





EXECUTIVE SUMMARY

AGAINST A BACKDROP OF HIGH COSTS, LONG LEAD TIMES, MASSIVE UPFRONT COMMITMENTS TO MANUFACTURING CAPACITY AND MATERIALS, AND INTENSE SCRUTINY OF THEIR ENVIRONMENTAL CREDENTIALS, BRANDS ARE LOOKING TO INVEST IN SUPPLY CHAIN TECHNOLOGY THAT CAN PROVIDE MEASURABLE IMPROVEMENTS TO SPEED, COST, INNOVATION, AND SUSTAINABILITY.

DIGITAL, ON-DEMAND DYEING OF THREAD AND YARN HAS, FOR SOME TIME, BEEN DELIVERING A QUIET REVOLUTION IN ALL THESE AREAS, IN SAMPLING, FOR A WIDE RANGE OF PRODUCT CATEGORIES. IT'S IMPROVED MANUFACTURING YIELDS, TRANSFORMED SAMPLE CREATION TIMES FROM WEEKS TO HOURS, REDUCED MINIMUM ORDER QUANTITIES FROM KILOS TO FRACTIONS OF A GRAM, REPLACED SUBJECTIVE, ITERATIVE DYEING WITH EXACT DIGITAL REFERENCE MATCHING, CUT TONS OF SYNTHETICS FROM FASHION'S ENVIRONMENTAL FOOTPRINT, AND UNLOCKED NEW CREATIVE POSSIBILITIES.

THOSE BENEFITS ARE NOW ABOUT TO EXTEND INTO FULL-SCALE PRODUCTION - EXEMPLIFIED BY THE LAUNCH OF TWINE'S NEW TWINEX4 PLATFORM, WHICH BRINGS SIGNIFICANT SPEED, CREATIVITY, AND SUSTAINABILITY IMPROVEMENTS TO THE LONG-UNTOUCHED PROCESS OF DYEING. NOW A SINGLE STEP IN THE SUPPLY CHAIN REPRESENTS A SHOWCASE FOR HOW BRANDS AND THEIR PARTNERS CAN TAKE QUANTIFIABLE ACTION ON THEIR SUPPLY CHAIN STABILITY, INCREASE THE LIKELIHOOD OF THEIR PRODUCTS SUCCEEDING, AND IMPROVE THE HEALTH OF THEIR BOTTOM LINE.



OVERCOMING UNCERTAINTY

2023 may be a new year, but uncertainty still surrounds us. Many countries managed to avoid an economic recession, but the cost of essential commodities is still a rollercoaster. Spikes in consumer pricing might make for better headlines, of course, but a similar tug-of-war is taking place both up and downstream from brands like yours – with a constant, unpredictable push and pull around manufacturing capacity, raw materials, processing and manufacturing, regulatory scrutiny, and consumer demand.

All of which means that stability comes at a premium right now. With so much that's unknown in the cultural and commercial landscape, and with the known quantities (like sustainability legislation) also undergoing historic change, fashion brands and their supply chain partners are all in pursuit of ways to target stability, methods to get ahead of unpredictability, and tools to blunt its impact.

For brands, those tools fall into four categories: creativity and innovation, speed, cost and efficiency control, and sustainability.

By creating exciting products, introducing fresh categories, building novel experiences, or targeting new markets and different demographics, brands can aim to outpace uncertainty by brute force; doing enough that's new to remain several steps ahead of disruption to their established business models.

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AND NO
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AS THEY COULD BE.

By optimising the route to market that existing products take, brands are able to shrink the gap between market demand and fulfilment, or between initial concept and finished product. And since longer development cycles increase the window within which disruption can take place, quick time to market does the opposite: making it more likely that final products will meet their predicted targets.

By identifying and exercising ways to control their costs, brands can increase that margin - adding a buffer between themselves and the unforeseen, ringfencing profitability expectations, and improving accountability.

