Status in the production of roll to roll high-product inkjet textile printers after the DRUPA fair 2024

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Professional paper**

At the international trade fair DRUPA 2024, various innovations in printing technology were showcased. Among the presented technologies, Inkjet was the most prominent, finding applications across multiple industrial sectors, including printing textile materials. This paper will describe high-productivity Inkjet machines specialized for textile printing manufactured by Konica Minolta, DURST, and EFI. These three multi-color models, equipped with different piezo Inkjet heads and integrated pre- and post-treatment systems, achieve impressive production speeds of 1,470 m²/h, 6,400 m²/h, and 828 m²/h. They are single-pass rotary machines with roll widths exceeding 2 meters, specifically the Konica Minolta NASSENGER SP-1, Durst Alfa 330, and EFI Reggiani HYPER ReNOIR 340 models.

Keywords: *Inkjet; Konica Minolta NASSENGER SP-1; Durst Alfa 330; EFI Reggiani ReNOIR 340*

Stručni rad**

Stanje u proizvodnji visoko produktivnih inkjet tekstilnih printera iz role nakon sajma DRUPA 2024.

Na međunarodnom sajmu DRUPA 2024. predstavljene su razne inovacije u tehnologiji tiska. Među predstavljenim tehnologijama Inkjet je bio najistaknutiji, pronašavši primjenu u više industrijskih sektora, uključujući tiskanje tekstilnih materijala. U ovom radu opisat će se visokoproduktivni Inkjet strojevi specijalizirani za tisak na tekstilu proizvođača Konica Minolta, DURST i EFI. Ova tri višebojna modela, opremljena različitim piezo Inkjet glavama i integriranim sustavima prije i nakon tiska, postižu impresivne proizvodne brzine od 1470 m²/h, 6400 m²/h i 828 m²/h. To su jednoprolazni rotacijski strojevi sa širinom valjaka većom od 2 metra, posebno modeli Konica Minolta NASSENGER SP-1, Durst Alfa 330 i EFI Reggiani HYPER ReNOIR 340.

Ključne riječi: *Inkjet; Konica Minolta NASSENGER SP-1; Durst Alfa 330; EFI Reggiani ReNOIR 340*

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1. Introduction

In the last few years (the analyzed period from 2018 to 2023), the application of Inkjet technology has increased significantly. Modern Inkjet machines and integrated production of Inkjet heads have enabled the production and coating processes of various materials. As a non-contact printing technique, Inkjet is increasingly used for direct printing on glass, ceramics, parts for the automotive industry, printing and decorating interiors, producing various printed promotional materials and packaging, textiles, printing electronic components, and preparing bio-medical preparations. An insight into global trends has shown that Inkjet printing of glass, automotive equipment, and Inkjet production of biomedical preparations has achieved constant growth in a small percentage. In US dollars, it globally amounts to $ 0,132 billion (glass), $ 0,4 billion (auto industry), and $ 0,350 billion (biomedicine) (Fig.1).

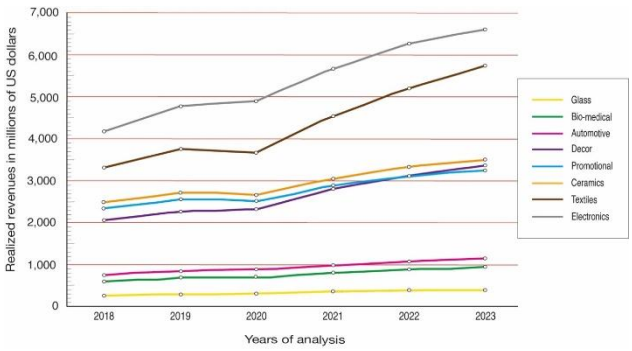

Fig.1 World Wide industrial Inkjet growth by segments

Inkjet printing on ceramics, interior printing, and inkjet printing of promotional materials are signify-cantly more profitable sectors. In the years following the global pandemic, these three sectors did not experience a notable increase in revenue. However, with the return to pre-pandemic conditions, a signi-ficant revenue boost was recorded. Over the investi-gated six-year period, the following revenue increases were noted: inkjet printing of promotional materials saw an increase of $0,9 billion, ceramic printing gained $1 billion, and inkjet printing in interior design rose by $1,3 billion.

