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Fast-Forward: Proposals for a Light and Restorative Fashion Alternative

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Abstract
The increasing dominance of 'fast fashion' in the current commercial context, has resulted in a market full of products designed to be economically efficient in production. Clothing sales are increasing in volume and their lifespan is reducing (Ellen MacArthur Foundation 2017). The prevailing, and rightly accepted response to this issue is to focus on 'slowing down the fashion system'. However, researchers here acknowledge that there may need to be an alternative for parts of the clothing market. Not all garment archetypes are suitable for long-life.

The emergence of 'fibre to fibre' recycling technologies allows us to think of longevity in a different way; from a 'material recovery' perspective and not only through extending product life. The question becomes; can we make fast-fashion better, with lighter impacts on the environment? Can fast-recovery become a viable circular strategy for at least part of the fashion and clothing market? Can we achieve an overall reduction in 'environmental cost per wear', with new material and production models?

This paper reflects on a practice-led and multidisciplinary project, within the Mistra Future Fashion programme (2011-2019), which tested new proposals for systemic change in the fashion market (Goldsworthy and Earley 2019). The design research task was both to challenge established understanding of best practice in sustainability and also to present alternative visions for consideration. Through the design of the project, the aim was to develop new ways to foster the deep collaboration needed to solve the complex problem of making fashion circular.

A new wearable 'paper' was developed and other commercially available nonwoven materials reworked, as inexpensive twenty-first century fabrics with intentionally short lifespans, that can be effectively recycled or industrially composted. The materials were transformed through innovative finishing techniques and tested with scientific partners for strength, recyclability, compostability, environmental impacts and importantly, user acceptance.

Keywords: practice-research; circular design; material innovation; design for recycling, fashion

Context: Fast AND Sustainable?

There are currently over seven billion people on the planet, increasing by 200,000 people each day (World-Population Clock 2019), and access to material resources is critical to their needs and to the future of production. Diminishing and finite supplies coupled with added demand, impact heavily on the environment, requiring creative solutions for more sustainable ways to live. By 2050 it is estimated that approximately 68% of the world's population will be living in urban areas, which currently occupy only 2% of the world's landmass and consume 80% of the world's energy. (World Urbanization Prospects, 2019:10)

What place does design for fashion have in this material future? The current fast fashion system's huge contribution to energy consumption, pollution and waste of resources is undeniable. In particular, environmental damage results from the material lifecycle stages of extraction, cultivation, production, transportation, use and disposal, leading to the need for urgent reform (Fletcher 20011, Fry 2009). While it is easy to identify the economic and environmental impacts of fast fashion, it is much harder to quantify the meaning and value of fast fashion to its many consumers – both for those in affluent societies, who can afford change and in burgeoning economies, where affluence is increasing.

Fashion plays a vital part in the psyche of people in all cultures. Trentmann (2016) in his concept of the 'material self', suggests that owning goods is part of a definition of being human. Fast-changing fashion offers us direct communication with others, even if it is subject to the manufactured narrative of a commercial retail system. A younger population uses fashion as a means of validation and inclusion. Certainly, if we want to encourage more sustainable behaviour in young fashion consumers - disparaging the use of fashion for experimental identity seems to be counter-productive, as sales are increasing. And, for a mature population with a more internalised concept of 'self', it becomes a means of recreation identity and play. Through ethnographic study, Miller (2010) suggests that our clothes '…don't so much change us as reveal us to ourselves: reveal the true inner and relatively consistent self within.' This is key to the importance of fashion '…in determining what the self is'. (Miller 2010: 220).

The biggest challenge to radical design proposals to challenge current behaviour around fashion, is any acceptance of change by consumers. This is true of any attempt to slow down consumption or encourage responsible disposal practices. Our goal, therefore, is to produce persuasive prototypes, which do not demand change but inspire it. Behavioural scientists agree that the brain's most powerful default settings are acquired habit and social copying (Bentley et al. 2011). This is not lost on advertising executives, who posit that we probably do not lack highly innovative designers but instead, lack confident, adventurous consumers (Skinner 1978). This applies just as much in developing countries, whose patterns of consumption copy what has been established elsewhere. However, the prospect of a well-designed product with an intentionally short or long lifespan, which reflects local social conditions makes the potential of a future 'materials ecology' become more tangible.

