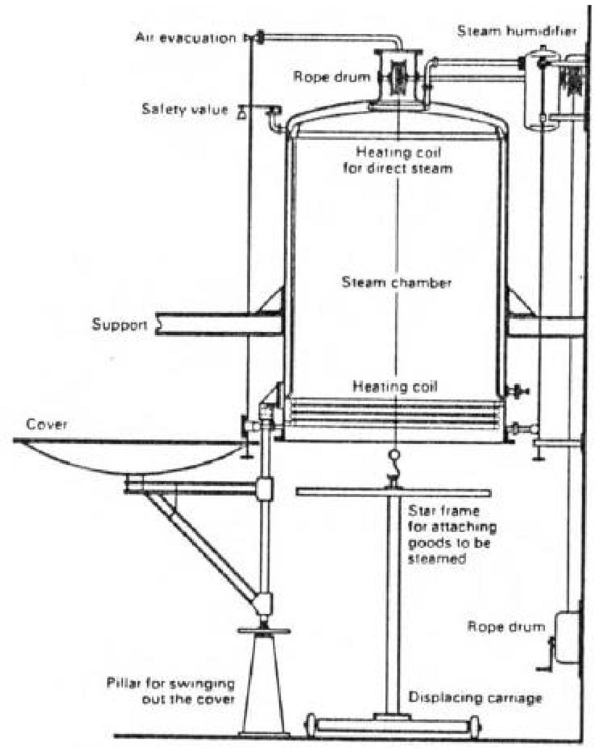
Star steamer

This type of steamer is suitable for short lengths of fabric, such as are printed with flat screens, and also for samples.

Loading the machine is labour intensive. Fabric is wound onto a frame and held with hooks so that successive layers are not in contact.

The steaming vessel is the shape of an inverted cup and this is either lowered over the frame holding the fabric or the frame is raised into the steamer from below.

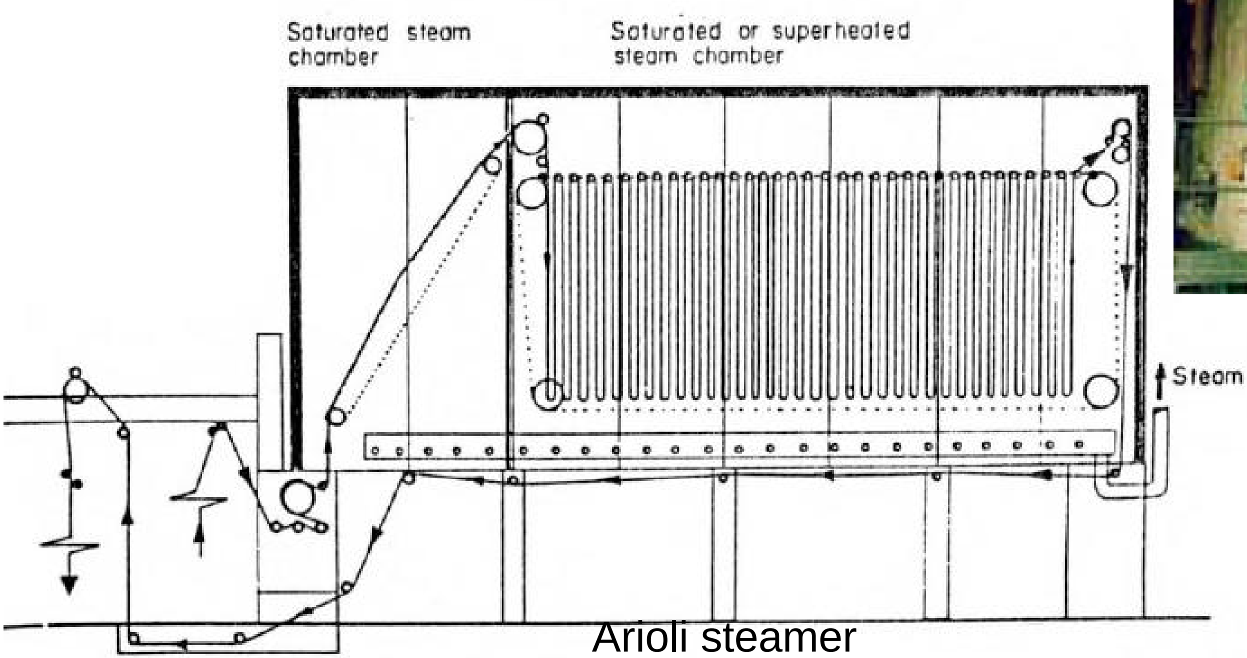




Continuous atmospheric steamer

Continuous steamers are particularly suitable for continuous printing methods such as rotary screen printing and automatic flat screen printing.

Fabric is fed to the printer in open width and automatically festooned inside the steam chamber.



Arioli steamer

Steaming

- When cool fabric enters steam-laden hot air, steam condenses on the fabric, releasing *latent heat of condensation.* This released heat needs to be lost if the fabric is to reach equilibrium with a saturated steam atmosphere. Heat is lost by evaporation of minute water drops suspended in the steam inside the steamer.
- In fact, the moisture content of the steam needs to be carefully controlled because too much free water in steam produces blurring of prints.
- Steam supplied to machines is usually under pressure (at say 130 kPa and 125°C) and contains little water vapour, although it may be close to saturation. When this steam is passed through valves into a steamer at atmospheric pressure, the steam expands and drops in temperature but the steam will be no longer be saturated and will be superheated. This steam will only become saturated, and its temperature reduced to 100°C, if free water is available to remove excess heat by evaporation. This is why steamers for wool need to be fitted with saturators to condition the steam and in addition to provide some atomised water in the steam before it comes into contact with fabric.

Stork HS4 universal steamer

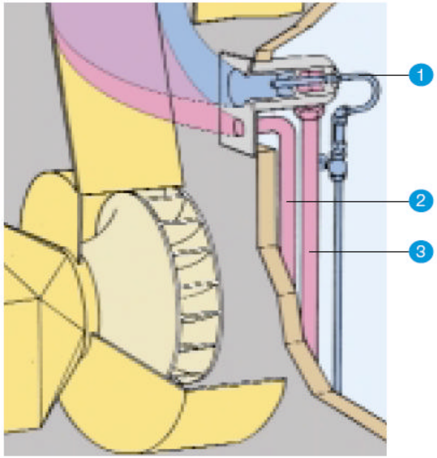
Well designed steamers always have systems fitted to ensure that a controlled amount of atomised water is present in the steam at 100ºC.

The HS 4 achieves steam at the optimal conditions for fixation of dyes on wool by circulating and cooling the steam.

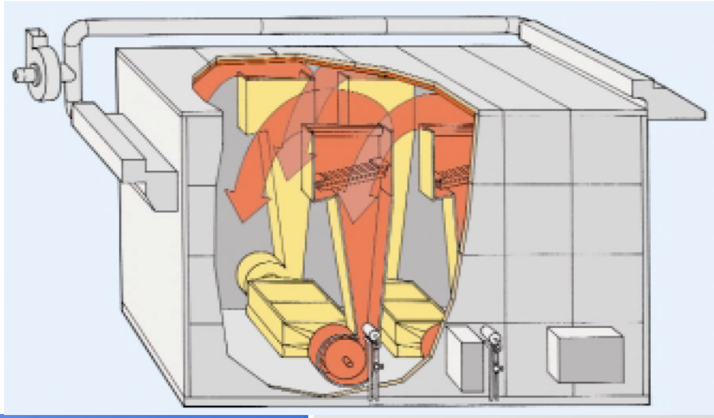
Steam is cooled by injecting finely atomised water into steam using a venturi system.