And by measuring and beginning to manage key sustainability variables such as waste, resource consumption, and carbon footprint, brands are aiming to equip themselves with the data they're going to need to meet the expectations of consumers and regulators.

For the fashion industry as a whole – across every segment, from broad-brush ones like apparel, to more fine-grained sectors like performance socks – each of these tools is currently a work-in-progress. No brand, no retailer, no manufacturer considers themselves as innovative, fast, cost-effective, and sustainable as they could be.

But each tool is also equally important, which has led to that constant push and pull of different variables, different commodities, and different priorities. For organisations that want to simultaneously improve their ability to innovate, their time to market, their efficiency and profitability, and their impact on people and planet, the impetus is to find ways of measuring and positively changing all those things at once.

What if the potential existed to make a quantifiable improvement to them all, by swapping an inflexible, slow, expensive, and wasteful analogue process that sits at the heart of prototyping, sampling, and production with a digital one? In the current climate, that's a possibility that every brand and manufacturer would want to explore. And it's also a possibility that digital dyeing has been quietly delivering against for some time in a focused way, concentrated on overhauling the way

prototypes and samples for a range of different products are produced. But those benefits are now set to be translated into large-scale production to increase efficiency, reduce the need for brands like yours to hold inventory, and much more.





DIGITAL DYEING: THE QUIET REVOLUTION GETS LOUDER

Digital dyeing is, like the name suggests, a digital replacement for the traditional dyeing process. Just as digital, direct-tofabric printing has done for the material space, digital dyeing swaps an iterative, analogue, high-volume offshore process for a fully digital alternative.

Digital dyeing allows anyone to dye smaller batches of raw thread or yarn to match a digital reference, using small-footprint hardware that brings the dyeing process inhouse, giving accurate single colour or gradient results, first-time, and outputting yarns that are ready to use, straight away, in sewing, knitting, or embroidery. It's also a waterless process, unlike traditional water-intensive and effluent-outputting dyeing.

And once a digital colour reference is set, it has two key advantages over traditional dyeing. If everything else goes to plan in sourcing, it's guaranteed to remain accurate, from initial intent to finished product. This gives brands full control over colour through the garment production process (including cutting and sewing) that can operate considerably faster and more cost-effectively than the analogue alternative - as well as empowering manufacturers to create samples faster and create confidence for their customers through precise colour-matching. And in the event that things change during sourcing, and a change in fabric colour necessitates a change in thread to match, digital dyeing offers both brands and producers the flexibility to switch to

address deviations quickly - without having to discard huge quantities of pre-dyed threads or yarns at a significant cost and with a marked environmental impact.

But while digital fabric printing has captured headlines, digital thread dyeing has so far been a quieter revolution – a profound shift for the brands and manufacturers that have made use of it by adopting previous-generation hardware from Twine Solutions for their prototyping and sampling processes, but a technology segment that's not as widely-known as its digital counterpart in materials.

Yarns and threads, though, have an outsize impact on all the variables – innovation, speed, cost, and sustainability – in fashion's future-facing toolkit today. Fabric may represent the lion's share of a product's composition, but threads are foundational to the lifecycles of a range of different product types and operations: jackets, accessories, athleisure, lingerie, shirts, dresses, trousers, and more.

This is before we consider categories where colour-matched yarns are the "hero" item on the bill of materials, such as socks and woven ribbons. In these scenarios, the benefits of replacing a longstanding, wasteful, analogue process that runs on iteration and interpretation are already felt especially strongly in the early cycles of product design, development, prototyping and sample iterations.





THE ANALOGUE TO DIGITAL UPLIFT IN SAMPLING, AND HOW IT TRANSLATES TO LARGER -SCALE SOURCING, AND PRODUCTION.

A lot happens in fashion during planning, merchandising, creative design and development. These are complex tasks, with a lot of variables to take into account. But their share of the overall timeline required to bring a product to market is small compared to the lengthy cycle of sourcing, prototyping, sampling, production, and logistics – which collectively make up the modern supply chain.