It is essential that definitions of sustainability are continually revised for effective action, to achieve system based, long term, ethical design (Madge 1997, Tonkinwise 2015). Design for fashion sustainability has inevitably and rightly concentrated on the benefits of 'slow', with an emphasis on product longevity. However, we believe that this has been at the expense of seeking a sustainable 'fast', which allows for short-lived garments and for longevity of the material.

There is a shocking lack of serious design thinking about disrupting patterns of the consumption of fast fashion through design innovation. The concept of 'fast', in relation to cheap fashion, simply refers to the speed of production and 'time-in-use' of a product. This does not allow for the potential recovery of the material which can continue on its journey into further product cycles. In this case the material itself could be considered 'slow'.

There is also a tendency to automatically associate 'fast' in a negative context. This is not always the case. In nature, short-lived cycles serve a valuable, useful purpose while being very beautiful and complementary to other, long-lived cycles. In the Japanese tradition 'mono no aware', short cycles in nature such as cherry blossom or falling autumn leaves are appreciated and prized because of, not in spite of, their dazzlingly brief existence. Latour (2005) suggests that while the concept of the material fabric of society is seen as different from nature and not intrinsic to it, the situation will not improve. So, a great opportunity exists in fashion to mimic the poetic qualities of transient cycles in nature, providing the nutrients for an ecology of fashion.

The approach to designing for 'fast' can differ from slow, heritage garments – a particular, fast aesthetic could be developed - and celebrated – from the constraints and advantages of a new fast system, freed from moral approbation. So, when we set about examining the narrative around sustainability, the insistence that sustainable should always equal slow is diminishing the urgency to redesign the production of high-volume, mass produced, inexpensive garments, which are a large and increasing, section of the market today. This is not purely a material consideration; if fast fashion is to become more sustainable, industry must also seek profit from the circuit of material flow (to retain resources in the system) or subscription services (to add value to the consumer). Designers can decide what would be in peoples' best interests and set about researching the design of persuasive offers to influence behaviour for the better. Or, they can recognise what it is that people want and offer design to transform and improve the consequential outcomes. Both are provocations for material and social change (Schon 1983).

Fast: working towards material recovery

Early in the project we framed potential approaches and technologies to define our briefs by unreviewing existing practice and industry. The goal was to develop strategies which might be used to reshape the mass-fashion market and, in the process, we identified three key approaches to guide us (Goldsworthy et al. 2018).

<u>1. Advancing Material Recovery: recovering virgin-quality materials from existing textile waste streams</u>
The rapid progress of recycling technology is providing hope for the future of material recovery. There are potential step changes in fibre-to-fibre recycling technologies; cellulose, polyester and nylon recovery are now possible at pilot scale. Even waste streams from other systems, such as food waste, are being utilised to a much higher value than ever before. Designers are becoming ever more involved in these technological and scientific developments, often bringing new insights and innovations.

<u>2. Designing FOR Recovery: In-built design features which enable more efficient recovery to support material recovery</u>
Designers now need to understand and assess which of these end of life opportunities is most relevant to their design process and be able to respond accordingly to the requirements of the system. Ease of recyclability can be built into design practices in a multitude of ways; through design for disassembly, use of monomaterials, which relate either to the biological or technical system, and use of biocompatible or technical finishes and production processes which also fit the end of life intention.

<u>3. Reducing Production Impacts; Innovative production systems which reduce overall impacts of garments.</u>
This concept of 'lighter' production systems which impact more gently on our environmental and economic systems is a huge area of potential improvement. We must enable more streamlined and vertical manufacturing opportunities, redistributed production, automation and mass customisation. Local and decentralised production can be connected to highly technological solutions.

A Trans-disciplinary Approach: the role of design

The design concepts were developed between 2015-2018 in close collaboration with the material and social science partners working on the project (figure 1). The resulting research concepts spanned the fast to slow spectrum. They explored the themes proposed at the start of the research and evolved through an iterative process during the project.