A proportional control system continuously measures the temperature inside the steamer and controls the water supply.

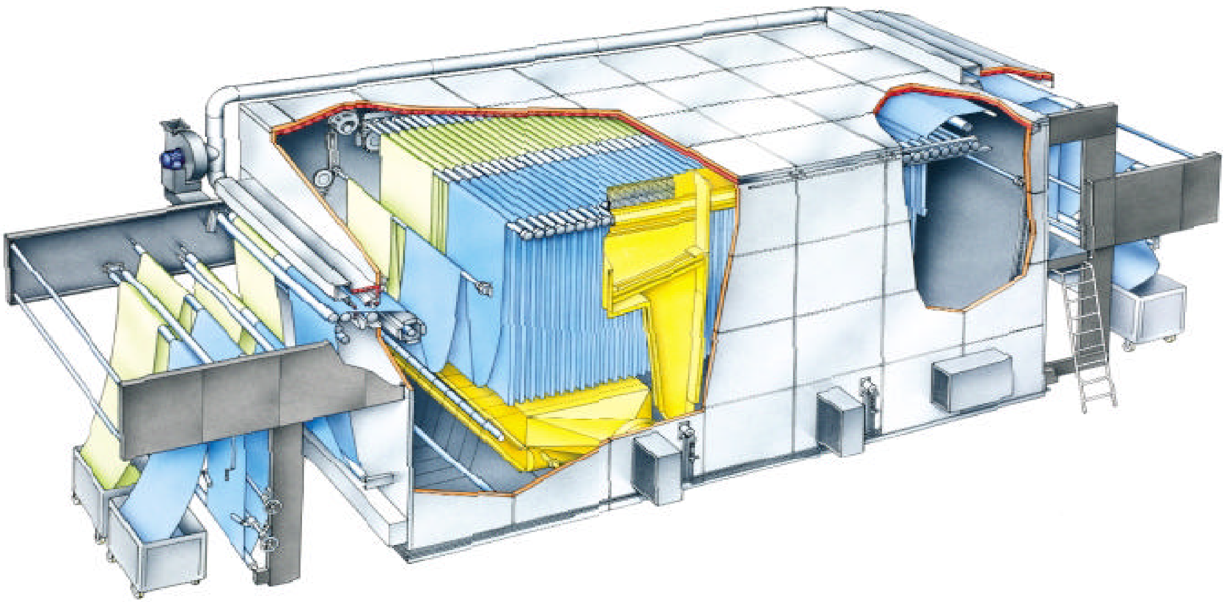
The steam temperature can therefore be kept at a constant level with minimum steam consumption.



1. Water injection
2. Steam refreshment pipe
3. Steam reconditioning pipe



Stork HS4 universal steamer



Fabric is festooned in the steamer and steam saturators and a circulation system are incorporated.

2.e Aftertreatment

Washing off

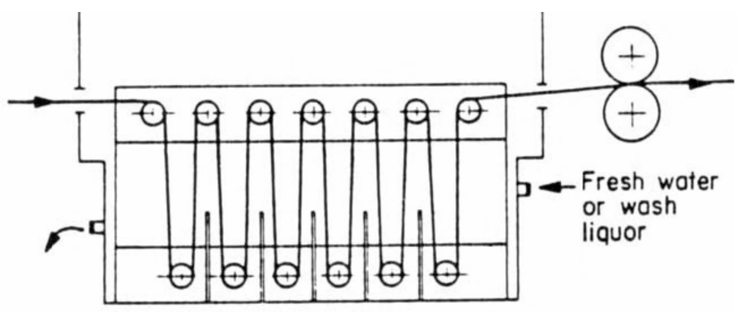
- Short lengths of fabric are often washed off in batch form using rope dyeing machines. Mild alkaline conditions (0.5 g/l ammonia) are used and auxiliaries are usually added to the wash liquor to reduce cross-staining.

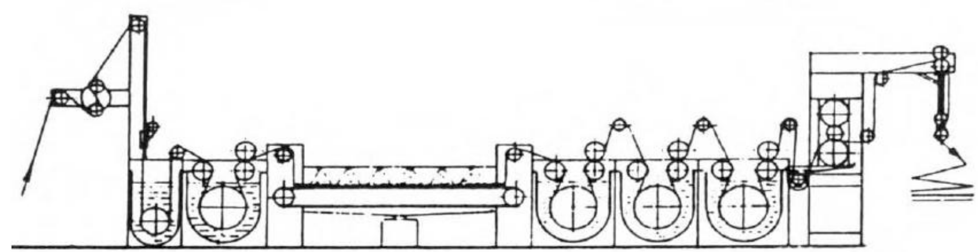
- Auxiliary products that improve the wet fastness of acid dyes on wool such as a sulphonic acid condensation product (e.g. Mesitol WLS (Bayer) or Erional NWS (CG)) can be applied at 60°C in an acidified final rinsing bath after washing off.

- Finally the fabric is hydroextracted and dried in a stenter.

Washing off

- For long runs, continuous washing ranges are more economical as far as in water consumption, energy, and labour costs are concerned.
- The first bowl consists of a cold rinse with overflow to remove much of the loose thickener and dye. Anti-staining agents may also be added (e.g. Albigen A, BASF).
- Subsequent bowls are heated to around 50°C and counter current flow is used.
- The last bowl can be used to apply an auxiliary product to improve the wet fastness of acid dyes on wool (e.g. Mesitol WLS (Bayer) or Erional NWS (CG)) at 60°C at pH 4-5.
- Finally the fabric is squeezed and dried in a stenter.





3. Styles

Printing styles

- **Direct prints -** colourant is applied directly to the surface of a white or previously dyed fabric. It is the largest category of printed fabrics.
- **Discharge prints -** a discharge paste is applied to remove color from localised areas of the fabric to create the design.
- **Resist prints -** a substance is applied to prevent colouration in the areas to which it is applied.
- **Illuminated discharge and resist prints -** an impervious colourant is applied to the discharged or resisted area together with the discharge/resist agent.
- **Burn-out prints –** one fibre of a blend is dissolved to give a translucent effect.

Discharge prints

- Discharge prints **have a dark background** (such as black, navy, or maroon), widely spaced motifs, and a rich, vibrant, expensive look.
- The fabric is first piece dyed then a **discharge paste is printed onto the fabric**. **This paste contains sodium or zinc sulfoxylate formaldehyde (Decrolin, BASF)**, which reduces the dye on the fabric, causing the dye to lose its colour.
- Thus, **the final fabric is not coloured in areas where the paste comes into contact with the dye**. If the discharge paste also contains dyes, usually specially selected dyes that are not destroyed by reduction, then **a coloured motif results because the colour-destroying chemical removes the previously dyed background colour while the illuminating dye colour is simultaneously printed**.
- The fabric is subsequently steamed at 100°C, washed off and dried.

