



“Screen vs DTG Printing: Comparative and Sustainability Analysis”

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Abstract : The debate between traditional screen printing and modern direct-to-garment (DTG) printing methods has garnered significant attention within the garment industry, prompting a comparative analysis that considers both operational efficiency and sustainability implications. This paper provides a comprehensive examination of screen printing and DTG printing techniques, focusing on their respective processes, performance characteristics, and environmental footprints. Through a comparative lens, we evaluate key factors such as print quality, production speed, material usage, energy consumption, and waste generation to ascertain the strengths and limitations of each method. Additionally, we conduct a sustainability analysis, assessing the environmental impact of screen printing and DTG printing in terms of resource utilization, chemical usage, emissions, and end-of-life considerations. By synthesizing empirical evidence and industry insights, this study aims to inform garment manufacturers, printers, and stakeholders about the trade-offs inherent in choosing between screen printing and DTG printing, ultimately guiding informed decision-making towards more sustainable and efficient printing practices in the garment industry.

Index Terms – Comparative analysis, DTG printing, Screen printing, Sustainability analysis.

1.INTRODUCTION

In the realm of garment decoration, the choice between screen printing and direct-to-garment (DTG) printing represents a fundamental decision that can profoundly impact both the production process and the final product's quality. Screen printing, a traditional technique dating back centuries, involves transferring ink onto a substrate through a mesh screen stencil, offering versatility and durability. In contrast, DTG printing, a relatively modern innovation, utilizes specialized inkjet technology to print designs directly onto fabric, providing intricate detail and vibrant colors. The comparative and sustainability analysis between screen printing and DTG printing has emerged as a critical discourse within the textile industry, driven by a confluence of factors ranging from economic considerations and technological advancements to environmental concerns and consumer preferences.

Firstly, a comparative analysis of screen printing and DTG printing reveals distinctive attributes that shape their suitability for different applications and contexts. Screen printing, renowned for its versatility and durability, remains the preferred choice for large-scale production runs and designs with bold colors and opaque coverage. The methodical process of screen preparation and ink application allows for precise control over print quality and consistency, making it ideal for commercial garment printing, promotional merchandise, and textiles requiring high wash durability.

In contrast, DTG printing offers unparalleled flexibility and precision, particularly for designs with intricate details, gradients, and photographic imagery. By leveraging advanced inkjet technology, DTG printers can achieve stunning color reproduction and fine detail, surpassing the limitations of traditional screen printing in terms of design complexity and customization. Moreover, DTG printing requires minimal setup time and allows for on-demand production, making it well-suited for small batch orders, personalized apparel, and rapid prototyping.

While both printing methods offer unique advantages, their sustainability implications warrant closer examination. Screen printing, characterized by its reliance on screens, squeegees, and chemical emulsions, can generate significant waste and environmental impact, particularly in terms of water consumption, energy usage, and chemical discharge. Additionally, the production of screens and the disposal of hazardous materials pose challenges in aligning screen printing practices with sustainable principles.

In contrast, DTG printing presents a more environmentally friendly alternative, thanks to its digital nature and reduced resource consumption. By eliminating the need for screens, stencils, and excess ink, DTG printing minimizes waste generation and streamlines production processes, thereby reducing energy consumption and carbon emissions. Furthermore, water-based inks used in DTG printing are typically eco-friendly and biodegradable, offering a safer and more sustainable alternative to traditional plastisol inks used in screen printing.

However, the sustainability analysis of screen printing versus DTG printing is nuanced and multifaceted, requiring consideration of factors such as ink usage, energy efficiency, material sourcing, and end-of-life disposal. While DTG printing may offer advantages in certain environmental metrics, it also presents challenges related to ink consumption, printer maintenance, and the disposal of electronic components. Moreover, the long-term durability and biodegradability of DTG prints compared to screen prints warrant further investigation to assess their true environmental impact over the product lifecycle.

