

# Digital Textile Printing

## Introduction

Digital textile printing equipment is available since more than 20 years. Today it is the fastest growing segment within textile machinery. Gherzi conducted a global study to identify the main reasons for investments into digital textile printing. The growth still is not driven by direct cost advantages (against traditional textile printing technologies), but by several indirect parameters underlining the advantages of digital textile printing such as a) speed to market b) design flexibility and c) new business models. Further increase of market penetration will also lower direct printing costs and therefore continuously increase the share of digital within textile printing (today ca. 3% volume wise).

## Digital textile printing equipment

Digital textile printing equipment can be segmented into 3 different types of machines:

Machine type	Segment description	Selected leading products		Target applications
1 Class I Class II <b>Plotter</b>	4 – 30 m/h (nominal performance) 30 – 100 m/h (nominal performance) Plotter based	Mimaki Roland Mutoh Epson Vutek (efi)	Hollanders DGI HP & many others	Sampling, transfer print, soft signage, small lots for any kind of printed fabric products
2  Class III <b>Scanner</b>	100 – 400 m/h (nominal performance), industrial production 25 – 200 m/h Scanning printing unit Step wise moving substrate Printing blanket integrated Pretreatment and drying could be added	efi Reggiani Renoir MS JP5, JP6, JP7, JPK Evo Zimmer Austria Colaris SPGPrints JAVELIN Durst Alpha Konica Minolta Nassenger 8/10 Epson Robustelli MonnaLisa Aleph LaForte Mimaki La Meccanica Qualijet Tiger Arioli ArioPrint		Sampling  Small to medium lots production mainly apparel, hometex (large width) but also signage  Transfer print
3  Class IV <b>Single pass</b>	20 – 70 m/min, (1'200 – 4'200 m/h) Printing unit with fixed position Continuously moving substrate Integrated drying unit	SPGPrints PIKE (3 installations) MS Lario (20 installed units 1.8-3.2m) Konica Minolta Nassenger SP-1 Atexco Vega One (1 installation)		Traditional rotary screen products, but also small to medium apparel and hometex products  Large print lots in short delivery times  Transfer print (MS Italy)

Source: Gherzi research

Picture 1: Digital textile printing machine types

**Type 1 - plotter type machines:** based on digital printing equipment originally designed for graphical application. In the field of textiles, they are used for sampling, for transfer print, for soft signage and small lots of any kind of printed fabric products. Production speed is limited, applied inks could be dye based inks (reactive, acid, disperse) but also pigment based inks.

**Type 2 - scanner type machines:** equipped with a printing blanket. It is the most important machine type for textile applications so far, used for sampling, small to medium production lots mainly for apparel and hometex products (widths are available up to 320cm) and also soft signage. Within industrially printed textiles, it is the most spread machine type.

**Type 3 - single pass type machines:** This is the latest type of textile printing equipment which allows (for the first time) production speeds in the range of traditional rotary screen printing equipment. That's a first important comparison parameter to fuel a substitution of traditional textile printing technologies.

Substrates are moved continuously, the position of the print-heads (grouped in printing bars) is stable.

Print quality to be achieved is always depending on the successful combination of substrate, pre-treatment, design, color coverage, ink, print-head, machine, post-treatment and process speed.

### Pre- and post-treatment

Successful digital textile printing still asks for an industrial environment with access to wet- and dry finishing equipment for the pre- and post-treatment. Processes cannot yet be standardized since treatments depend on type of substrates, type of inks, print penetration and type use of the final product. The importance of an adequate pre- and post-treatment and its influence on the print quality is often underestimated by involved parties.

### Inks

Dye based inks dominate digital printing for textile applications, however a pre- and post-treatment is always requested