Discharge prints

- Discharge prints are not widely found.
- Production is more costly than for blotch prints because it is necessary to dye the fabric prior to printing.
- The process is long and must be carefully and precisely controlled. Improper discharge procedures result in either poor colour removal, poor shades, or weakening of the fabric in the patterned areas.
- In recent years, blotch prints that rival discharge prints in vibrancy have become available through the use of automatic and rotary screen methods.

Resist printing

- This style produces patterns of white or of a contrasting colour on a dyed ground.
- The pattern is printed on to undyed fabric using substances that prevent dye uptake in the printed areas during subsequent piece dyeing or overprinting.
- Resist and discharge prints have a similar appearance, but resist printing can use faster dyes than the dischargeable dyes used in discharge printing.
- Resist print pastes for wool usually contain sulphamic acid or sulphonated derivatives, Thiotan WS or Sandospace R or S.BASF Reactive Resist Agent liquid. These prevent the uptake of anionic dyes in the printed areas.
- Continuous dyeing with pad application of the ground shade after resist printing involves less contact time of dye liquor with the resist agents than during batch dyeing. In general, resist styles are not commonly used on wool.

Burn-out (devoré, etched or pattern-milled) prints

- Burn-out prints, result from the **destruction of some of the fibres in the fabric by a chemical printed onto certain areas, often from a colourless paste**.
- On flat fabrics, some areas of the fabric become more translucent than others. On pile fabrics, a raised design on a sheer background is produced.
- Suitable fabrics contain a **blend of two types of fibres**, one of which is resistant to the printed chemical and the other is destroyed by it.
- A suitable concentration of sulfuric acid in a print paste, will destroy (dissolve) cellulosic and nylon fibers but leave most other fibres (including wool) unaffected.
- On the other hand, wool can be dissolved with a print paste containing urea and sodium hydroxide, while cotton and polyester are unaffected.

Summary of burn-out printing

1. Prepare blend fabric:
   - scour, heat set or steam set
   - fabric may be dyed, sometimes with different colours on the two types of fabrics.
2. Print with paste containing:
   - dyes (optional depending on the desired effect)
   - burn out assistants:
     for cotton and nylon - sulphuric acid
     for wool - sodium hydroxide
     for cellulose acetate - acetone
   - thickener, as for conventional prints but must be stable to the dissolving agent.

1. Dry.
2. Steam under saturated conditions for up to 30 minutes to damage fibre to be dissolved.
3. Wash out the damaged fibre and dry.

4. Transfer printing

Transfer printing

This is any process by which a print on another medium such as paper is transferred to a textile. There are several ways of doing this:

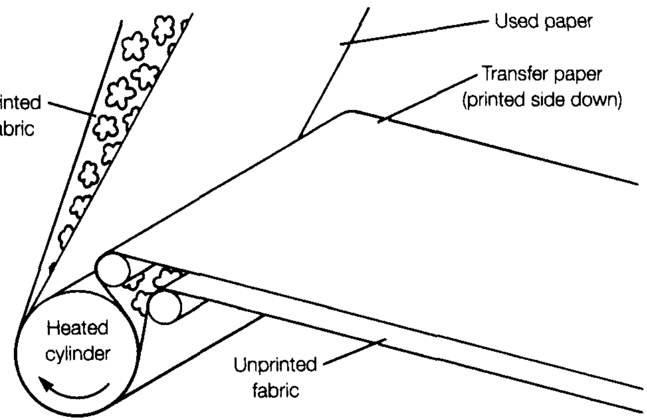
1. **Melt-transfer:** Melt-transfer was originally used to transfer embroidery designs to fabric from a paper by hot pressing. Melting of waxes or polymers in the design causes transfer of the design.
2. **Film-release:** A film layer containing the colour design is transferred completely from a release paper to the textile substrate during heating. On heating, the design film develops a surface tack that provides stronger adhesion to the fabric than to the release paper.
3. **Semi-wet processes:** Water-soluble dye printed on paper is transferred to a water-based paste previously padded on to framed garments made from chlorine-Hercosett treated wool, while heat and pressure are applied. The Fastran process by Dawson international was used for wool.
4. **Sublimation transfer printing:** Dye in the printed design on paper is volatilised by heat and absorbed by the textile material with which it is in contact. Conventional acid, premetallised and reactive dyes for wool do not sublime, making this printing methodology unsuitable for the printing of wool.

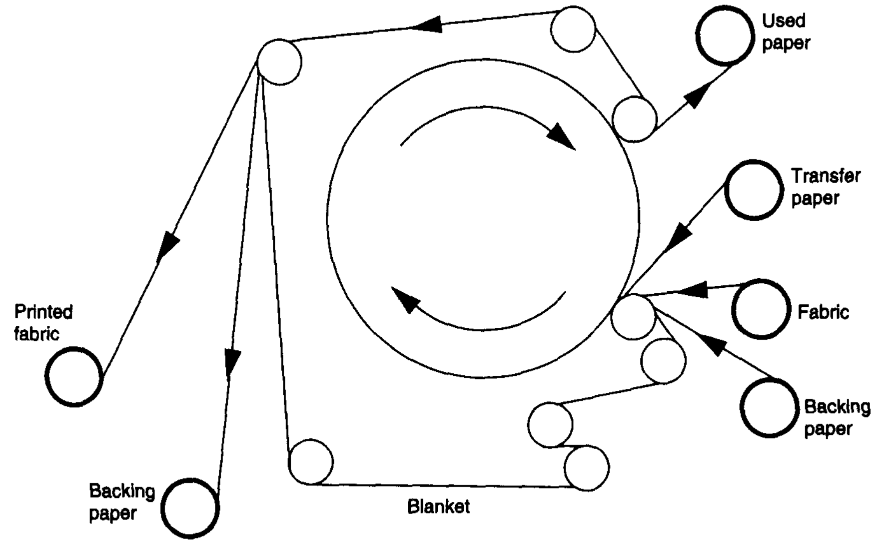
In spite of substantial research efforts, to date there is no viable way of transfer printing wool fabrics to achieve commercial quality. Thus we will not discuss this method printing further in this lecture.

Heat transfer printing

- Heat-transfer printing, also called sublimation printing, or Sublistatic printing was developed in France in the late 1960s.
- Designs printed on paper were transferred to fabric using a heated press or calender.
- The designs were printed with selected disperse dyes using any suitable printing technique.
- The disperse dyes were capable of vaporising from the paper under the heating conditions used and the dye vapour was rapidly taken up by synthetic fibres which were close to their glass transition temperatures under the conditions used.
- This process was found to be ideal for printing polyester fabrics, especially circular polyester knits. However the process is not suitable for wool.
- Currently, less than one-tenth of all printing is by heat transfer.

Heat transfer printing



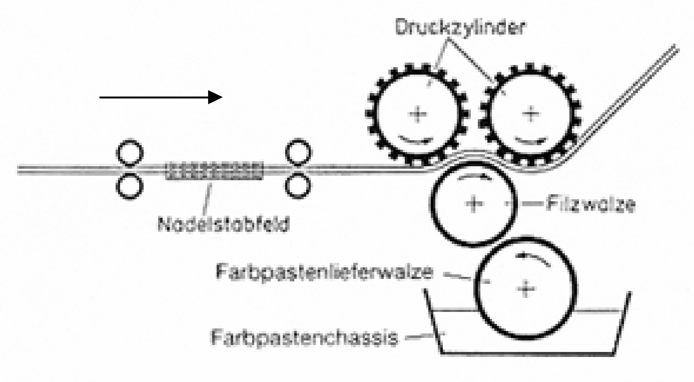


Fabric and printed paper are held together by a blanket under light pressure as they pass around a heated drum at 180 - 220^{o}C. The contact time is around 30-60 seconds.