Additionally, digital printing of textiles and electronics printing are areas where the Inkjet technique significantly contributes to development. Income stagnated due to the COVID pandemic. However, in the analyzed period from 2018 to 2023, the most substantial revenue growth occurred in electronics printing, which saw an increase of $2,43 billion. Inkjet printing on textiles experienced a slightly lower increase of $2,42 billion. This results in a Compound Annual Growth Rate (CAGR) of 11,5% for digital textile production, with a realized income of $5,79 billion in 2023 [1].

2. Theoretical part

The Inkjet printing segment in textiles is diverse, featuring various market segments. Digital printing using inkjet technology primarily relies on the type of substrate, which can include natural fabrics, synthetics, weaving, and knitting, as well as the specific inkjet inks formulated for these materials. Consequently, whether the focus is on printed clothing (such as sportswear and fashion), printed fabrics for interior decoration (like home furniture and hotel décor), or promotional textile materials (including t-shirts and canvas bags), different ink types are utilized: acid inks, disperse inks, dye sublimation inks, reactive inks, and pigment inks.

Furthermore, the processes of pre-treatment and post-treatment of the prints, along with the appropriate selection of integrated inkjet heads (considering their construction and how they connect to larger printing modules), are essential. Currently, we can classify inkjet machines based on their technology into three main types: direct roll-to-roll printing on fabrics, direct-to-garment printing, and direct-to-film printing [2].

This paper analyzes three key manufacturers of textile inkjet machines: DURST from Europe, Konica Minolta from Japan, and EFI from the United States. All of their models operate on the roll-to-roll principle. A notable feature of these three selected models is that they can be equipped with units for pre-treatment, thermal curing, Heat Transfer, and Wash units for fixation and post-treatment, depending on whether they utilize pigmented, reactive, or dye sublimation inkjet inks. Although ink pigmentation predominates in rotary analog textile printing (accounting for 57%), it represents only a small fraction (6%) in digital printing. In the digital print arena, disperse and dye sublimation inks dominate, making up 46%, followed by reactive inks at 27%, and acid inks at 9% [3].

2.1. Durst Alfa 330

The Durst ALPHA 330 printing machine, designed for a printing width of 3300 mm, is ideal for producing home textiles, apparel, fashion items, flags, banners, and outdoor signage. It operates using either 32 or 64 Ricoh GEN5 series print heads, allowing for 8 color channels with 4 or 8 heads per

color. The Ricoh head model MH5441 features a variable drop size of 7/14/21 picoliters and a drop frequency of 30 kHz. This setup ensures high reproduction quality with a resolution ranging from 300 x 600 dpi to 500 x 600 dpi. The machine offers varying production speeds based on the chosen resolution and number of passes. Possible speeds include: 1024 m²/h for 1 pass at 500 x 600 dpi, 1472 m²/h for 1 pass at 300 x 600 dpi, 512 m²/h for 2 passes at 500 x 600 dpi, 736 m²/h for 2 passes at 300 x 600 dpi. While a higher number of passes and increased print resolution yield better quality, this also results in lower productivity (approx. half).

The Durst ALPHA 330 (Fig.2) is equipped with quality units for unwinding various textile materials, including cotton, polyester, polyamide, silk, viscose, blends, wool, and sublimation paper. It can print on rolls of fabric weighing between 40 to 500 g/m². Depending on the printing substrate used, the machine can be configured for 9 colors (CMYK plus gray, green, orange, light magenta, and light cyan) and utilizes different types of ink. These include: Pigment ink (commonly for home textiles, apparel, and fashion), Reactive ink (for home textiles, apparel, and fashion), Reactive HDi ink (for home textiles, apparel, and fashion), Reactive Acid ink (for swimwear, home textiles, apparel, and fashion), Disperse ink (for home textiles, apparel, fashion, flags, banners, and outdoor signage) [4].