Integral to the development of good design practice are the current ideas from relevant disciplines: anthropology, business studies, materials science, behavioural economics, design studies, histories of dress and theories of sustainability. This multi-disciplinary integration is at the very heart of the project. From the outset, it was clear that we would need to find new methods of collaboration if we were to be able to implement scientific insight into the heart of the design process. We wrote these collaborations into the project at the development stage; with recycling science to set the brief for recyclability; with social science to test the user perception and acceptance of our materials; with material scientists to co-develop new materials; and with environmental scientists to understand the implications of our design decisions along the way.

Design research serves as a vital means of connection between these scientific practices. In 1986, Appadurai described the social role of artists as critical as '…they are thinking about new ways to arrange things'. He commends their ability to imagine new possibilities and form alliances with other disciplines, which can have practical applications (Appadurai 1986). To benefit social progress, the imagination of artists and designers needs to be connected to innovation in science and technology. In an interview, Tonkinwise (2015) pointed out that the job of design is not connected to the creation of artifacts, whether communications, products, or environments. But the practice of design is actually about persuading a wide range of actors – fellow designers, suppliers, investors, logistics managers, users in households, workplaces or public spaces, etc. to work together on materialising a future in which such an artifact exists.

Figure 1: Workshop images from collaborative aspects within the project.

Developing a Paper Textile for 'Fast & Light' Fashion

Textile nonwovens, in general, are an underdeveloped material in fashion, which can offer sustainable advantages for some garments. We took the decision to work with paper production, as an extreme test for 'fast' material credentials for our specific needs. Being an established Swedish industry using ubiquitous materials and processes, it represents the extreme end of textile nonwovens and is an industry with many credentials appropriate for sustainable production and with established recycling systems. So, fashion could lead the way for industries to embrace automation and collaborate across different industries to benefit from speculative design with a sustainable agenda.

Through collaboration with Dr Hjalmar Granberg (Research Institutes of Sweden - RISE) and his team, we worked to produce a wearable paper with its function enhanced through finishes (figure 2). Using unbleached wood pulp and other bio-based sources, a new paper non-woven material has been developed using natural dyes, laser surfacing and ultrasonic construction methods, to reduce chemicals and energy at all stages of the lifecycle of this 'fast-fashion' replacement.

Figure 2: Workshop images from collaborative aspects within the project.

This twenty-first century version of wearable paper capitalises on new technologies, employed to provide automated production and potential for customisation. Rapid manufacture includes the production of the material and garment shapes in the same machine, for a lifecycle that is intentionally short but responsible. Local production and reduced carbon footprint are enhanced by light, flexible materials and processes. Efficient recovery at end of life, through standard paper recycling processes, avoids plastic in the ocean and introduces a guilt-free approach to the fast section of a modern wardrobe, otherwise composed of quality and vintage pieces.

We identified two paper recipes from RISE research, suitable for fashion prototypes. Using a StratEx semi pilot Sheet Former, layered structures with randomly deposited fibres were produced (figure 3). The two papers: one predominantly made of wood pulp and one with a large Polylactic Acid (PLA) content. In short, a strong but stiff structure which needs finishing to soften it and a soft but weak structure, which needs finishing to strengthen it. The PLA-rich paper The PLA (polylactic acid) is derived from corn starch, while current research in Sweden is enabling PLA to be developed also from wood pulp.