When it comes to calculating the performance of a product, material and labour represent by far the biggest cost and time implications. And as a result, the impact that the supply chain has on the success of an individual product, and the brand and manufacturer who collaborate to make it, is large. And that impact has the potential to be both positive and negative – either causing bottlenecks, delays, cost overruns and imperfections, or providing agility, transparency, and efficiency.

This may sound simplistic, but often the difference between those two outcomes is whether a supply chain is made up of analogue or digital links. Analogue supply chains are largely made up of sequential processes that are architected around the principle of high-volume orders and upfront commitments. Once a product enters an all-analogue supply chain, there's little flexibility along the well-worn, time-consuming route to market: multiple rounds of inexact samples, large commitments to material, yarn, thread, and trim ordering, and the necessity to reserve production capacity at scale.

An all-digital supply chain would offer the polar opposite: virtual sampling followed by on-demand, in-house digital production of physical samples in days or hours; exact results; low minimum order quantities for materials and components, and agile, turnkey digital manufacturing.

For forward-thinking executives, the idea of an all-digital value chain is right now driving a great deal of investment and innovation across the apparel and accessories sectors, even though – so far at least – no single brand or manufacturer has completely realised that vision, at scale. But it's important to realise that a marked competitive advantage can be achieved by replacing just one analogue step in the supply chain with a digital one – both in the initial prototyping and sampling stage, and in the compounded benefits that are now ready to be realised during full-scale production.



A MARKED COMPETITIVE ADVANTAGE CAN BE ACHIEVED BY REPLACING JUST ONE ANALOGUE STEP IN THE SUPPLY CHAIN WITH A DIGITAL ONE – BOTH IN THE INITIAL PROTOTYPING AND SAMPLING STAGE, AND IN THE COMPOUNDED BENEFITS THAT ARE NOW READY TO BE REALISED DURING FULL-SCALE PRODUCTION.

Let's think back to uncertainty – the dominant force in the fashion market in 2023. In an environment where it's unclear how much product needs to be made in order to meet fluctuating demand, production is at the heart of margin – it's the key that needs to be turned precisely the right amount (on exactly the right timeline) in order to avoid under or over-production.

And in a world where manufacturing timelines are far longer than evershrinking market windows allow for, the speed of prototyping and sampling is directly correlated with the ability to make a quick, correct decision on what products to bring to market – followed by production that must run smoothly and quickly enough for a product to reach the market in time to maximise its chances of selling-through at full price. How fast you make, determines the performance of what you make.

In addition to speed, let's also consider the other tools that brands and their partners have to get ahead of uncertainty, and how swapping one or more analogue steps for digital alternatives can improve those tools.

Consider innovation first. Trying something new - whether it's a new colour, a new embellishment, a new style, or a new category - is expensive and time-consuming when it relies on an iterative process of repeat sampling, with each cycle having its own footprint in time, waste, and material consumption. This steady erosion of value in the process of refining a new idea leads, almost inevitably, to organisations leaning away from innovating too heavily, because the analogue process of bringing those innovations to life is so fraught with delays, bottlenecks, and other roadblocks. Replacing that sampling process with one that's faster, more cost-effective, and that makes smarter, more sustainable use of resources would, therefore, give brands and their partners greater confidence in their ability to invent - and with the introduction of Twine's X4 hardware, that same confidence can be relied on in full production.

Let's also think about cost and efficiency. Whether we're talking about sampling or production, manufacturing is not a perfect process; even when the right materials and components are sourced, turning them into a sample or finished product that meets the original design intent is not guaranteed. Using analogue methods, the typical production yield is believed to be somewhere between 85% and 90%, with inefficiencies baked into the cycle due to delays, set-up times, and inaccuracies. All of these can be reduced to a greater or lesser extent by substituting traditional methods with digital-native ones.