The Durst Drying Concept offers two configurations: a standard version, which includes a single drying section, and a full drying line version, equipped with two drying sections. Both configurations can incorporate the Passages option, effectively doubling the drying time. Users can choose from a variety of energy sources, including Gas Dryer options (Natural Gas, Methane, Liquid Gas Propane, and Liquid Gas - Butane), Electric Dryer, Thermo-Oil, or Steam [5].

Depending on the type of substrate, the printed rolls can undergo several final exposure configurations after drying. To facilitate this, the following units can be installed: Material Guiding Options, Knit Wear Options, Dual-Roll Options (which require a Dual-Roll Entry for smaller rolls), Motorized Small Rolls (with Pneumatic Shaft available in 2" and 3" diameters), Jumbo-Roll Entry Options (available in 1 m or 2 m), and Folded Material Entry Options (Fig.3).

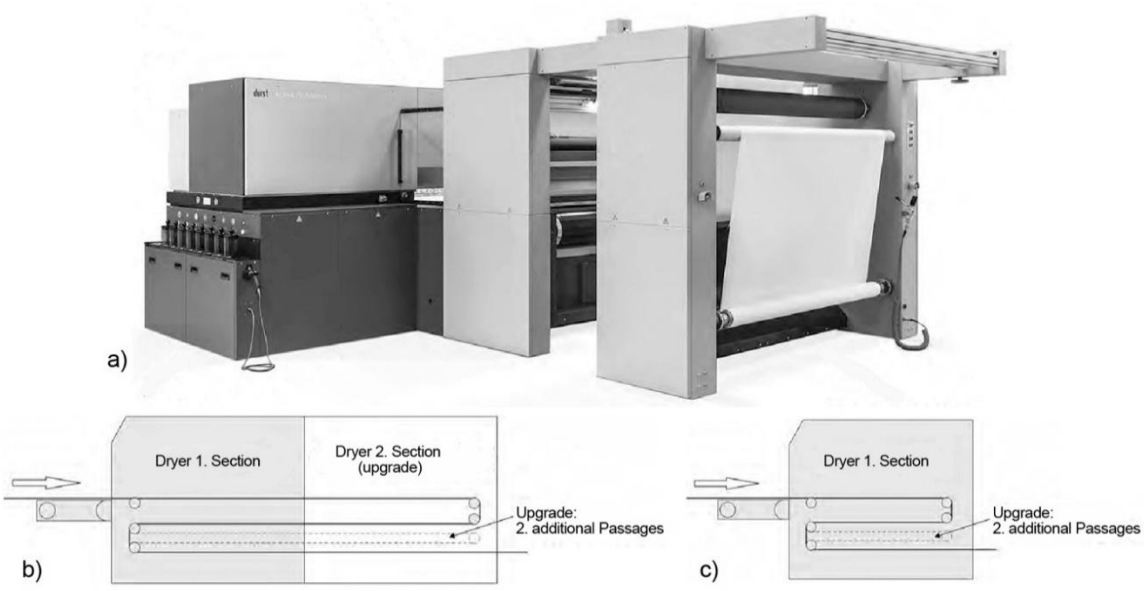

Fig.2 Durst Printing machine for textile printing: a) Durst ALPHA 330: b) dryers option version long for Durst machine; c) dryers option version short for Durst machine

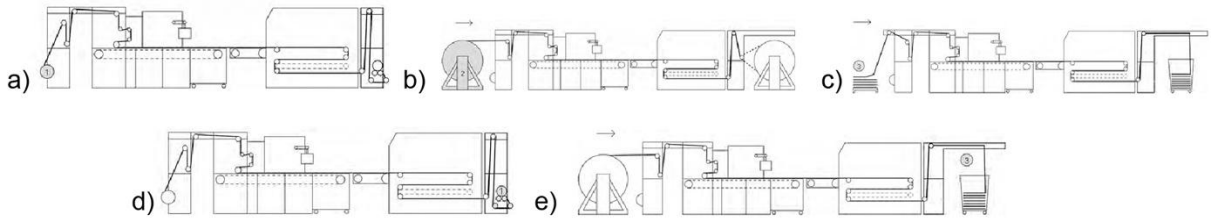

Fig.3 Input and output configuration for Durst machine: a) Motorized Small Roll XC75150; b) Jumbo-Roll Entry-Option - 2m XD75420; c) Folded Material Entry-Option XD75450; d) Small Roll Exit-Option XD75640; e) Jumbo-Roll Exit-Option - 2m XD75620. [5]