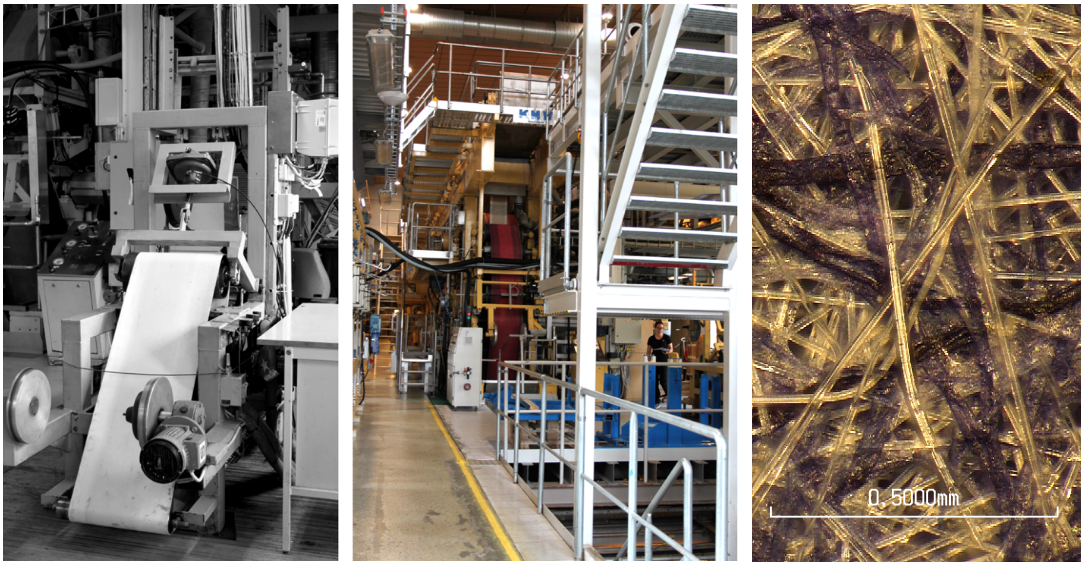

Figure 3: Developing a new nonwoven with the team at RISE Bio Innovation, Stockholm.

Samples with low PLA fibre content showed excellent strength, and hand crimping imbued samples with stretch and a muffled sound. Samples with a large PLA fiber content showed considerably smaller strength but were softer to the touch. A spot-welding pattern at a 3 mm distance, similar to the fibre length, increased both strength and strain at break. Industrial dry creping resulted in excellent stretch and some drape.

For the third material story we chose to work with existing commercially available nonwovens. In 2017 we conducted a thorough materials review resulting in a library of over 200 samples from most major fibre groups. This collection is housed at Centre for Circular Design (CCD) at University of the Arts London and was the basis of many material decisions for the prototypes.

This study demonstrated that it is the interplay of choices made throughout production, such as mixture of input fibers, in combination with choices at the finishing stage, such as crimping and welding, that determines the span of textile-like characteristics possible in a paper-based nonwoven.

Three Design Concepts / Three Recovery Ambitions

The Fast-Forward concepts explore alternative modes of production and use for a sustainable ‘fast-fashion’ application (figure 4). ‘…for textiles, about 50% of the climate impact is caused by textile processing (yarn production, fabric production and wet treatment.’ (Roos et al 2019:22) Life Cycle Analysis (LCA) advantages are therefore to be gained by reducing production impacts through lighter material choices; nonwoven fabric production; no laundering; clear routes to recovery (designed-in at the outset); redistributed manufacturing systems. A sliding scale of ‘speed’ is explored from ultra-fast forward (shortest-life scenario) through to a more accepted length of use with adaptations to production processes and end of life.

This offer amplifies the opposite approach of designing slow and enduring pieces to better understand the full spectrum of challenges from fast to slow fashion. Materials have been specifically developed for the project in collaboration with scientific partners, and processes imagined as mass automated systems. For this version of fast fashion to be complementary to durable quality products, industry must shift profit-making activity from the one-off sale of goods to gain value from the circuit of material flow or service-based models. These concepts evolve through multiple lifetimes but rather than change over time as a product, this story reflects the idea of 'material longevity' with multiple loops of efficient recovery at the heart of the sustainability focus. We see a great opportunity to mimic the qualities of transient cycles in nature, to provide the nutrients for an ecology of fashion.

Paper Leather (CEL)	**PULP-IT** (CEL/PLA)	**LASER LINE** (RPET)
Natural dye, cellulose adhesive seams, bio-based water repellence.	Natural dye (indigo), laser quilted layers, sonic welded seams.	Industrial nonwoven fabric, laser quilted layers, sonic welded seams.
Newspaper Recycling	**Industrial Composting**	**Chemical Recycling**

Figure 4: Fast-Forward concepts and final prototypes.

Paper Leather Jacket: Paper Recipe No 9

This concept was designed for short-life with light and low-impact materials and recovery at end of life through paper recycling processes (figure 5).

Figure 5: Paper Leather Jacket, prototype and lifecycle map by Politowicz, 2018.