And the impact of analogue sourcing and production on fashion's environmental and humanitarian footprint is well-documented. Both prototyping and bulk production create significant amounts of waste, deplete essential resources, and compound those issues over multiple rounds of iteration. If we concentrate on dyeing only, as an example, switching from analogue to digital processes for sampling and production could save up to half a million litres of water in a single year, reduce CO2 output and chemical usage by between 40-50%, and divert up to 50% of thread from either ending up in costly storage or in landfills.

Sustainability is different from the other tools we've mentioned, because while targets for speed, cost, and innovation are all set by brands and their partners, environmental and ethical legislation is applying formal, external pressure. Supply chains are increasingly becoming subject to data disclosure requirements that cover carbon footprint, material waste, pollution, water usage and more. And while some brands have worked towards quantifying

the environmental impact of finished products, very few have done the same at the sample stage or in the finite detail required to measure the impact of, for example, dyeing large volumes of thread that subsequently go unused.

Sustainability, then, is perhaps the area where making an analogue-to-digital swap in the means and the mechanics of manufacturing can make the most difference – and it's one where digital dyeing especially, as a waterless, right-first-time process, has a very clear-cut benefit.

These, though, are all industry-wide shifts. And as we've already established, brands like yours are likely trying to improve all of these variables, making it impractical to make simultaneous, sweeping changes everywhere. So now that we understand the theory of replacing analogue supply chain links with digital ones, let's take a look at a discrete example: a case where replacing just one centuries-old analogue process with a single-step digital alternative can have an outsize impact on not just how

inventive a finished product can be, how quickly it can get to market, the cost of sampling and producing it, or its sustainability profile, but all of those things at once.



THE DIGITAL DYEING DIFFERENCE.

The traditional dyeing process has remained relatively unchanged for close to a millennium. Its industrial scale might have changed, but the essential pillars of taking raw thread and colouring it to a desired specification are still based on an additive, iterative, resource-intensive process that successively dyes different batches to achieve a result that, subjectively, looks like it matches the original intent, before a large minimum order is placed for the final, approved, recipe. Digital dyeing is a resource-efficient, single-step process that dyes any length of raw thread to an exact, objective, digital colour reference.

So what would it look like in practice to swap traditional dyeing to digital dyeing? As we've established, threads and yarns feature on the bill of materials for many different products – from outerwear to intimates – but to really examine the results of this swap, we should examine product categories where yarns and threads are the main component: socks and woven ribbons and tapes. As basic staples, and categories with firmly-established seamless manufacturing methods, these are products that change very little in their shape and purpose, making them prime candidates for examining the benefits of digital dyeing in isolation.

And these are also categories where we don't need to rely on guesswork. In both athletic socks and woven ribbons, major brands and their production partners have already been stress-testing Twine's prior-generation dyeing system for their sampling processes, and the data they have anonymously provided allows for direct quantification the results in each of the four key areas we know that brands, retailers, and manufacturers are investing to overcome uncertainty.

In innovation: swapping analogue dyeing for digital dyeing has allowed these organisations to experiment with more colours of polyester threads and yarns than ever before, due to the ability to instantly dye small lengths rather than commissioning bulk orders that take time to deliver. And at the same time, the companies using the Twine system have also been able to innovate with dyeing in digital gradients – achieving results that are literally impossible to accomplish with analogue methods – as well as giving themselves the flexibility to visualise new ideas by doing this all in-house.



In speed and cost: unlike traditional dyeing, where these brands and suppliers were accustomed to having to order kilos' worth of yarn in order to meet MOQs, digital dyeing has allowed them to dye only what they need to create a sample, which can be as little as 0.5 grams. As well as eliminating waste and unnecessary cost, this switch has transformed the pace of sample production; rather than waiting 5-7 days, these Twine users can now dye enough thread to produce 10 pairs of socks, or a batch of ribbons, in hours.