2.2. Konica Minolta NASSENGER SP-1

The NASSENGER SP-1 (II generation) is the most productive textile machine (Fig.4) offered by Konica Minolta. In this latest generation, the previous KM Inkjet head 512HX has been replaced by the more efficient KM1024a from the SHE-Q series, provides double the productivity. The machine maintains the concept of color single-pass ink with a printing width of 1830 mm. Depending on the type of ink used (either reactive dye ink or disperse dye ink), the standard configuration can feature six colors, or it can be expanded to eight colors. The color options for reactive dye ink include Yellow, Extra Magenta, Cyan, Black, Orange, Blue, Pink, Gray, XK, and UK. For disperse dye ink, the available colors are Yellow, Magenta, Cyan, Black, Pink, Sky, Gray, Red, Violet, and Cyan2.

The KM1024aSHE-Q heads are arranged modularly in two rows, with 26 print heads dedicated to each color. Each head, connected in a dual housing, achieves a print resolution of 2048 dpi. In total, 416 heads (208 dual heads) are used to print all eight colors in the maximum configuration. The printing process is characterized by a variable drop size that ranges from 6 to 20 picoliters, with a drop frequency of 40 kHz in binary mode or 22 kHz in 8-bit mode with four formed drops.

The system achieves high-quality color reproduction with resolutions ranging from 720 x 360 dpi to 720 x 900 dpi. Depending on the selected resolution, four production speeds are available: Ultra-high speed: 67,3 m/min at 720 x 360 dpi, with a productivity of 4038 m²/h, High speed: 44.9 m/min at 720 x 540 dpi, with a productivity of 2694 m²/h, Standard speed: 33,7 m/min at 720 x 720 dpi, with a productivity of 2022 m²/h, High density: 26,9 m/min at 720 x 900 dpi, with a productivity of 1614 m²/h. For continuous printing, the system includes several components: a small roll unwinder, a big roll unwinder, a big roll winder, a quality camera for register inspection, a laser device for white line compensation and nozzle check correction, and a sensor for detecting creases. Due to its large dimensions (length of 16,00 m and width of 5,43 m), the drying unit is not included in the standard price, but there is an option for coordination and mutual connection between the units [6].

2.3. EFI Reggiani HYPER ReNOIR 340

In 2021, the American inkjet manufacturer EFI introduced its most productive textile printing machine, the Reggiani HYPER ReNOIR 340. This machine is designed to print from a roll with a width of 3400 mm, making it the largest available for digital textile printing.