The comparative and sustainability analysis between screen printing and DTG printing represents a dynamic discourse within the garment decoration industry, driven by evolving technology, market trends, and environmental imperatives. While each printing method offers distinct advantages and challenges, their compatibility with sustainable practices hinges on holistic considerations spanning production efficiency, resource utilization, waste management, and environmental stewardship. By critically evaluating the merits and drawbacks of screen printing and DTG printing through a sustainability lens, stakeholders can make informed decisions that balance economic viability with ecological responsibility, fostering a more sustainable and resilient future for the textile industry.

2.NEED OF THE STUDY

Screen printing and DTG printing offer distinct advantages and limitations in terms of print quality, color vibrancy, detail reproduction, and production speed. Understanding the performance attributes of each method is essential for printers to optimize their production processes and meet customer expectations. By conducting a comprehensive performance evaluation, this study will provide objective assessments of the strengths and weaknesses of screen printing and DTG printing, enabling printers to make informed decisions based on their specific requirements and priorities. Cost considerations play a significant role in determining the viability of printing methods for garment decorators. Factors such as equipment investment, material costs, labor requirements, and production efficiency need to be carefully evaluated to determine the cost-effectiveness of screen printing versus DTG printing.

With sustainability becoming a key driver of business decisions, there is a critical need to evaluate the environmental footprint of screen printing versus DTG printing. This includes assessing factors such as resource consumption, energy usage, waste generation, and chemical usage associated with each printing method. By conducting a comparative sustainability analysis, the study will provide valuable insights into the environmental implications of adopting either screen printing or DTG printing, aiding businesses in aligning their practices with sustainable goals.

3.RESEARCH METHODOLOGY

3.1Population and Sample

The population for the study "Screen vs DTG Printing: a Comparative and Sustainability Analysis" comprises individuals with extensive knowledge and expertise in garment printing, including industry experts, scholars, professionals, researchers, and industry practitioners. These individuals possess in-depth understanding and practical experience in various aspects of garment printing processes, including screen printing and direct-to-garment (DTG) printing. Total individuals for the survey were 49.

3.2 Data and Sources of Data

To conduct a comprehensive comparative analysis of screen printing versus direct-to-garment (DTG) printing, targeted survey and interviews were conducted to gather primary data from industry experts, garment printers, and manufacturers. The survey questionnaire was meticulously designed to cover various aspects of screen and DTG printing, including economic factors, environmental considerations and performance attributes. To gather more significant information, secondary data has also been used.

4. RESULTS AND DISCUSSION

4.1 Color vibrancy

Color vibrancy is a crucial aspect of print quality in both screen printing and direct-to-garment (DTG) printing processes. Vibrant colors enhance the visual appeal of printed designs, ensuring eye-catching and attractive results.

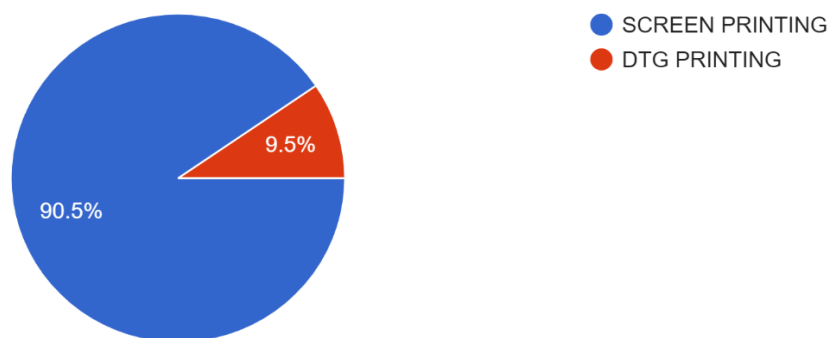


Figure 1- Color vibrancy Pie-chart

In screen printing, color vibrancy is influenced by various factors, including ink formulation, mesh count, printing technique, and curing process. Screen printing inks come in different formulations, such as water-based, solvent-based, and plastisol inks, each with unique characteristics affecting color vibrancy. Plastisol inks offer superior color vibrancy and opacity on both light and dark-colored substrates. Plastisol inks sit on top of the fabric surface, forming a solid layer of color with excellent vibrancy and durability. These inks are widely used in textile printing applications, including T-shirts, hoodies, and sportswear.