In sustainability: where they were previously reliant on sourcing environmentally-damaging nylon yarns for the creation of designs and logos, the switch to digital dyeing has allowed them achieve similar results with less resource-intensive PBT yarns. In practice this has translated between 0.5 to 1 ton reduction in the use of synthetic yarns. And as a fully waterless system, every time these brands opted to use digital in place of traditional dyeing (which is also a heavily polluting process), their sustainability credentials measurably increased.

And it's important to remember that these results were seen just in sampling, using Twine's previous system. With the release of the new X4 system, designed for full-scale production at a capacity that will allow these and other brands (and their partners) to swap manufacturing, at scale, from analogue to digital, the X4 system is design to build on what's gone before, and to boost production floor efficiency, yield, cost, and sustainability.

For supply chains that manage millions of pairs of socks, or similar volumes of woven ribbons, compounding these innovation, speed, cost, and sustainability benefits across production volume is likely to deliver a transformative impact at both the individual SKU level (since margins are low on products that are sold for a few dollars a piece) and the overall bottom line. Saving days of lead time, up to 8 tons of waste, huge volumes of water, at the same time as unlocking new creative possibilities and closing the distance between represents a stepchange in the way the industry operates.

The potential quantifiable impact would also reflect the depth of the transformation: even a single percentage point of improvement made to production efficiency (achieved through the combination of speed, efficiency, waste reduction, and sustainability) could translate into hundreds of thousands of dollars of direct and indirect savings – all from the replacement of a single step in the supply chain with a digital alternative. And where Twine's X4 system is concerned, efficiency savings of up to 3% are expected – representing a direct monetary saving measured in hundreds of thousands, if not millions, of dollars per year.

And while the most pronounced benefits will be seen in categories where yarns and threads make up the bulk of the bill of materials, the relative difference achieved by switching from analogue to digital dyeing in the wide variety of other product categories that also incorporate threads and yarns will be the same.

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IN A WORLD OF SWEEPING CHANGE, A SINGLE STEP CAN STILL MAKE A MASSIVE DIFFERENCE.

There have long been compelling arguments for improving the way the fashion industry sources and produces. In the eyes of brands, mills, manufacturers, consumers, and analysts, the current model has continued primarily due to a lack of alternatives. And when those alternatives have been proposed, they have required the industry to make huge, sweeping changes on a scale that few companies are comfortable with.

Digital dyeing, on the other hand, represents something different – something closer, more achievable, and something that's already demonstrated results that logic suggests will scale in a major way now that the same principles can be extended from sampling into production.

Threads and yarns may be a "hidden" part of the supply chain for many organisations, but their impact on speed to market, innovation possibility, cost, and sustainability are measurable – and improving them can translate into a big difference to your bottom line.

2023 is likely to be a year in which big changes continue to take place outside your direct control. From the cost of raw materials to the shape and scope of consumer demand, the world is still characterised by unpredictability – meaning that any changes you can make to your core business of designing and making fashion to soften the impact of that uncertainty will be a net benefit to your bottom line.

Based on the results we're already seeing in sampling, and the potential for the future of full-scale production, making an investment in digital dyeing, now that it's ready for use in full-scale production, could be a very strong start to changing your supply chain to better fit this new world.



ABOUT THE AUTHORS



Twine Solutions is a technology company that has developed a digital thread and yarn dyeing technology, that dyes white/raw/recycled polyester thread and yarn using a waterless process. With Twine dyeing systems and proprietary inks, brands and manufacturers are able to dye their thread in-house, on-demand, ready for immediate use for their sewing, knitting and narrow weaving needs.

Twine technology saves on lead times, thread waste by removing the minimum order requirements and logistics around thread orders. In addition to waste reduction, Twine's technology helps brands reach their goals of sustainability with zero water used in the dyeing process and less energy consumption than the conventional process. All this, without compromising on colour and creativity, with the capability of dyeing multiple colours and colour gradients on a single yarn.

INTERLINE

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