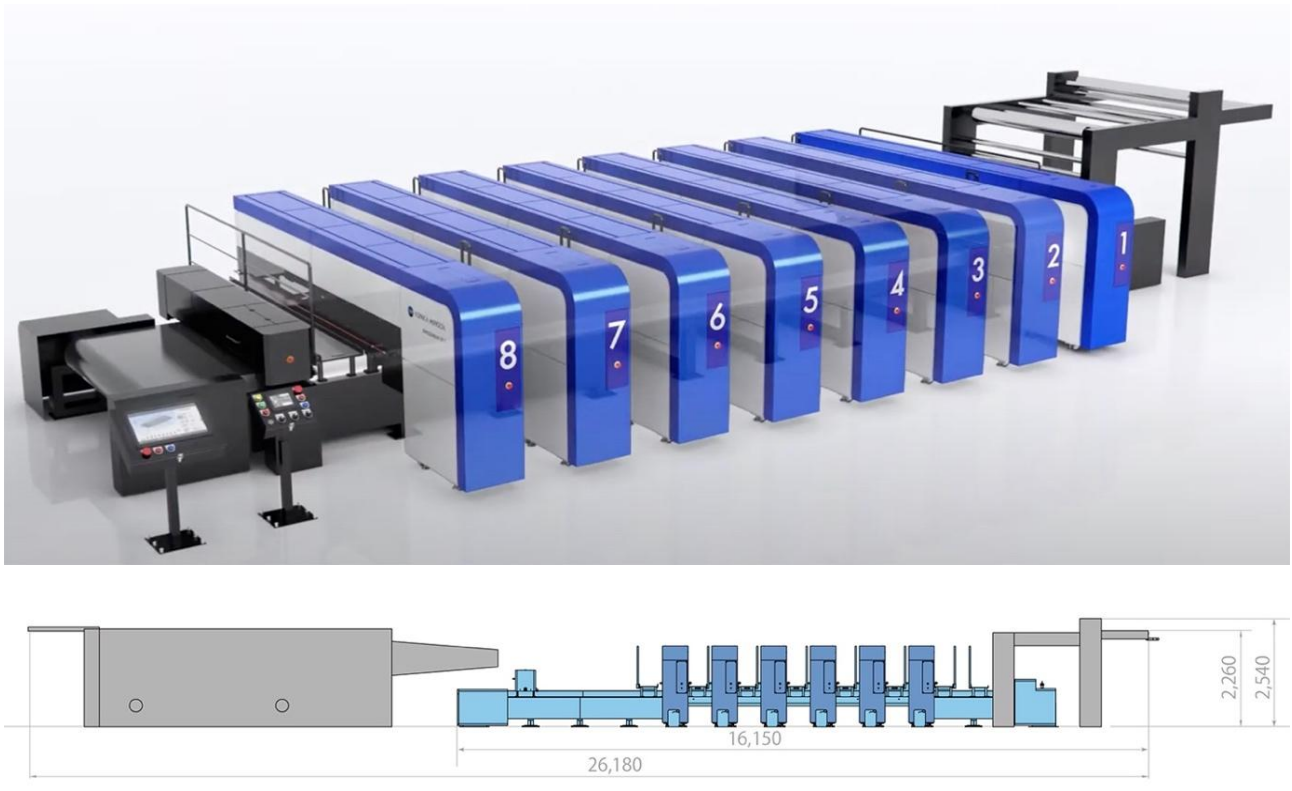

Fig.4 Single-pass construction of the Konica Minolta Nassenger SP-1 inkjet textile printing machine: a) photography of a typical configuration; b) a schematic view with dimensions [6]

The Reggiani HYPER ReNOIR 340 (Fig.5) supports a variety of inks, including Disperse Direct Inkjet inks, Reactive Inkjet inks, Acid Inkjet inks, Disperse Sublimation Inkjet inks, and Textile Pigment inks. This versatility allows for the successful printing of materials used in apparel and accessories, home textiles, sportswear, footwear, and outdoor products.

It can effectively print on a range of fabrics, such as cotton, polyester, polyamide, silk, viscose, blends, wool, and sublimation paper. The machine features a printing unit comprised of 72 piezo Inkjet heads from the Kyocera KJ4B series, which operate simultaneously across eight channels (eight print rows). Each color (KMCY+ORVB) is printed using a color module with nine heads arranged in a line. The Kyocera KJ4B piezo Inkjet head is notable for its variable drop technology, which produces droplet volumes ranging from 5 to 16 picoliters at a dripping frequency of 30 kHz. As a modular head capable of moving translationally from left to right, it allows for color printing with one, two, three, or four passes. This feature ensures high-quality reproduction with a maximum resolution of 600 x 2400 dpi. The production speed varies based on the resolution and the number of passes selected. The speeds are as follows: 3150 m²/h at 600 x 300 dpi with 1 pass, 1899 m²/h at 600 x 600 dpi with 2 passes, 1266 m²/h at 600 x 900 dpi with 3 passes, and 951 m²/h at 600 x 1200 dpi with 4 passes. [7]