<u>Material and Production:</u> Made from a new bio-based nonwoven material co-developed by RISE & UAL. The composition of the paper in this prototype is 95% Cellulose pulp and 5% bio-based PLA fibre. Whilst the first product in this cycle will be made from virgin materials it is hoped that it would be possible to use recovered or regenerated materials (CEL and PLA) in subsequent cycles, or recycled paper fibre content.

<u>Use:</u> The use phase of this product is intentionally short. It is designed to be worn around 12 times over 6 months without laundry or maintenance and then returned for recovery and reprocessing. The whole cycle from raw material to recovered raw material is 10 months. Over a period of 50 years it is estimated that there would therefore be 60 ownership cycles (and 720 wears).

<u>Finishing and Dyeing:</u> The raw material is designed to be very strong but in its raw state is too stiff to be wearable. Finishing techniques are employed for both aesthetic and functional improvements. The paper is manipulated through repeated rolling in transverse directions, which softens it without appreciable loss of strength whilst colour is achieved through use of ground cochineal mixed with 2% Iron, ferrous sulphate powder, and 2-3% soaked logwood chips, applied to the finished paper or ideally into the pulp at the fibre stage.

<u>Recovery:</u> At the end of the six-month wear period, the user returns the jacket for recovery through domestic paper recycling channels. This is the beginning of the next material cycle. Results of recyclability testing show that the material is 99.9% recoverable as paper pulp which means it could be efficiently recycled.

Pulp-It Striped-T: Paper Recipe No 7

This prototype was produced from 100% bio-based materials and finishes and designed to be Recoverable at End of Life Through Industrial Composting (figure 6).

Figure 6: Pulp-It T, prototype and lifecycle map by Goldsworthy and Politowicz, 2018.

<u>Material and Production:</u> Made from a new bio-based nonwoven material co-developed by RISE & UAL. The 45 g/m^2 paper in this prototype is composed of 40% sulphate softwood paper pulp from sustainable forests, unbleached and unrefined; 3% CMF microfibrillated cellulose from wood; 57% polylactide (PLA corn starch) staple fibres. The main attribute of this material is its thermoplastic quality enabling many processes not usually possible with paper.

<u>Use:</u> The use phase of this product is intentionally short. It is designed to be worn around five times without laundry or maintenance intervention and then returned for recovery and reprocessing. The whole cycle from raw material through use to recovery is estimated at two months. Over a period of 50 years it is estimated that there would be 300 ownership cycles (and 1500 wears).

<u>Finishing and Dyeing:</u> The paper is prepared using a heat process to fix the fibres for further finishes and 'crushed' to soften the surface. The material is then naturally dyed without mordants, including dyestuffs: cochineal (Striped-T) and natural indigo (Panel-T). Laminated layers of PLA are added through various laser and welding processes. The garment is constructed using a Pfaff Ultrasonic machine as an alternative to traditional stitched seams.

<u>Recovery:</u> At the end of the five-week wear period, the user returns the top for industrial composting (into Co2, water and 'biomass'). This is the beginning of the next material cycle.

Laser Line Mono-T: Recycled Polyester

This fashion garment was produced with 100% RPET materials and integrated digital production and recovery cycles – local and flexible systems were a key feature to the concept (figure 7).