5. Vigoureux printing

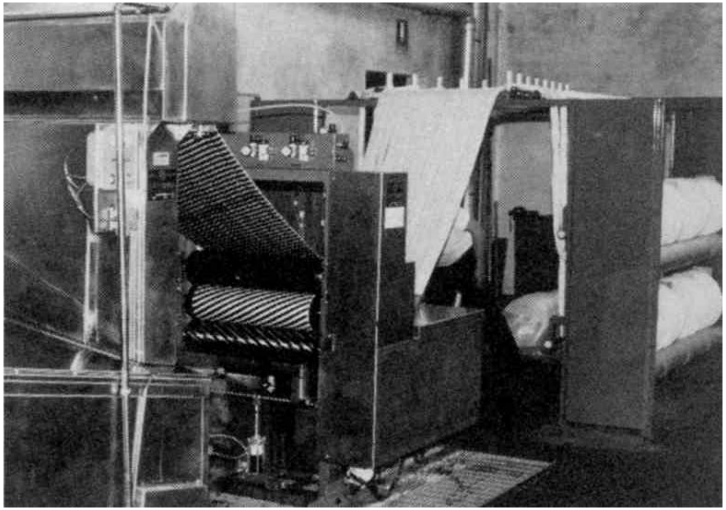
Vigoureux printing

- This process produces very even mixture effects superior to those obtained by blending differently coloured tops.
- Bands of thickened dye paste, with intervening blank areas, are printed across a web made from gilled tops.
- The process was patented in 1863 by Jacques Stanislas Vigoreux of Reims.
- In the printing head, dye paste is transported from a trough to a felt-covered bowl by means of a rubber-coated dipping roller. The raised bars of the printing roller (engraved roller), which is placed above the bowl, pressed the sliver against the felt-covered roller carrying the dye. The dye paste impregnates the sliver only at these points of contact.
- The printed sliver is either coiled into perforated cans or plaited onto pallets.
- The wool is subsequently steamed in an autoclave, washed, and re-combed to produce a very even mixture of dyed and undyed lengths of fibre.



Vigoureux printing

- A new system, known as Siroprint, was developed by CSIRO, Division of Wool Technology (Australia) and has been commercialized by OMP, Bodega, Italy.
- The new printing head eliminates the need for pre-gilling of slivers and prints are made directly from a gravure roller, thereby avoiding the need for a felt-covered roller.
- This has led to improvements in production speeds, shade reproducibility and shade matching.
- Use of the Sirosteam steamer gives a completely continuous process, and the printed and steamed tops can be fed directly to a backwasher.
- The Sirosteam atmospheric steamer is suitable only for metal-complex, milling or reactive dyes. For chrome dyes, batchwise autoclave steaming is required.



SIROPrint and SIROSteam

6. Space dyeing

Space dyeing of yarn

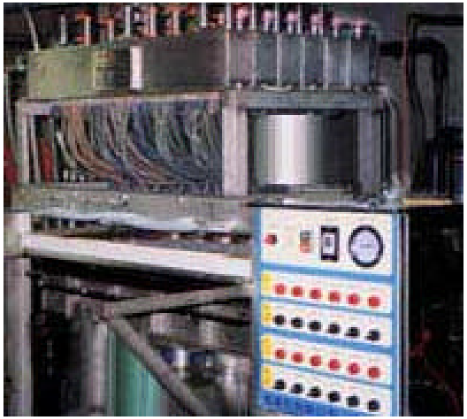
Certain space dyeing methods can be classified as printing in that the aim is to produce a patterned, or random coloured effect, on textile yarn rather than fabric.

Hank spray

Hanks of yarn (undyed or dyed to a ground shade) are placed on a conveyor and sprayed with up to four colours of dye liquor. The hanks are then steamed continuously at atmospheric pressure for 9-12 minutes. After steaming the hanks may be washed off in a tape scour and dried (e.g. Superba, SWA, Techno Roma, Texinox).

Knit-de-knit

Yarn is knitted into fabric (tubular or flat sheet) then optionally, a ground colour may be applied by pad mangle then colours are printed by profiled rollers or computer controlled spray jets. The fabric is then steamed to fix the dyestuffs, washed, dried deknitted and wound onto a cone (e.g. Fleissner, Lawer, Superba, TAG).



Jamerry (Taiwan) hank space dyer

Space dyeing of yarn

Yarn Form	Coloration Method	Company	Colour length	No. of colours*
Hank	Spray dye Spray dye Spray dye Dip dye Dip/steam	SWA Texinox Tecno Rama - -	long long long long long	4-6 4-6 4-6 4-6 4-6
Package	Injection Injection Dip	Astro Dye Tecno Rama -	med-long med-long long	4 4 2
Package-to-package (yarn coils)	Spray	Superba	very short-medium	3
Warp sheet	Roller Roller	Lawer Superba	short-medium very short-medium	? 4
Knitted fabric	Roller	TAG Fleissner	short-long	3-4

7. Jet printing

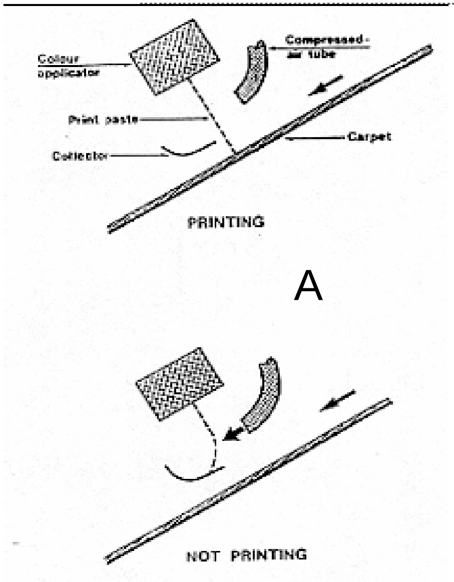
Ink jet printing

- This was first introduced for carpets where only low resolution prints are required.
- As ink jet printers have developed for paper printing, textile machines have piggybacked on the technology.
- The main difference between printing textiles and paper is that greater quantities of ink are needed for textiles.
- The resolution of printing on textiles is lower than paper and ultimately related to the surface structure.
- In principle, jet printing could replace any direct printing method with any type of dye or pigment.
- The method has the advantage that it does not require contact with the textile surface.
- Because of the high resolution possible, discharge and resist printing may become redundant.

Jet printing on carpet

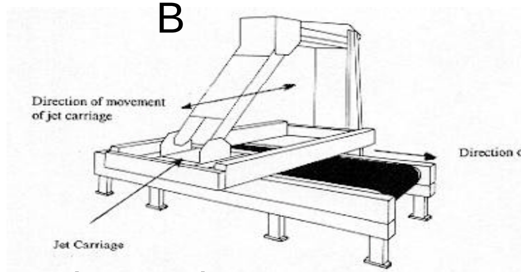
- This continuous method for patterning carpets was introduced in the late 1970s.
- The machines were based on drip-dye methods in which drops or streams of dye paste were directed onto the carpet using hydraulic valves or mechanical applicators under automatic control.
- After printing, the carpet was continuously steamed and dried.
- Random or simple-design repeat patterns of variable sizes were be obtained in several colours.
- Printed carpet only has appeal in the cheaper sector of the carpet market.