In DTG printing, color vibrancy is primarily determined by ink formulation, pretreatment application, and printing technique. DTG printers use inkjet technology to apply water-based pigment inks directly onto the garment substrate, requiring careful consideration of color vibrancy requirements. Water-based pigment inks used in DTG printing offer vibrant colors with excellent wash-fastness

and durability. These inks are designed to penetrate the fabric fibers while maintaining color vibrancy and sharpness. Achieving vibrant colors with DTG inks may require proper pretreatment application and printing technique, particularly on dark-colored or textured substrates. 90.5% of the respondents chose screen printing to be better in terms of color vibrancy.

4.2 Comfort and feel

Screen printing, a traditional and versatile printing method, often produces prints with a distinct texture and feel on garments. The ink used in screen printing sits on top of the fabric's surface, creating a slightly raised texture that can be felt when touched. This tactile sensation is often associated with the quality and durability of screen-printed designs. One of the key factors contributing to the feel of screen-printed garments is the type of ink and the curing process. Plastisol ink, a popular choice in screen printing, creates a smooth and slightly rubbery texture when cured. This texture provides a soft hand feel, making the printed design comfortable to wear against the skin. Additionally, screen-printed garments tend to have vibrant colors and sharp details, enhancing their visual appeal.

However, it's essential to note that the thickness of the ink layer in screen printing can vary depending on factors such as mesh count, ink viscosity, and printing technique. In some cases, heavy ink deposits may result in a stiffer feel, especially on light-colored garments where the ink layer is more noticeable. DTG printing, a relatively newer digital printing technology, offers a different approach to printing on garments. Unlike screen printing, which involves transferring ink through a stencil onto the fabric, DTG printing applies ink directly onto the garment's surface using a specialized printer. This direct application of ink results in prints with a softer and smoother feel compared to screen printing. One of the advantages of DTG printing in terms of comfort is its ability to achieve a thinner ink layer, which blends seamlessly with the fabric fibers. This thin ink layer provides a lightweight and breathable feel, making DTG-printed garments more comfortable to wear, particularly for everyday use or activewear. 71.4% of the respondents chose screen printing to be better in terms of comfort and feel.

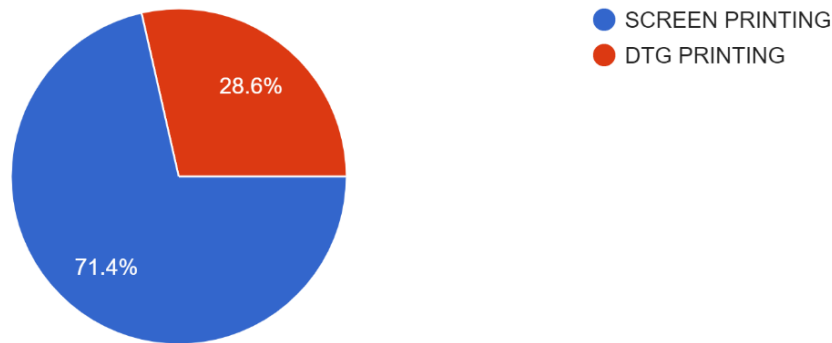


Figure 2- Comfort and Feel Pie-chart

4.3 Design complexity

Screen printing, also known as silkscreen printing, is a versatile and widely used technique for printing designs on garments. While screen printing excels in producing vibrant colors and durable prints, its suitability for complex designs depends on several factors. Screen printing involves creating separate screens for each color in the design. Complex designs with multiple colors require precise registration and alignment of screens to achieve accurate color placement. As the number of colors in a design increases, so does the complexity of the screen printing process. Printers must carefully plan and coordinate color separations to ensure consistency and accuracy in the final print. DTG printing, a digital printing technique, offers the advantage of printing complex designs directly onto garments with precision and detail. However, DTG printing also presents challenges related to design complexity. DTG printers utilize inkjet technology to apply water-based inks directly onto garments. While DTG printing can reproduce a wide range of colors and gradients, achieving accurate color matching for complex designs may require careful calibration and color management. Printers may need to adjust color profiles and perform test prints to ensure consistency and fidelity in color reproduction across different garments and substrates. 72.7% of the respondents chose DTG printing to be better in terms of color vibrancy.