Ink type		Suitable substrates	Applications	Pro / Contra
Pigments		All type of substrates, including blends	<ul style="list-style-type: none"> <li>• Signage</li> <li>• Flags</li> <li>• Apparel (mainly DTG)</li> <li>• Hometextiles</li> </ul>	<ul style="list-style-type: none"> <li>+ No post washing required</li> <li>+ UV resistance</li> <li>+ Fits to all types of substrates</li> <li>+ No or limited pre-/ post-treatment</li> <li>- Touch &amp; feel issues</li> <li>- Color fastness</li> <li>- Ink cost (50 – 90 US\$/l)</li> <li>- Ink consumption 2-2.5 times&gt;reactive</li> <li>- Quality without pre-/post-treatment</li> </ul>
Dyes	Reactive	Cellulosics, linen (polyamide, silk)	<ul style="list-style-type: none"> <li>• Apparel</li> <li>• Hometextiles</li> </ul>	<ul style="list-style-type: none"> <li>+ Fastness</li> <li>+ Runnability</li> <li>+ Color gamut</li> <li>+ Ink cost (25 – 50 US\$/l)</li> <li>- Substrate pre-/posttreatment</li> </ul>
	Acid	Polyamide, silk, wool	<ul style="list-style-type: none"> <li>• Apparel</li> <li>• Hometextiles</li> </ul>	<ul style="list-style-type: none"> <li>+ Fastness</li> <li>+ Runnability</li> <li>+ Color gamut</li> <li>- Substrate pre-/posttreatment</li> </ul>
	Disperse	Polyester, polyester / cotton blends	<ul style="list-style-type: none"> <li>• Signage</li> <li>• Flags</li> <li>• Apparel</li> <li>• Hometextiles</li> </ul>	<ul style="list-style-type: none"> <li>+ Fastness</li> <li>+ Runnability (direct or transfer)</li> <li>+ Color gamut</li> <li>+ Ink cost (25 – 50 US\$/l)</li> <li>- Substrate pre-/posttreatment</li> <li>- High share of PES needed for blends</li> </ul>

Source: Gherzi research

Picture 2: Digital textile printing ink types

### Print-heads

Currently, Kyocera is the most spread print-head for scanner and single pass type digital textile printing machines. For none of the print-head suppliers, digital textile printing is the key focus of their business activities. Product leadership is fast changing with each new generation of print-head offered for digital textile printing.

Print-heads are perceived as one of the most critical component in a digital textile printing machine. The printing performance of a machine depends on the number of print-heads installed. Life span of a print-head is depending on the quality and type of ink in use, by the

printing machine itself (especially electronics) and the physical construction of the head itself (multiple thin metal layers or solid silicone block). Even with most suitable inks life span of print-heads currently is between one and two years what results in an elevated maintenance and replacing cost. The print quality of a print-head is changing over its lifetime what challenges the print lot allocation to machines in a digital textile printing mill (that's at least the experience of printers having thin layer heads like Epson or Kyocera in use).

Reliability of print-heads is one of the major requests for future improvements in digital textile printing. Machine manufacturers are aware of this issue and partly offer support to their clients to share the risk of failure.

Product	Main features	Printing machines in use	Remarks
Kyocera KJ4B	Resolution: 600 dpi (native) 300 dpi (2 colours) 150 dpi (4 colours) Nozzles: 2'656 Drop size: 5 – 18 pl Firing frequency: 30 kHz	Efi Reggiani, MS, Atexco, La Meccanica (Mimaki), Arioli	Current market leader in terms of quantities (offers different models, also with 2 or 4 color channels)  18 pl drops only up to 20 kHz
Fuji Dimatix Starfire SG1024	Resolution: 400 dpi Nozzles: 1'024 Drop size: 10 – 80 pl Firing frequency: 11 – 50 kHz	Zimmer Austria, Kornit	Zimmer changed from Seiko to Fuji, suitable for large drops (requested for high pile substrates) Former Spectra
Fuji Dimatix Samba	Resolution: 1'200 dpi Nozzles: 2'048 Drop size: 1 – 10 pl Firing frequency: 30 - 100 kHz	SPGPrints, Atexco (1 beta installation in China so far)	Large distance substrate – nozzle Recirculating ink channel
Ricoh Gen 5	Resolution: 150 dpi Nozzles: 1'280 Drop size: 7 – 35 pl Firing frequency: 60 kHz (native)	Durst, Mimaki, Shima Seiki,	9 cm width rel. small size
Konica Minolta KM module	Resolution: 720 dpi Nozzles: 2 x 1'024 Drop size: 7 – 18 – 28 pl Firing frequency: max 30 kHz	Konica Minolta, Luescher-Tschudi	Large size print-head, offers different models, some also offered to other machine manufacturers
Epson T2	Resolution: 180 dpi Nozzles: 1'440, 8 rows Drop size: 3 – 6 pl Firing frequency: 50 kHz	Robustelli Monnalisa (limited number of machines in the market with this print-head type so far)	8 different colors per head

Picture 3: Digital textile printing print-heads

## Print cost calculation

Taking into consideration the pure print cost, digital textile printing in most cases is more expensive than traditional textile printing. The real cost advantage is limited to the fact, that with digital textile printing no screens are needed. Since for every color in use, one screen is needed with traditional textile printing, more colors are used, more attractive the digital printing is in direct comparison with traditional.