Jet printing on carpet



A

B



C

A - Chromojet carpet injection printing machine.
B - Millitron computer injection dyeing machine.
C - Fleissner carpet printer.

These are some typical continuous jet printing machines for carpet. Similar machinery is also manufactured by Godfrey Hirst, Australia (Titan), Otting International, USA, and ETF Machinefabriek, Netherlands (tiles only).

Printing wool

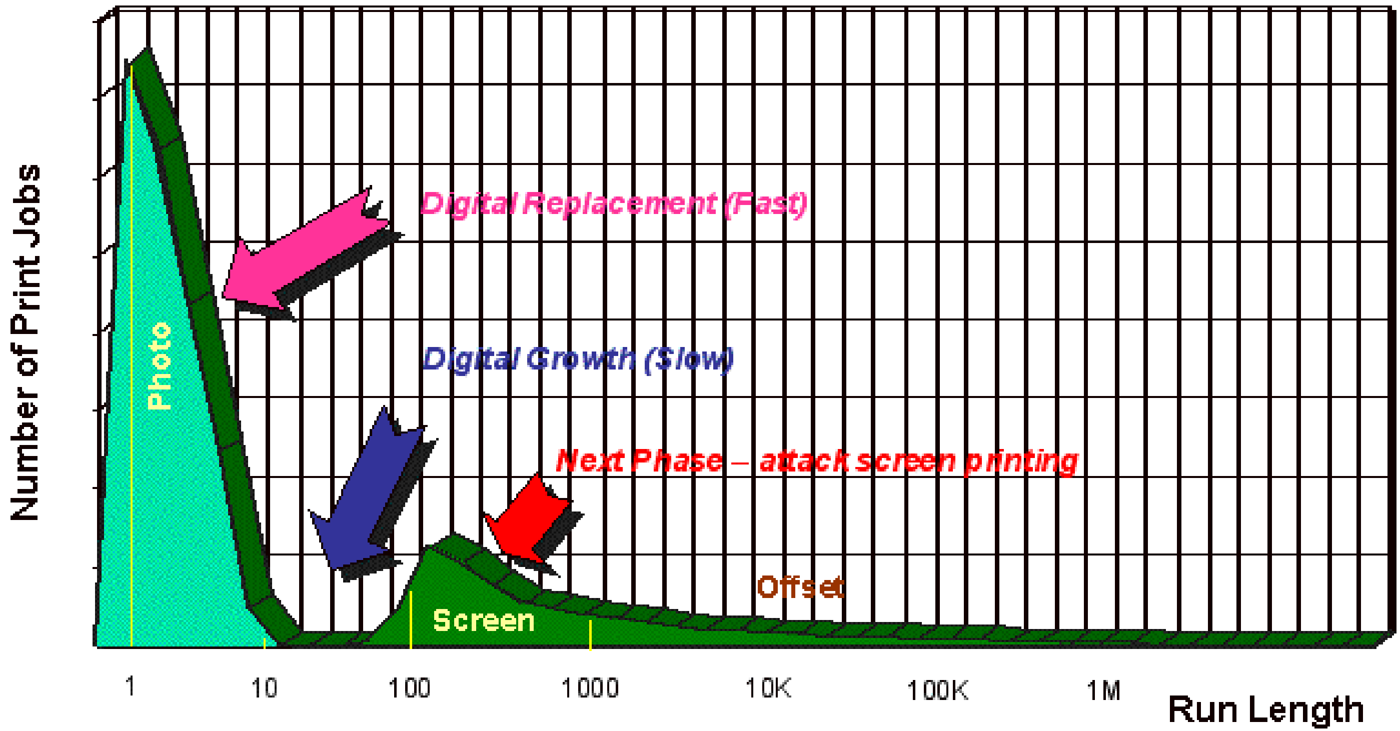
- Printing of wool fabrics is a costly process, especially for short runs.
- Screen printing has been the method of choice for printing on wool fabrics. However, major costs are incurred in setting up screens and equipment for printing and this has limited printing on wool because the long runs required are not generally available.
- Additional costs are incurred in printing wool because it must be pre-treated before printing, prints need to be fixed by steaming under saturated conditions and the fabric must be washed off and dried.
- All these factors conspire to confine printed wool to products to low volume, high fashion, sectors of the market. However, the situation has changed very recently because of the availability of new technology.

High-resolution ink-jet printing

- Digital printing uses a computer to control a series of ink-jets in a printing head that traverses across the width of the fabric as the fabric moves intermittently forward underneath the printing heads.
- Patterns can be made and transmitted as electronic data using computer-aided design systems. Patterns can be loaded, modified and duplicated swiftly and easily.
- Ink-jets operate using two technologies:
  - drop-on-demand, usually with piezo heads
  - continuous ink-jet.
- Resolutions of greater than 600 dots per inch are obtainable. This makes photographic quality prints on suitable fabrics a reality.

There is plenty of potential for digital printing to move into the screen printing market for printing short fabric lengths.