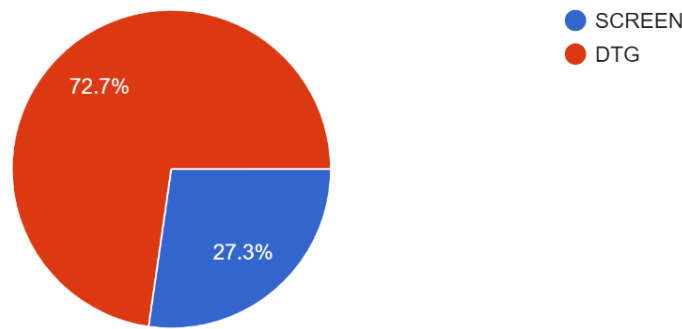


Figure 3- Design complexity Pie-chart

4.4 Durability

Screen printing is renowned for its durability, particularly when using plastisol inks. Plastisol inks are highly resilient and form a strong bond with the garment fibers when cured with heat. This results in prints that can withstand repeated wash cycles and maintain their color vibrancy for extended periods. The thickness of screen printed ink layers also contributes to durability, as the ink penetrates deeply into the fabric fibers, creating a robust bond that resists cracking, peeling, or fading over time. DTG printing offers excellent print quality and versatility but may raise questions regarding durability compared to screen printing, particularly when using water-based inks. Water-based DTG inks tend to be softer and more flexible than plastisol inks, which can affect the durability of prints, especially on certain fabric types such as polyester or blends with synthetic fibers.

While both screen printing and DTG printing can produce durable prints under the right conditions, screen printing is often perceived as the more durable option, especially for designs requiring solid colors or large areas of coverage. 72.7% of the respondents chose screen printing to be better in terms of durability.

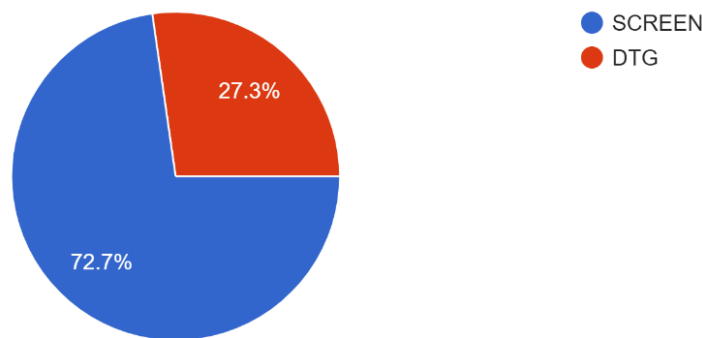


Figure 4- Durability Pie-chart

4.5 Production Speed and Volume

Screen printing remains a dominant method in the textile industry due to its efficiency and effectiveness, particularly when dealing with large-scale production and designs that require vibrant, precise color application. This method, rooted in ancient techniques and refined through modern technology, offers distinct advantages in terms of production speed and volume, making it a favored choice among many businesses. Screen printing involves pushing ink through a mesh screen to create a design on a substrate, typically fabric or paper. Each color in the design requires a separate screen, making the setup process intricate. However, once the setup is complete, the actual printing process is relatively fast. This balance between initial setup time and subsequent production speed is crucial in understanding the overall efficiency of screen printing.