With an example of a printed 100% Co substrate, rotary screen printing has cost advantage, the cost structure of digital does not differ strongly in the analysed geographical markets:

# 100% Cotton - Ne 40 X Ne 40 / EPI 132 X PPI 72 - 58" finished width, 140 g/m², Reactive printing

	Rotary screen printing				Digital printing			
Costing parameters	Printing - Rotary CN: Euro/m	Printing - Rotary IT: Euro/m	Printing - Rotary DE: Euro/m	Printing - Rotary IN: Euro/m	Printing - Digital CN: Euro/m	Printing - Digital IT: Euro/m	Printing - Digital DE: Euro/m	Printing - Digital IN: Euro/m
Dyes & Chemicals	0.1302	0.1875	0.1875	0.1200	0.1869	0.2000	0.2000	0.1750
Ink					0.8678	0.4200	0.4200	0.3413
Spare parts/Maintenance	0.0134	0.0100	0.0100	0.0136	0.1541	0.2000	0.2000	0.2211
Utilities	0.1328	0.1671	0.1671	0.1596	0.1797	0.2050	0.2050	0.1249
- Power	0.0504	0.0504	0.0504	0.0575	0.1175	0.1200	0.1200	0.0368
- Steam	0.0401	0.0600	0.0600	0.0467	0.0113	0.0200	0.0200	0.0353
- Thermopack/Natural Gas	0.0267	0.0267	0.0267	0.0235	0.0481	0.0500	0.0500	0.0481
- Raw water	0.0039	0.0100	0.0100	0.0100	0.0007	0.0050	0.0050	0.0016
- Waste water treatment	0.0117	0.0200	0.0200	0.0200	0.0022	0.0100	0.0100	0.0032
Wages & Salaries	0.0707	0.0844	0.1144	0.0184	0.2083	0.1350	0.1830	0.0980
Supervisory & technical staff + Administrative	0.0134	0.1000	0.1400	0.0133	0.0134	0.1000	0.1400	0.0133
Packing	0.0200	0.0200	0.0200	0.0240	0.0200	0.0200	0.0200	0.0240
Interest	0.0027	0.0027	0.0027	0.0667	0.0027	0.0027	0.0027	0.0028
Depreciation	0.0185	0.0175	0.0175	0.0504	0.1802	0.4167	0.4167	0.2000
<b>Total cost per meter</b>	<b>0.4016</b>	<b>0.5892</b>	<b>0.6592</b>	<b>0.4660</b>	<b>1.7930</b>	<b>1.6993</b>	<b>1.7873</b>	<b>1.2004</b>
	100%	147%	164%	116%	100%	95%	100%	67%

Remarks:  
1) without screen costs  
2) Chinese digital printing costs are high due to lack of efficiency of the specific company

Source: Gherzi interviews

Picture 4: Digital textile printing / rotary screen printing country cost comparison

In addition to the number of colors in use, the batch length to be printed is the second cost parameter to be taken into consideration for a direct cost comparison of digital textile printing with rotary screen printing. Following example shows the classical break even calculation:

## Costs for digital printing

Costs for printing:

Company 1	
Textile print with medium coverage	
Print length	Σ Costs
[meter]	[€/meter]
to 1*	25
1 to 15	5.252
15 to 60	3.725
60 to 210	3.179
210 to 1'000	2.932
1'000 and more	2.717

\*Fix cost for sampling

## Costs for rotary screen printing

Costs for printing:

Company 1				
	Costs in €/m			
N° of colors	1	2	3	4
Print length [m]				
1 to 300	1.281	1.859	2.210	2.535
300 to 600	1.222	1.768	2.119	2.379
600 to 1'000	1.164	1.671	1.989	2.308
1'000 to 2'000	1.060	1.541	1.794	2.119
2'000 to 5'000	1.027	1.443	1.671	1.983

Costs for screens:

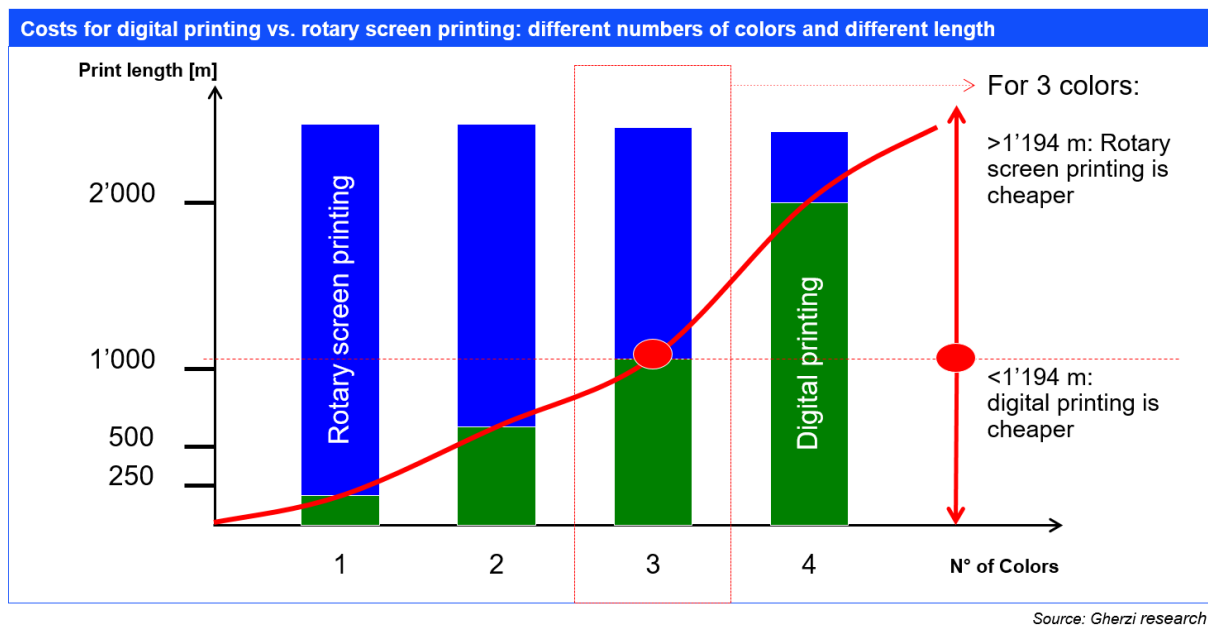
Type LEX 1'750 mm width, cost € 367.50 / screen

Source: Gherzi research

Remark: The cost indications for digital and rotary screen printing of a reactive printed cotton fabric are from the same company

Picture 5: Digital textile printing cost comparison with rotary screen printing

Following graph shows that the break even for a one color print is at about 200m, for a two color print at about 700m, for a three color print at about 1'200m and for a four color print at about 2'000m.



Picture 6: Digital textile printing break even cost calculation

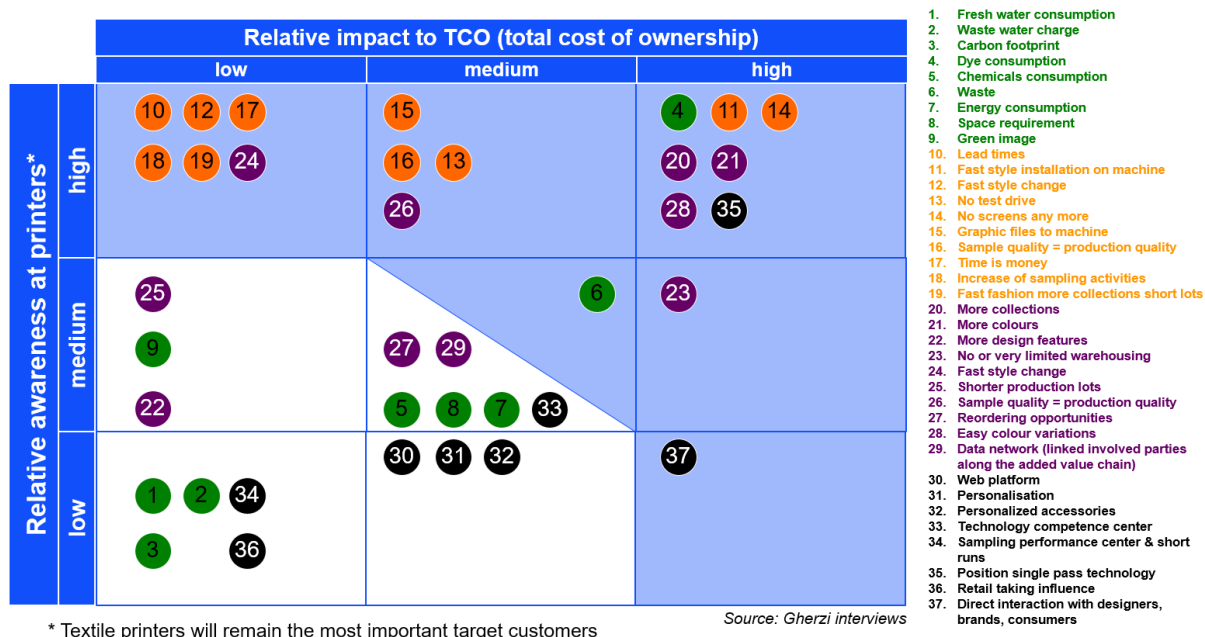
Obviously, that's not the only driver in favor of digital textile printing. More important are other parameters identified by Gherzi which are difficult to quantify directly in monetary values but there is a direct correlation with the demand of digital textile printing.