Digital Penetration of Graphics Market

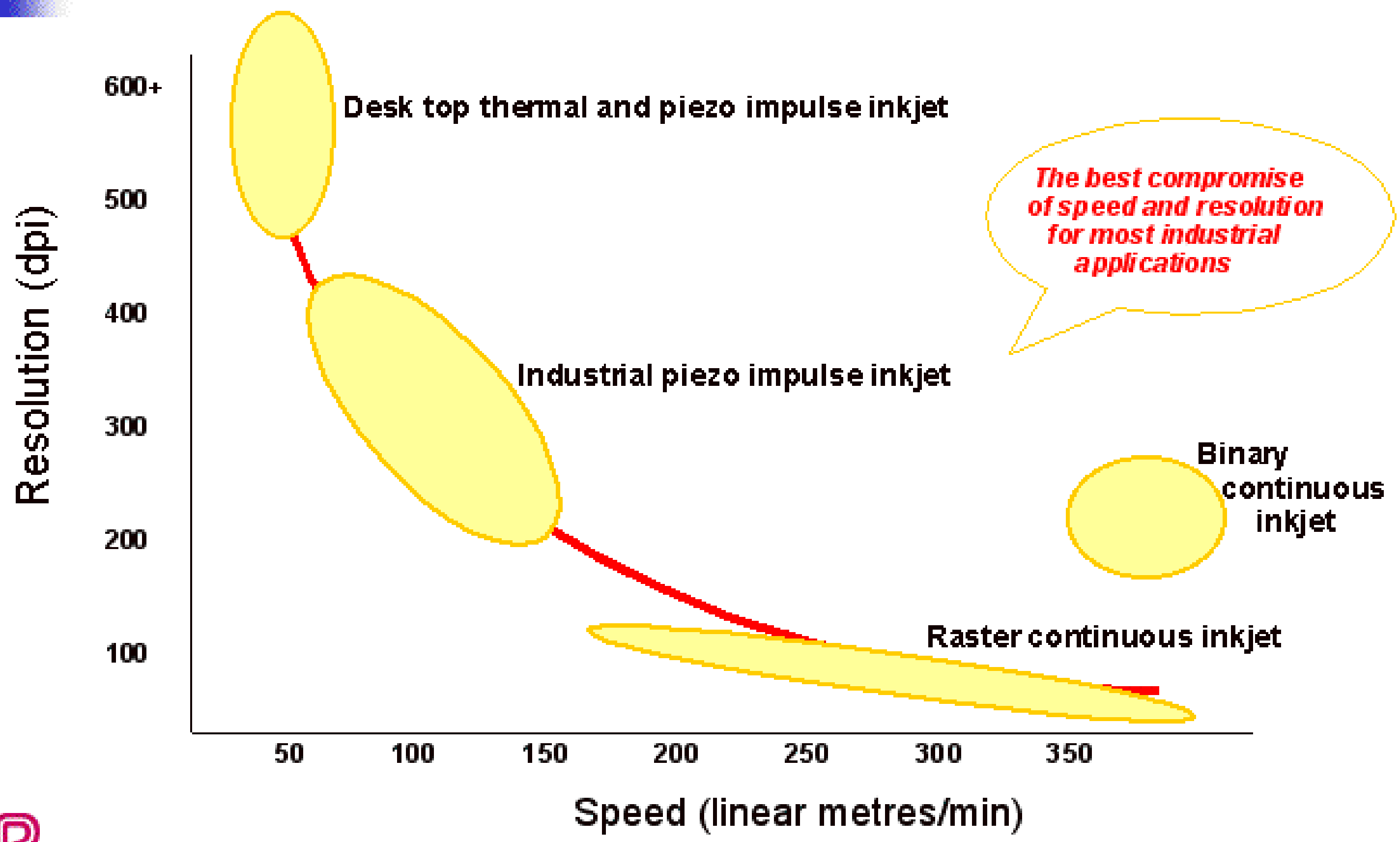


Markets for Digital Textile Printing

- Carpets / Carpet Tiles (Milliken, Zimmer)
- Sampling & Proofing (Stork, Iris, Epson, Mimaki)
- Outdoor Banners (Mesh) & Building Wraps
- Scarves & Ties (Mimaki, DGS, Sophis)
- Garments (T-shirts, Sportswear, Sportsgear)
- Short-run Apparel Printing
- Theatre Backdrops, Canvas/Mesh (NUR, Vutek, Scitex)
- Automotive Fabrics (Seiren)
- Flags & Banners (Color Wings, Xerox, Gretag, Zimmer)

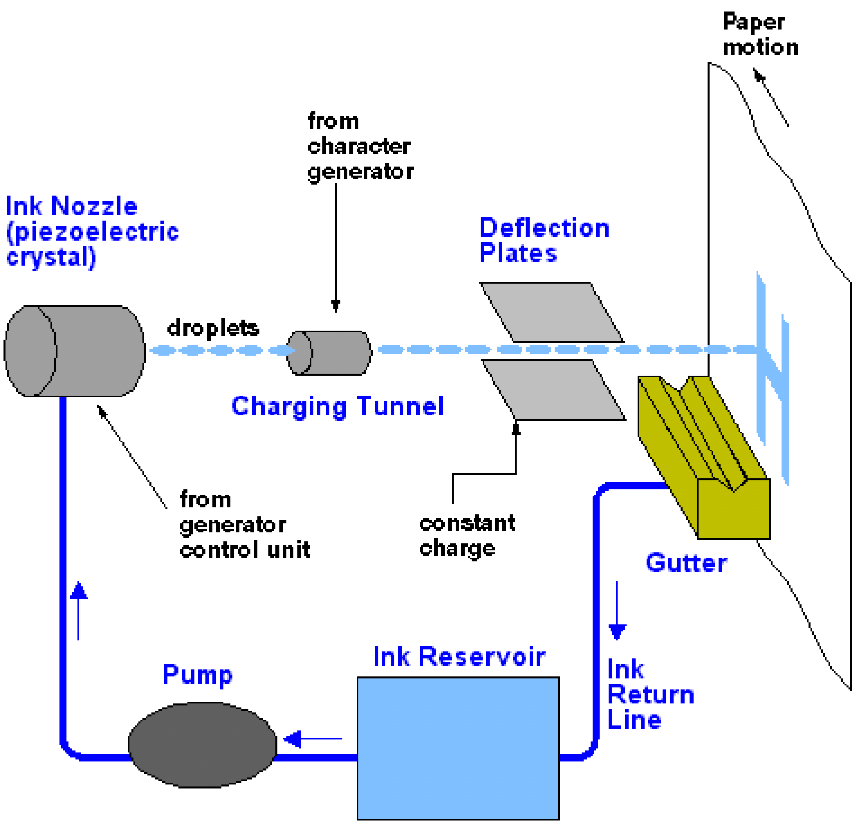
Piezo jets appear to be best, at present, for fabric printing in the fashion market.