Additionally, the Reggiani HYPER ReNOIR 340 can be equipped with various options, including a small roll unwinder (40 cm diameter), a big roll unwinder (A-frame with 160 cm), fold entry, fold exit, a small roll winder (40 cm), and a big roll winder (A-frame with 160 cm). To accommodate different colors, the in-line dryer can be duplicated with an industrial double-section design, featuring symmetric ventilation and high-efficiency exhaust capacity. Available heating sources include gas, electricity, oil, and steam.

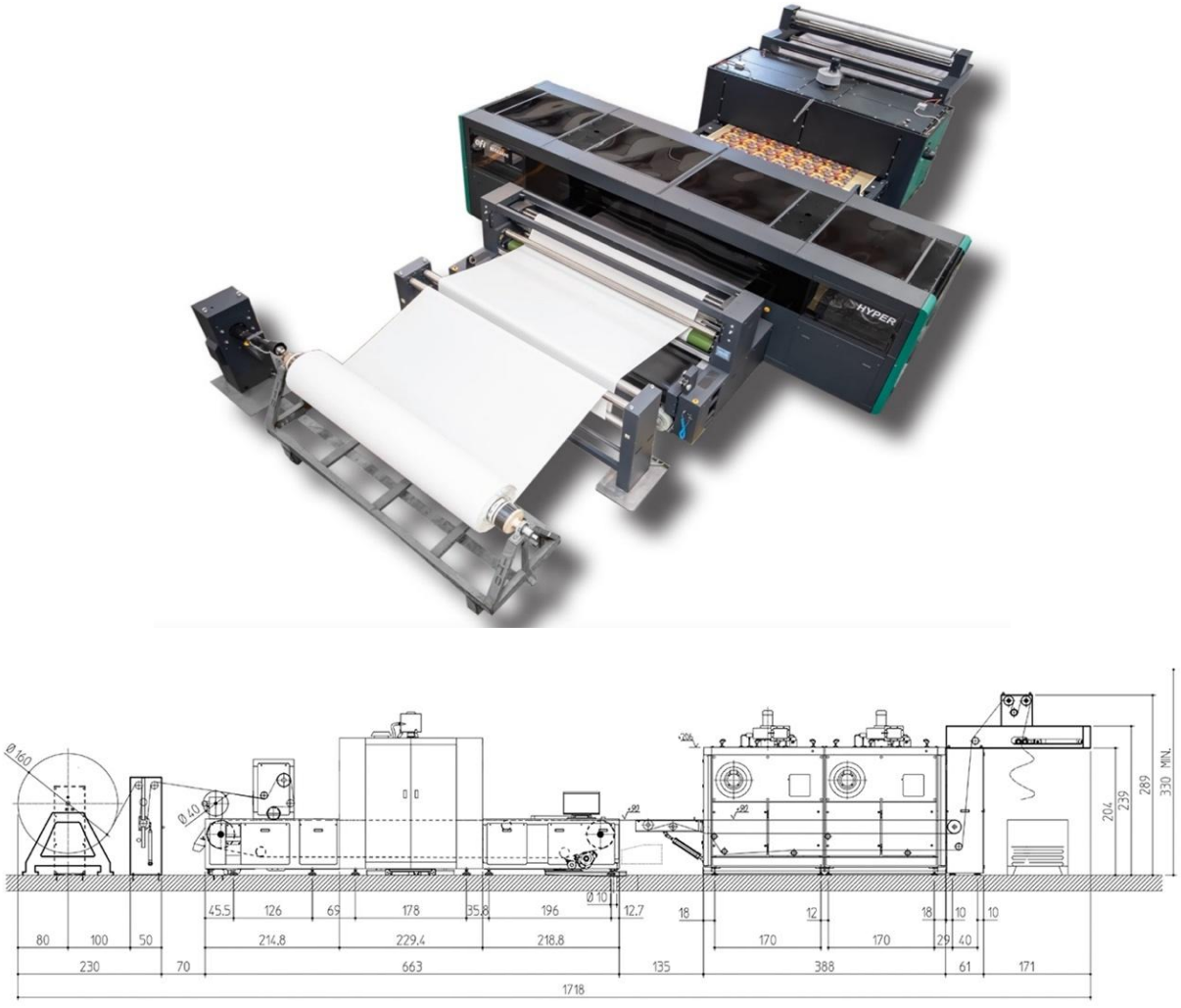

Fig.5 Multi-pass design of the Reggiani HYPER ReNOIR 340 EFI Inkjet textile printing machine: a) photography of a typical configuration; b) a schematic view with dimensions [7]

3. Discusion

There is no standard design for roll-to-roll printing machines in the textile market, as each manufacturer approaches development in a unique way. The development process primarily relies on existing platforms for inkjet heads and inks, which are also utilized in simpler, lower-productivity machines. This makes it technically challenging to make direct comparisons between different devices.

The European manufacturer Durst, with its Alfa series, collaborates with local inkjet ink producers and customizes the configuration of finishing outlets and dryers accordingly. Utilizing the proven Ricoh 5th generation inkjet head and a successful scanning mode concept, Durst's machines ensure consistent application of eight colors, along with automatic compensation for potentially blocked nozzles. Konica Minolta is a pioneer in the production of inkjet printing machines for textiles and uniquely offers a single-pass configuration. This approach maximizes productivity by applying separations one at a time. To monitor quality, it is essential to install cameras that track the register quality and a system for monitoring droplet distribution to avoid the appearance of white (unprinted) lines. Their development strategy focuses on proprietary inkjet solutions, specifically inkjet heads that operate on the piezo shear principle, along with machine components that support future advancements in productivity. The renowned American manufacturer EFI bases its development of textile machines on the Japanese Kyocera KJ4B series heads.