### Indirect cost

Gherzi has identified 4 different fields of totally 37 indirect cost parameters, influencing the digital textile printing activities related to

- Sustainability
- Speed
- Flexibility
- New business models

Gherzi positioned the parameters in a grid with the relative awareness of textile printing companies against the relative impact on total cost of ownership



Picture 7: Digital textile printing indirect cost drivers

## Sustainability

At textile printers, sustainability issues are not perceived as the main driver criteria for digital textile printing with the exception of low dye consumption and the reduced waste of printed fabric. However, facts as reduced fresh water consumption and waste water charge, reduced consumption of chemicals and reduced consumption of energy compared to classical textile printing technologies are a fact even if carbon footprint and green image are no issue for the majority of textile printers (at least in combination with digital textile printing).

## Speed

Speed related parameters are the main positive drivers in favor of digital textile printing. The advantage of no need for screens results in shortened lead times from defined design to printed fabric. A style installation on machine is basically a software issue since a graphic file is fed directly to the printing machine. Sampling activities could be accelerated, further the quality of printed samples are equal to the production quality as long as it is printed on the same type of machine. The ongoing trend for fast fashion in combination with more collections and shorter lots also favor the digital textile printing technology.

## Flexibility

Digital textile printing is a very flexible production process. It allows more collections, more colors, more design features (even different ones than traditional textile printing) and very easy color variations. Warehousing became nearly unnecessary. Production quality can be expected similar to sample quality. Further the production even of short lots became much more attractive.

## New business models

The digital textile printing technology itself offers the potential of a variety of new business models. The direct interaction via web opens new possibilities of communication and interaction between involved parties (brands, designers, retail, printers, consumers), the single pass machines further allow unique opportunities of large production lots in very short time after order.

## Trends which could change the world of textile printing

### Single pass digital textile printing

With the market introduction of the Lario in 2012, MS Italy presented for the first time a digital textile printing machine offering similar production performance as a traditional rotary screen printing machine. In the meantime, beside MS Italy also SPGPrints (PIKE), Konica Minolta (Nassenger SP-1) and Atexco (Vega One) have sold and installed single pass digital textile printing machines in the industry.

The market for this type of equipment is limited so far since an interested investor has to rely on an industrial environment (pre- treatment and finishing equipment) and has to have an annual production volume of more than 2mn running m to be produced on the single pass machine. In theory, there are many potential customers around the world however main challenge for them is that they simply don't know how to sell the added value of digital, thus cannot achieve a volume of minimum 2 mn m that are necessary to justify the investment in single pass. A single pass digital textile printing machine has to be operated 24/7 in order to be profitable.

#### Advantages

- Capability to produce important quantities in a very short time (lead time advantage)
- Fast style change (design, colors) with nearly no installation time
- Production speed as rotary screen printing
- Nearly unlimited flexibility

#### Disadvantages

- Limited market so far
- Fast developing technology
- Heavy investment
- Lifespan of print-heads
- Quantity of suitable orders to fill capacity
- Industrial environment (pre- and after-treatment necessary)

Unique opportunities are offered by this type of machinery in terms of reaction speed and the potential to produce large quantities in very short time. Style changes can be prepared while the machine is still producing. There are nearly no limitations in quantities of colors and complexity of designs.

Once the technology is mature, production cost are further lowered and the reliability of print-heads is given (what is a question of time) there is the potential to replace an important part of installed rotary screen printing capacity.

#### Pigment inks

As of today, digital textile printing with dye based inks ask for an industrial environment with highly sophisticated pre- and after-treatment equipment. This fact limits the spread of machines towards garmenting mills, brands, designers, retail or other parties.