Speed vs. dpi Resolution

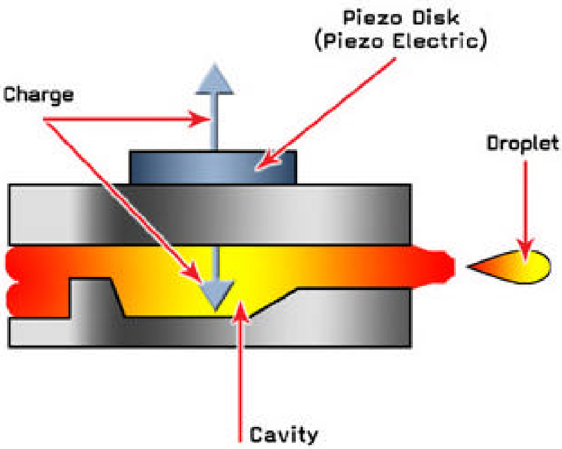


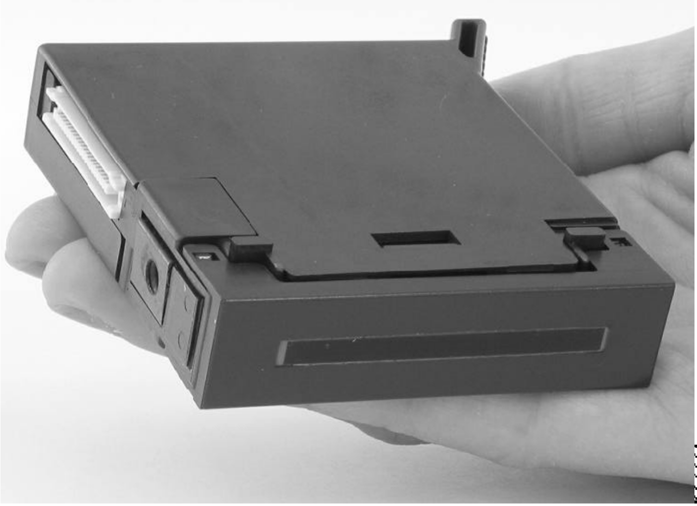
Continuous ink jet print head

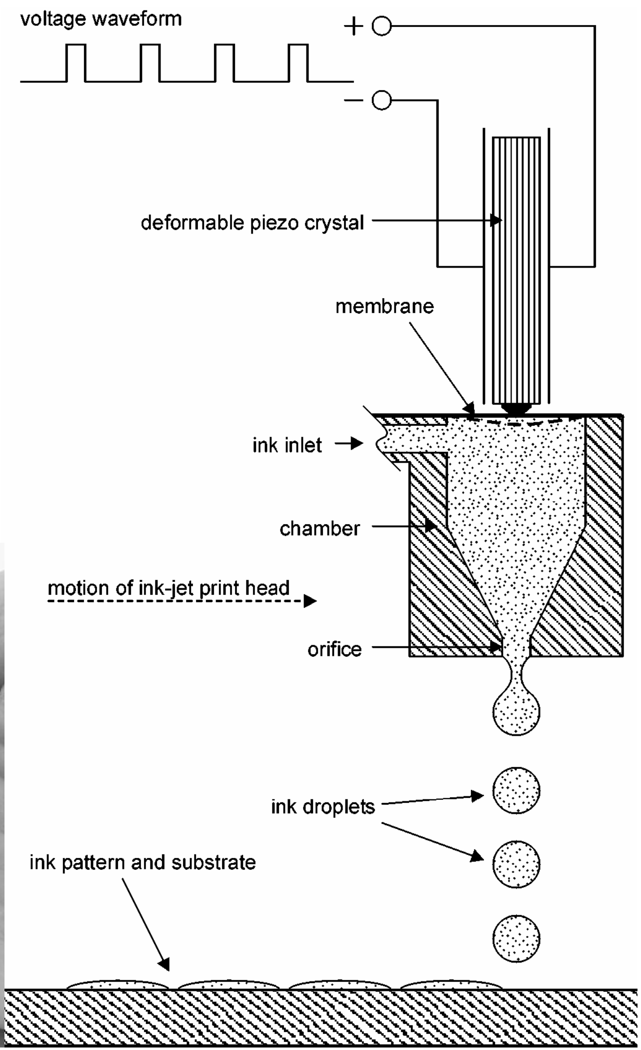
This method sprays continuous droplets of ink that either reach the paper or wind up in the return gutter. The nozzle uses a piezoelectric crystal to synchronise the chaotic droplets that arrive from the pump. The charging tunnel selectively charges the drops that are deflected into the gutter. The uncharged droplets make it to the paper. The diagram depicts a single nozzle.



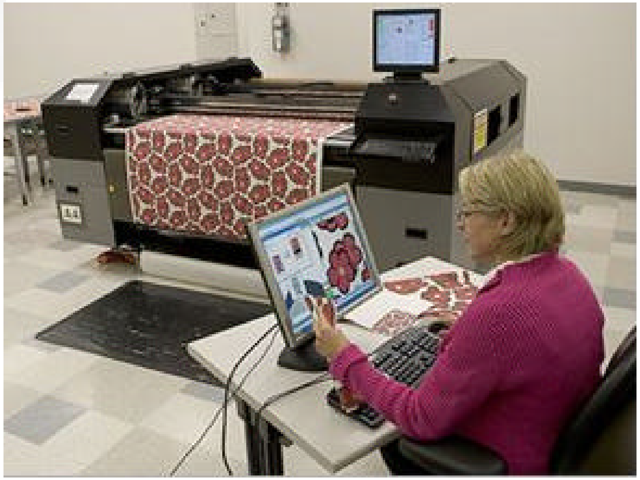
Drop on demand piezo print heads







Dupont Artistri digital jet printer



Digital jet printers

Mimaki TX2 (Mimaki)

Ichinose 2020
(DuPont and Toshin Kogyo)

Reggiani DReAM digital printer

DReAM Specifications

- Printable width - 1,800 mm maximum (71 inch
- Material width - 1,850 mm maximum (73 inche
- Number of print heads - 16
- Printhead type - drop-on-demand piezo
- Ink capacity - one litre per print head; two litres per colour
- Ink types - acid dye, reactive dye, disperse dye and pigment
- Ink delivery system - one litre sealed cartridges

Print speed and resolution

Resolution (d.p.i.)	High speed (sq. m/hr)	Standard interlacing (sq. m/hr)	Highest quality (sq. m/hr)
360	66	45	23
540	44	30	15
720	33	22	11

Inks for high resolution jet printing

- Most major dye makers now supply specially formulated inks for different types of print heads.
- Inks can contain pigments, dyes or resist agents, depending on the textile to be coloured.
- Colourants are fixed using a method appropriate for the fibre.
- In the case of wool, best results are obtained on pretreated (oxidised) fabric.
- Prints on wool are fixed by steaming after printing, and washed off, as with other direct printing methods.

Inks for the DReAM printer

From Ciba Specialty Chemicals. These inks have been developed specially for use with the Aprion inkjet heads of the DReAM printer:

- CIBACRON RAC, for cellulose fabrics, ensure high application performance and bright shades
- LANASET RAC inks, for polyamide, silk and wool fibres, TERASIL RAC disperse inks, for polyester and transfer printing
- TERASIL RAC TOP disperse inks, for direct printing of polyester apparel and auto motive products
- IRGAPHOR RAC pigment inks, suitable for all fabrics.

Digital printing inks from DuPont

Printer Type	Compatible Ink Type	Recommended or Potential Fabric Type	DuPont™ Artistri™ Ink Chemistry
DuPont™ Artistri™ 2020 Printer	DuPont™ Artistri™ 700 Series Ink	Nylon, Nylon/Lycra®, Silk, Wool	Acid Dye Ink
		Polyester, Nylon*, Nylon/Lycra®*	Disperse Dye Ink
		Cotton, Polyester*, Cotton/Poly Blends*, Viscose/Rayon*, Linen, Nylon*, Nylon/Lycra®*, Silk*, Wool*	Pigment Ink
		Cotton, Viscose/Rayon, Linen, Nylon*, Nylon/Lycra®*, Silk*	Reactive Dye Ink
		Solarmax™	Solarbrite Ink
Mimaki TX 1600, TX2, DGS, Roland, Epson	DuPont™ Artistri™ 500 Series	Nylon, Nylon/Lycra®, Silk, Cotton Cotton/Poly Blends, Wool, Viscose/Rayon, Linen	Acid Dye
		Cotton, Poly, Cotton/Poly Blends	Pigment

Inks for DReAM

Ciba® CIBACRON® RAC
Reactive range for inkjet printing on Reggiani DReAM industrial textile machine

- Yellow RAC-100
- Orange RAC-300
- Red RAC-500
- Light Red RAC-550
- Blue RAC-600
- Turquoise RAC-700
- Light Turquoise RAC-750
- Black RAC-900

Ciba® LANASET® RAC
Acid range for inkjet printing on Reggiani DReAM industrial textile machine

- Yellow RAC-100
- Orange RAC-150
- Red RAC-300
- Light Red RAC-350
- Blue RAC-400
- Turquoise RAC-500
- Light Turquoise RAC-550
- Black RAC-700

Ciba® TERASIL® RAC
Disperse range for inkjet printing on Reggiani DReAM industrial textile machine

- Yellow RAC-100
- Orange RAC-200
- Magenta RAC-300
- Light Magenta RAC-350
- Blue RAC-400
- Cyan RAC-500
- Light Cyan RAC-550
- Black RAC-700

Pigment inks are in development

Ciba

Jet printing inks

Ciba® CIBACRON® MI
Reactive inks for inkjet printing on Cellulosic fibers/silk

- Yellow MI-100
- Golden Yellow MI-200
- Orange MI-300
- Red MI-400
- Red MI-500
- Blue MI-600
- Turquoise MI-700
- Gray MI-800
- Black MI-900
- Strong Black MI-950