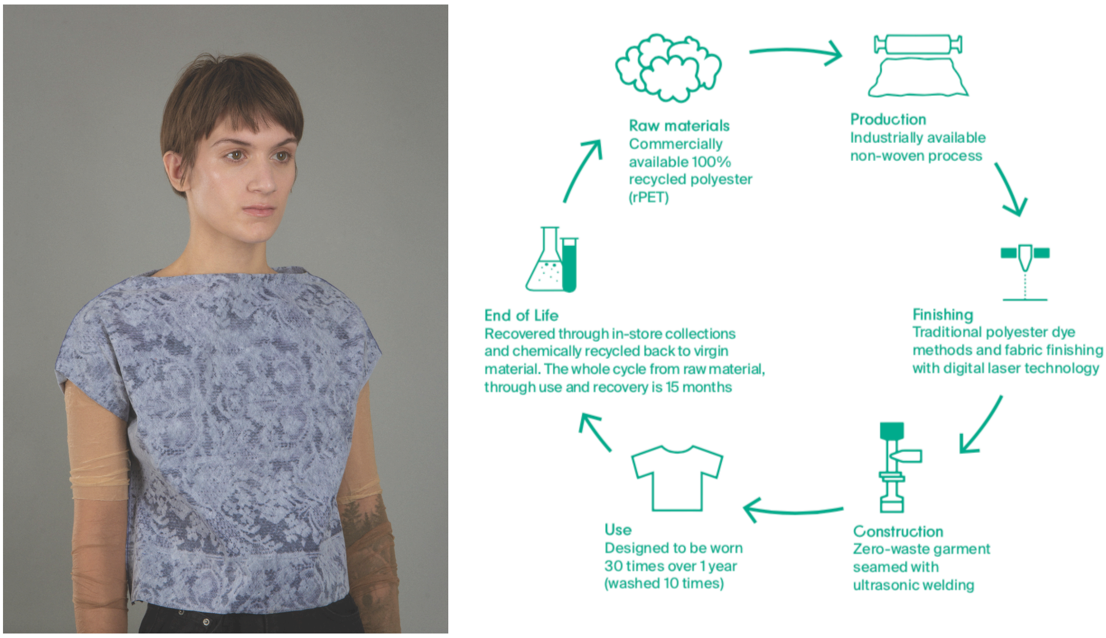

Figure 7: Laser Line T, prototype and lifecycle map by Goldsworthy, 2018.

<u>Material and Production:</u> The material in this concept has been enhanced through a laser welding finishing process. Made from commercially available 100% recycled polyester (RPET), the surface material is nonwoven in construction. No additional materials are added during the finishing and construction stages.

<u>Use:</u> The use phase of this product is comparable to a standard fashion top. It is designed to be worn around 30 times over one year with laundry anticipated after three wears and then returned for recovery and reprocessing. Durability of the nonwoven material is improved through the finishing techniques.

<u>Finishing and Dyeing:</u> The double-layer fabric is finished using a laser finishing print alternative which simultaneously adds decoration and material reinforcement. Designs can be digitally engineered and customised for local production close to market. Recyclability is retained through monomateriality. The garment is constructed using ultrasonic seaming technology with flat-bed construction.

<u>Recovery:</u> At the end of use the user returns the top for recovery through a chemical recycling system. The whole cycle from raw material to recovered material is 15 months. Over a period of 50 years it is estimated that there would be 40 ownership cycles.

Finishing Processes and Treatments

The transformation of these materials was absolutely key. By treating the original 'raw' nonwovens in varied and innovative ways we could create multiple end products with enhanced aesthetic and tactile qualities as well as improved performance and even recovery.

Each product concept was designed for a different end-of-use recovery method and as such needed to be 'treated' in accordance with that particular set of criteria. We focused on bio-based or mechanical processes and treatments in order to create the minimum impact during their production.

	Paper Leather	**Pulp-It**	**Laser Line**
Nonwoven Construction	Stratex Paper making Machine	Stratex Paper making Machine	Commercial Spun Laid Nonwoven
Fibre Content	95% CEL Pulp 5% PLA Fibre	43% CEL Pulp 57% PLA Fibre	100% RPET (recycled polyester)
Recovery Intention	Recycle as Paper (reslushing)	Industrial Composting	Chemical F2F Recycling
Colouration	Natural Dye (pulp dye possible)	Natural Dye (pulp dye possible)	Disperse Dye (fibre dye possible)
Water Resistence	OrganoClick	OrganoClick	NA
Stitch Alternative	CEL Adhesive	Ultrasound	Ultrasound
Stretch	NA	Micro Pleating	Micro Pleating
Multi-Layers	CEL Adhesive	Laser Quilting	Laser Quilting

Figure 8: Features of each of the three fast-forward concepts.

The pulp-rich paper was dyed open width in conventional, hot, natural-dye baths, using indigo, cochineal and buckthorne, largely without the use of mordants. A very strong material, it was nevertheless too stiff to be wearable in its manufactured state, so finishing techniques were employed for both functional and aesthetic purposes. Garment construction is with an aqueous cellulosic experimental adhesive from VTT Finland, from their current research into bio-adhesives.