Screen printing's real efficiency shines when producing large batches of a design. The nature of the setup process means that the cost and time per unit decrease significantly as the quantity increases. For bulk orders, screen printing often becomes the most cost-effective and quickest method. On average, screen printing can achieve production speeds ranging from 50 to 500 garments per hour, with some high-speed automatic machines capable of printing over 1,000 garments per hour for simple designs. However, for multi-color designs requiring multiple screens and precise registration, production speeds may decrease to around 100 to 200 garments per hour.

Direct-to-Garment (DTG) printing has revolutionized the textile industry by offering a digitally enhanced method for printing designs directly onto apparel. This technology is distinguished for its efficiency and suitability for short-run orders, providing significant implications for production speed and volume.

One of the standout features of DTG printing is its scalability and flexibility in handling orders of varying sizes. Unlike screen printing, which is more cost-effective for large batches due to the setup involved, DTG is economically viable even for small batch sizes. This makes it an ideal choice for businesses that require on-demand printing or have a high variety of designs but lower quantity needs. DTG printing machines can typically produce garments at speeds ranging from 30 to 100 garments per hour, depending on factors such as design complexity, garment material, and print resolution. While DTG printers are capable of producing intricate designs with high color vibrancy, the printing process involves multiple passes for each color layer, which can affect overall production speed.

4.6 Cost Analysis

Screen printing.

- **Initial Investment:** Screen printing requires a large initial investment in equipment such as screens, squeegees, exposure units, and drying racks. Additionally, multiple screens may be needed for different colors or designs, adding to upfront costs.
- **Material Costs:** Screen printing ink, screens, emulsion, and substrates contribute to material costs. While screen printing inks are generally more cost-effective per print, the need for separate screens for each color in the design can increase material expenses, especially for multi-color prints.
- **Labor Costs:** Labor costs for screen printing include wages for screen preparation, printing, and post-printing processes such as curing. The labor-intensive nature of screen printing, particularly for setup and cleanup, can contribute to higher labor expenses compared to DTG printing.
- **Overheads and Maintenance:** Overheads for screen printing include utilities, rent, maintenance of equipment, and consumables such as cleaning chemicals. Annual maintenance costs for screen printing equipment can add to the overall operational expenses.

DTG Printing:

- **Initial Investment:** DTG printing requires the purchase of digital printing equipment, including DTG printers and pre-treatment machines. The initial investment in DTG equipment can be substantial, particularly for high-quality printers capable of handling large volumes and intricate designs.
- **Material Costs:** DTG printing primarily involves ink and pre-treatment solution costs. While DTG inks may be more expensive per unit compared to screen printing inks, the ability to print full-color designs without the need for separate screens can result in lower material expenses for multi-color prints.
- **Labor Costs:** Labor costs for DTG printing are generally lower compared to screen printing, as the process is more automated and requires less manual intervention. However, skilled operators are still required for tasks such as design preparation, printer operation, and maintenance.
- **Overheads and Maintenance:** Overheads for DTG printing are similar to screen printing and include utilities, rent, and maintenance of equipment. Annual maintenance costs for DTG printers may vary depending on the model and usage but are generally comparable to screen printing equipment.

4.7 Sustainability Analysis

Sustainability has become a significant consideration in the garment printing industry, prompting a closer examination of the environmental impact of printing methods such as screen printing and direct-to-garment (DTG) printing. This sustainability analysis assesses various aspects of both printing techniques, including resource consumption, waste generation, chemical usage, and environmental footprint.