By employing a multi-pass technology and utilizing eight colors, they have produced high-quality machines capable of printing at a resolution of 600 x 2400 dpi.The addition and installation of different types of pre-treatment and finishing devices (dryers) enables application on almost all textile substrates and application in the production of Apparel and Accessories, Home textiles, Sportswear & Footwear, Outdoor. As with the competition, a system for monitoring the quality of reproduction and the uniformity of reproduction is built into the system.

4. Conclusion

The latest analysis from Smithers predicts significant growth in the production of roll-to-roll digital textiles in the coming years, with data extending until the end of 2028. This sector is expected to experience a compound annual growth rate (CAGR) of 8,3%, increasing from 3,3 billion printed square meters in 2022 to 5,5 billion in 2028. In contrast, conventional textile production is projected to see minimal change, with a predicted CAGR of around 0,3%. This means production will increase from 49.7 billion square meters in 2022 to 53,4 billion square meters in 2028.

Global manufacturers of inkjet machines are actively developing new concepts to enhance productivity. However, they face challenges due to limited resources, including substrate availability and various application issues. These challenges involve factors such as the types of substrates (porous, non-porous, flat or warp), printhead and throw distance considerations (head options, addressability, consistency or variability in distance to surface, speed, technology), as well as ink and surface treatments (chemistry, fastness, regulatory considerations, properties, number of colors, white ink, laydown order, treating/priming, open time, and environmental factors). Additional challenges arise in drying and curing processes (radiation, air quality/solvent drying, environmental impact, exhaust, heat, and post-coats), as well as mechanics and automation (feeding, transport, stacking, rejecting, automation level, robotics, spatial footprint, power requirements, ancillary processes, and integration with manufacturing systems).

In future publications, the authors will provide a more detailed comparative analysis of CMYK textile prints produced by these machines. This analysis will specifically focus on the color reproduction capabilities of high-productivity roll-to-roll inkjet machines.In future publications, the authors will conduct a more detailed comparative analysis of the realized CMYK textile prints produced by these machines. This analysis will focus specifically on Inkjet color reproductions produced by highly productive roll-to-roll Inkjet machines.

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