Water resistance is an obvious concern about wearing paper - so we experimented widely with bio treatments, using a recent Swedish innovation – an organic cellulose–based showerproof coating from OrganoClick and waxes from soy.

Figure 9: Sample of finishes on nonwoven materials developed by Politowicz, Goldsworthy & Paine.

As all three material types contained a percentage of thermoplastic content (either in the PLA or RPET fibres) they could be manipulated through heat processes (figure 8). This proved to be an essential part of the material transformation for most end-uses. In the 'paper' textile qualities it could be used to impart extra strength and make other processes possible.

With the polyester-rich nonwovens, (both PLA and RPET qualities) it could be used to a much more dramatic effect. Laser-welding, sonic-welding and heat-pressing were all used to 'finish' the materials to impart strength, shine, lustre, colour changes, pleating, three-dimensional (3D) surfaces and even translucency. As well as surface effects, heat processes could also be used to laminate or combine multi-layers of different nonwoven qualities together for further enhancement (figures 9 and 10).

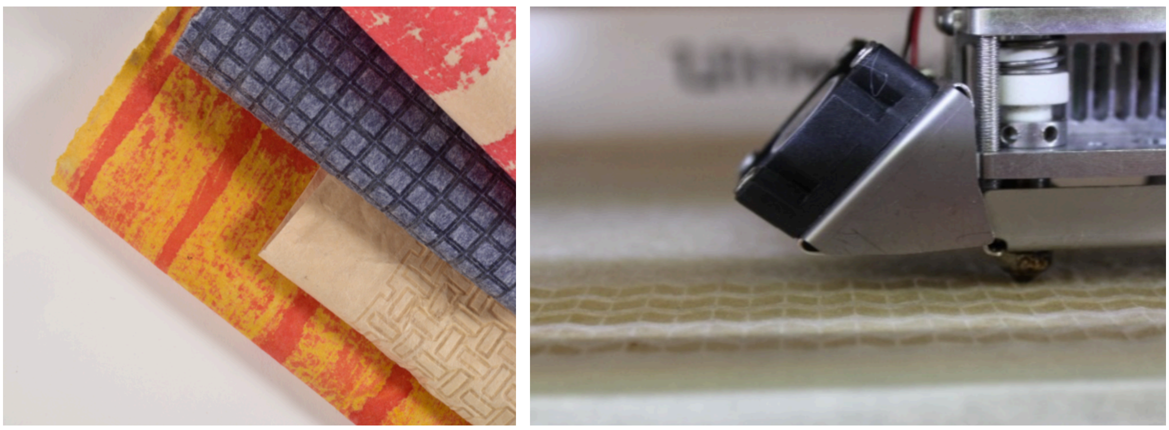

Figure 10: Using an Ultimaker 3D printer as a digital-drawing tool for surface finishes.

Conclusions

There is potential for these fast-forward concepts to be scaled up in an industrial context. Local networks of manufactures at all scales will be essential for this vision. Extended technical understanding within an existing manufacturing landscape presents opportunities for future development of local, fast and circular material and fashion systems.

Using garment prototypes we were able to test the viability of the idea, revising the garment to exploit and enhance the sustainable features. In all cases, design for benign obsolescence deliberately ends the life of the garment but preserves the life of the material. Future directions being developed include the use of 100% forest sources: recovered or regenerated materials, dyes developed from production waste to dye the pulp before production and bio degradable stretch fibres.

In a twenty-first century climate of political and environmental uncertainty, designers are trying to develop sustainability strategies in 'best design practice' for diverse global manufacture, where the nature of the material itself and its characteristics are key to design development. While the resulting discourse around appropriate material selection for fashion is dominated by promoting avoidance of the causes of damage, we believe there is a need for greater investment in proposals of successful alternatives. Today, we need equilibrium more than ever and no more simplistic binary arguments. The future for fashion fast and slow rests between the two, where it belongs, to include viable strategies for both. The reality is, throughout a lifetime, owning a mix of 'faster' and 'slower' garments is the solution to a vast range of cultural and economic conditions. How we view and design products, not as static objects but as dynamic and evolving systems, is key to this more sustainable future.