- **Resource Consumption:** Screen printing typically consumes more resources compared to DTG printing due to the need for screens, emulsion, and other materials for each color in the design. Additionally, screen printing may require larger quantities of ink and water for setup and cleanup processes. DTG printing generally consumes fewer resources than screen printing as it eliminates the need for screens and uses digital printing technology to apply ink directly onto garments. While DTG printing still requires ink and pre-treatment solution, the quantities used are typically lower compared to screen printing.
- **Waste Generation:** Screen printing generates waste in the form of used screens, emulsion, and ink residue. Improper disposal of screens and chemicals can contribute to environmental pollution, particularly if hazardous substances are involved. DTG printing produces less physical waste compared to screen printing since it does not require screens. However, waste generation can occur from unused pre-treatment solution, ink cartridges, and packaging materials. Proper waste management practices are essential to minimize environmental impact.
- **Chemical Usage:** Screen printing involves the use of chemicals such as emulsion, solvents, and cleaning agents. These chemicals may contain volatile organic compounds (VOCs) and other harmful substances that can pose health and environmental risks if not handled properly. DTG printing generally requires fewer chemicals compared to screen printing, as it eliminates the need for emulsion and screen cleaning solvents. However, pre-treatment solutions used to prepare garment substrates for printing may contain chemicals such as surfactants and wetting agents.
- **Energy Consumption:** Screen printing equipment, particularly drying units and curing ovens, consume energy during operation. Energy usage can vary depending on factors such as equipment efficiency, production volume, and curing temperature. DTG printers also require electricity for operation, including powering the printing mechanism and heating elements for ink curing. While DTG printers may be more energy-efficient compared to screen printing equipment, energy consumption depends on factors such as printer model and printing speed.

- **Environmental Footprint:** The environmental footprint of screen printing is influenced by factors such as resource consumption, waste generation, chemical usage, and energy consumption. Sustainable practices, such as using eco-friendly inks, recycling screens, and implementing energy-efficient processes, can help reduce the environmental impact of screen printing.
- DTG printing offers advantages in terms of resource efficiency and waste reduction compared to screen printing. However, concerns may arise regarding the environmental impact of ink formulations, pre-treatment solutions, and energy consumption associated with digital printing technology.

5.CONCLUSION

The comparative and sustainability analysis of screen printing versus DTG printing illuminates key considerations for garment decorators and industry stakeholders. Through a comprehensive examination of environmental impact, performance attributes, cost-effectiveness, and market relevance, valuable insights have emerged to inform decision-making processes within the garment printing industry.

In assessing the environmental sustainability of both printing methods, it becomes evident that DTG printing offers advantages in terms of reduced material consumption, setup time, and waste generation compared to traditional screen printing. With its ability to eliminate the need for screens and emulsion, DTG printing minimizes resource consumption and chemical usage, aligning closely with sustainability objectives and reducing environmental footprint.

However, while DTG printing showcases superiority in environmental sustainability, screen printing maintains its relevance and viability in certain contexts. Screen printing's ability to handle high-volume production, print on a wide range of substrates, and achieve vibrant colors makes it a preferred choice for many garment decorators, particularly in commercial settings where efficiency and versatility are paramount.

The comparative analysis of performance attributes underscores the distinct strengths and weaknesses of each printing method. Screen printing excels in producing high-quality, durable prints on various fabric types, making it ideal for large-scale production runs and specialty applications such as specialty inks and effects. On the other hand, DTG printing offers unparalleled flexibility in printing complex designs with intricate details and gradients, catering to the growing demand for customization and personalized apparel.

Cost-effectiveness remains a critical consideration for garment decorators, with both screen printing and DTG printing offering unique advantages in terms of investment requirements, material costs, labor efficiency, and overhead expenses. While screen printing may entail lower initial investment and material costs for large production volumes, DTG printing offers competitive pricing for smaller batch sizes and variable data printing, making it an attractive option for on-demand and short-run printing.

Market relevance and consumer preference play a pivotal role in shaping industry dynamics and adoption trends. As consumer demand for customized, sustainable apparel continues to grow, DTG printing's ability to deliver high-quality, eco-friendly prints on-demand positions it as a compelling solution for garment decorators seeking to meet evolving market demands and differentiate themselves in a competitive landscape.

In conclusion, the comparative and sustainability analysis of screen printing versus DTG printing underscores the importance of considering multiple factors—including environmental impact, performance attributes, cost-effectiveness, and market dynamics—when selecting a printing method for garment decoration. While both screen printing and DTG printing offer distinct advantages and applications, the choice between the two ultimately depends on the specific requirements, priorities, and objectives of garment decorators and businesses within the evolving garment printing industry.

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