In traditional printing pigment based printing paste is the solution found for the requirements 'simple process', 'low cost' and 'acceptable quality'. In digital printing pigment inks cannot fulfill any of these 3 criteria so far. In order to find a solution to meet those goals, the industry should search for another chemistry / solution than pigments. The industry wants to have a solution for these issues, but nobody has ever seen it.



Several market players are working hard on bringing pigment based inks to the market. However, there is no solution so far available, which allows a high quality textile printing without any pre- and after treatment. Market prices of pigment based inks are still very expensive compared to dye based inks, further the all in one ink solution is not yet available.

Producer / Sales	Product name	Printer-/ print-head suitability	Remarks
Bordeaux Digital Printink	Velvet Jet	various	'One ink for all fabrics' meets requirements of many printers
Durst	Alpha Ink P	Durst (Ricoh)	Exclusively Durst with inline pretreatment system
EFI Reggiani / Dupont	Artistri PK2600	Reggiani (Kyocera)	Special pretreatment chemistry (perceived nice results)
For.Tex / Epson	Genesta PG-2	MonnaLisa	Exclusively MonnaLisa with PreGen PG pretreatment
Fuji Imaging Colorants	ProJet TX411	Dimatix Starfire	Probably based on ProJet RxD pigment dispersion
Kilian / JK Group (Dover)	Digistar K-Choice	Kyocera	Need for pretreatment and thermofixing, int. deco, fashion
Kornit	Neo Pigment Pure	Allegro	Exclusively Kornit with integrated preparation and fixation
Matsui	DigiAce	various	Micro capsuled nano pigments for each substrate
Mimaki	TP400	NA	No pretreatment needed
MS Printing Solutions (Dover)	Pigmento PML	JP (Kyocera)	Pretreatment chemistry from Lubrizol
Pigment Inc.	Pigmentinc T60i	Epson DX7	No pretreatment, steaming, washing, natural fibers, PES, blends; 9 colours available, pre-coating optional (Co, PES)
Sensient Technologies	Elvajet PY570	Kyocera	Pretreatment probably from C.P.L. Prodotti Chimici
SPC (ex Sawgrass)	MXTR K+	Kyocera	No pretreatment, steaming, washing, all fibers, 12 colours
Sun Chemicals	SunTex Encore	Epson DX	Pretreatment recommended, all fibers, 9 colours

Source: Solunaris, Gherzi research

Picture 8: Digital textile printing pigment inks

## Future requirements

Digital textile printing will continue to grow and increase its share within textile printing. It has to be understood as a chain of processes from preparation to finishing which so far is not standardized.

Preparation	Printing	Drying	Fixing	Finishing
<p>Many different drying technologies in use, no established standardisation</p> <p>Preparation quality depending on</p> <ul style="list-style-type: none"> <li>Substrate quality (evenness, selvages, size stability)</li> <li>Primer application (foulard, foam,...)</li> <li>Chemicals in use</li> <li>Pick alignment</li> </ul>	<p>3 main technologies, fast developing</p> <p>Current requirements for improvements:</p> <ul style="list-style-type: none"> <li>Lower production cost</li> <li>Print-head reliability and life-span to be improved</li> <li>Ink penetration</li> <li>Dark colours</li> <li>Mechanical precision of printing equipment</li> <li>Speed- /quality ratio</li> </ul>	<p>Many different drying technologies in use, no established standardisation</p> <p>Drying quality depending on</p> <ul style="list-style-type: none"> <li>Type of ink</li> <li>Coverage</li> <li>Print speed (drying in line with printing)</li> <li>Temperatures</li> <li>Process time</li> <li>Drying technology (hot air, IR,...)</li> </ul>	<p>Estimated 30% influence on final print quality, therefore quality deciding process, no established standardisation</p> <p>Requirements:</p> <ul style="list-style-type: none"> <li>Process related equipment (progress recently achieved from Salvadè)</li> </ul> <p>Process depending on</p> <ul style="list-style-type: none"> <li>Ink type</li> <li>Coverage</li> <li>Substrate type</li> </ul>	<p>More ecological washing cycles with process optimized equipment (e.g. offered from MCS)</p> <p>Future potential to implement finishing agents with digital textile printing technology</p>

Source: Gherzi interviews

Picture 9: Digital textile printing production process

An accelerated spread of digital textile printing could be expected as soon as there are price attractive reliable printing solutions available which don't ask for an industrial environment and allow also high quality prints at brands, retail and design organisations. They will opt for plotter type and scanner type of digital printing machines, single pass technology will remain limited to industrial printers due to the huge production output.