During the course of this research we reflected on our results and identified some key insights towards future research. In summary:

- All the Fast Forward concepts focused particularly on nonwoven materials. This was due to their potential for simultaneous mass manufacture and impact savings compared with traditional techniques (Peters et al. 2018).

- The key with this material was to develop new and appropriate finishing processes to improve their aesthetic, handle and performance while still preserving the necessary features for onward recycling. Over 200 physical samples were produced around a variety of finishing themes. They could be used to cost effectively produce large quantities of a single generic material in a paper machine, that later can be converted or tailored into a multitude of products fitting the needs of many.

- One way to circumnavigate the impacts of fast fashion could be to develop materials with significantly lower impacts during production, and which avoid the barriers to recycling faced by conventional garments. These short-life garment proposals have lower material impacts, compared with conventional cotton, due to the fact that they are relatively light weight and lower impacts in garment production and use (Peters et al. 2018).

- All finishes and construction needed to also be compatible with both recycling and composting processes. Therefore, natural dyes requiring no heavy mordants in their fixation were used; water-repellency was added through a bio-based treatment; garment seams were constructed using a new bio-based adhesive.

- The thermoplastic quality of the Pulp-It material enabled an extended range of finishes and construction techniques to be used; laser-finishing; sonic welded seaming; 'heat-soaking' of the material enabled natural dyes to be applied in a wet-process.

- In Laser Line both synthetic and bio-based nonwoven polyesters were explored to extend the potential of the process for chemical recovery (and also to extend the lifespan of an existing fast-fashion product.

- Additional spot-welding processes were also developed in collaboration with RISE using widely-available commercial equipment.

- The potential to enhance the materials in local hubs using digital non-toxic finishing methods also presents significant environmental gains.

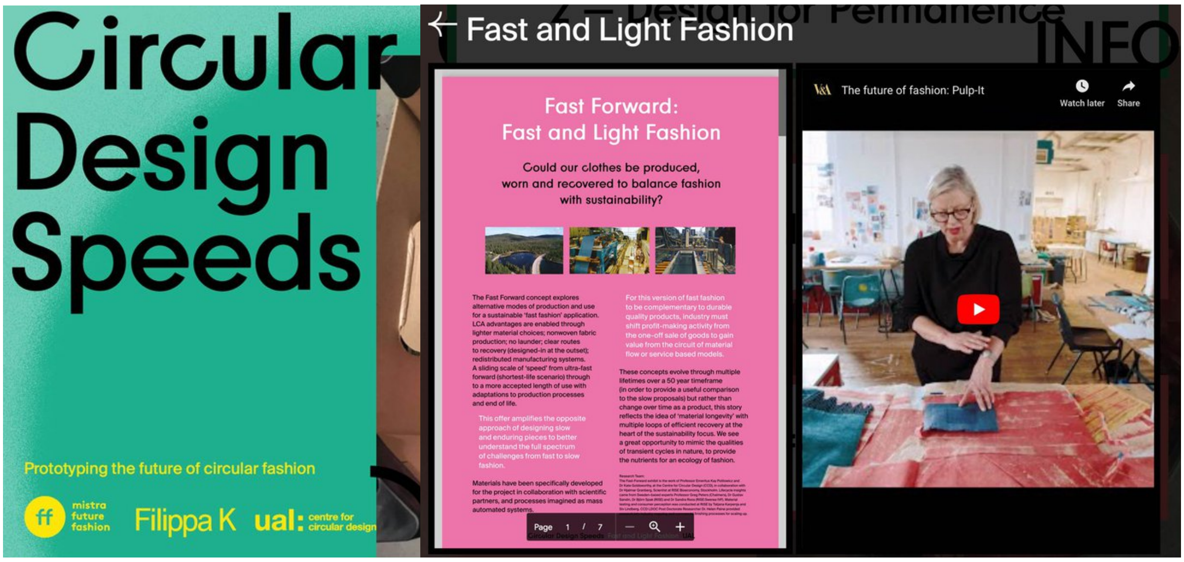

Figure 11: further information, videos and images can be found on the CDS Website.

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The Circular Design Speeds (CDS) project is available online at: www.circulardesignspeeds.com

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