Ciba® LANASET® SI- HS
Acid inks for inkjet printing on Silk/Polyamide/Wool

- Yellow SI-100
- Orange SI-150
- Red SI-200
- Red SI-330
- Blue SI-400
- Turquoise SI-500
- Gray SI-600
- Black SI-710

Ciba® IRGAPHOR® TBI-HC2
Pigment inks for inkjet printing on all fibers (Piezo only)

- Yellow TBI-120HC2
- Red TBI-350HC2
- Magenta TBI-380HC2
- Navy TBI-450HC2
- Cyan TBI-580HC2
- Green TBI-650HC2
- Gray TBI-700HC2
- Black TBI-850HC2

Ciba® TERASIL® TI
Disperse inks for transfer inkjet printing on Polyester

- Yellow TI-1000
- Orange TI-2000
- Red TI-3100
- Red TI-3200
- Turquoise TI-4000
- Blue TI-5000
- Blue TI-5500
- Black TI-700

Ciba® TERASIL® TS
Disperse inks for inkjet printing by transfer or direct onto polyester fabric

- Yellow TS-4100
- Orange TS-4200
- Magenta TS-4300
- Light Magenta TS-4350
- Blue TS-4400
- Cyan TS-4500
- Light Cyan TS-4550
- Black TS-4700

Launch Q4 2005

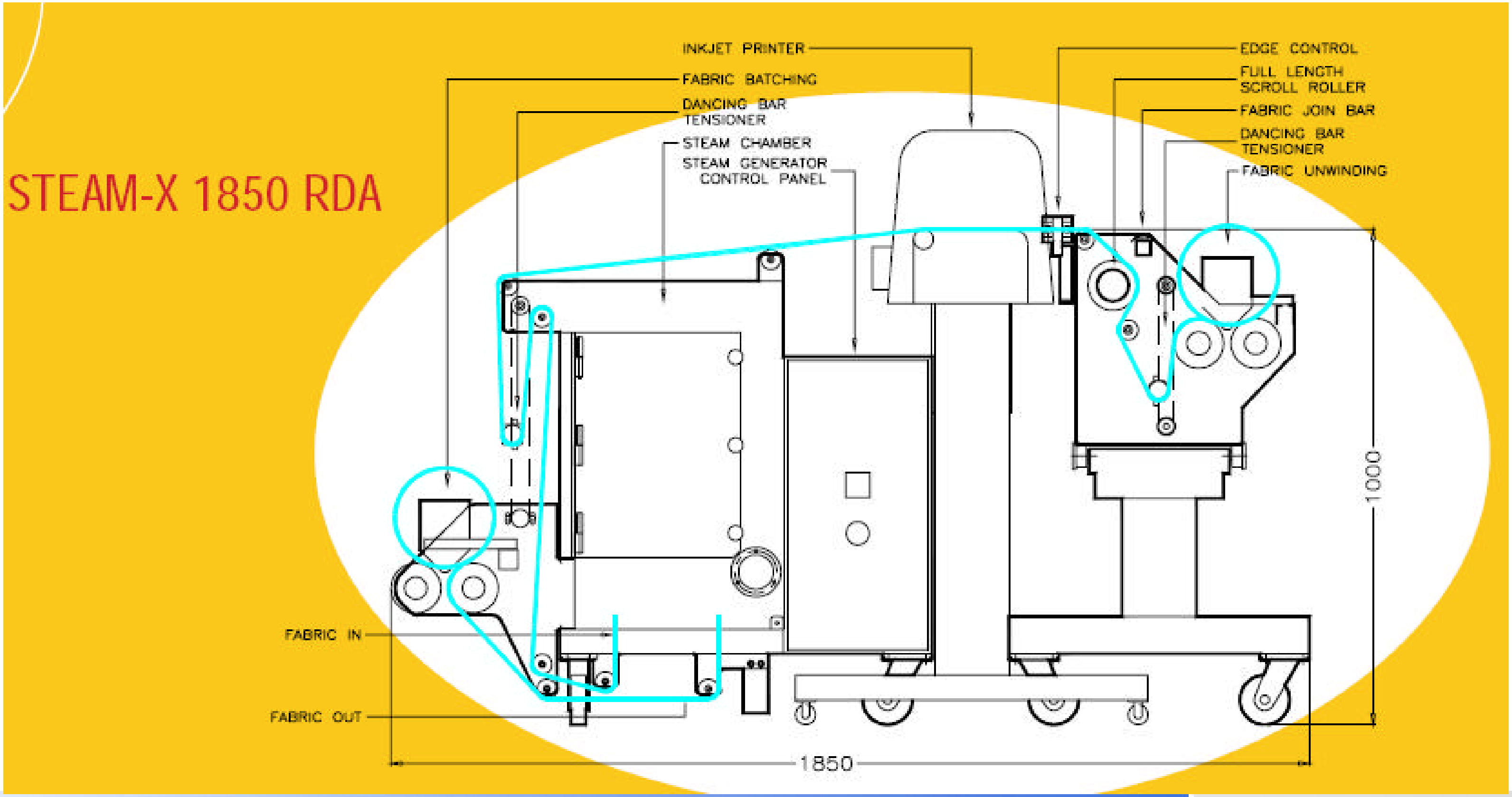
Ciba® TERASIL® DI HL
Disperse Inks for inkjet printing on Polyester for Fashion & high light fastness applications

- Yellow DI HL-5100
- Bright Yellow DI -5110
- Golden Yellow DI-5120
- Red DI HL-5200
- Pink DI HL-5300
- Violet DI HL-5400
- Navy DI-5450
- Blue DI HL-5500
- Green DI HL-5600
- Gray DI HL-5700
- Black DI HL-5800

New for PES Fashion, Automotive & Home Furnishing

Ciba

Stork digital printer and Rimslow STEAM-X 1850 SDA steamer



Rimslow STEAM-X 1850 RDA (Stork) steamer for digital printing

Digital print washer

The Rimslow Wash-X designed for digital printers washes and dries fabric continuously from roll to roll.

Rimslow digital printer and steamer

Operating parameters

	Units	Natural Fibre (reactive Dyes)	Silk (Acid Dyes)	Polyester (Disperse Dyes)
Fabric Maximum width	mm	1830		
Steaming Temperature	C	102		175
Maximum Speed	m^2/hr	44	22	110
Steaming time	min	15	30	6
Fabric length inside the Steamer	m	6.0		
Machine Length	m	2.0		
Machine Width	m	2.5		
Machine Height	m	1.3		
Water Tank Capacity	L	20		
Power Consumption	kW	7.0		
Fabric Roll Diameter Max	mm	200		
Fabric Feeder	-	included		

Summary

- Textile fabrics can be printed using a variety of methodologies including block, roller, flat screen, rotary screen, heat transfer and digital. Resist and discharge printing styles may also be used.
- In the case of wool fabrics the most common printing methodologies are flat screen and rotary screen, with digital printing emerging as a prospect for short print runs.
- For the printing of wool with conventional wool dyes (acid dyes, premetallised dyes and reactive dyes) the processing sequence involves seven steps as follows: prepare for print, dry, print, dry, steam, wash-off and dry.
- Clearly the screen printing of wool fabrics is a costly process, especially for short runs. It is not surprising, therefore, that only about one% of wool fabric currently is printed.
- **Digital printing has potential to make wool printing much more economical in short runs**.