

FROM RESPONSIVE DESIGN TO SUSTAINABLE SYSTEMS: DIGITAL LASER PROCESSING ACROSS THE TEXTILE PRODUCTION CYCLE

Dr Laura Morgan^{1,2}, Prof Jinsong Shen²,
Dr Janette Matthews¹, Prof John Tyrer³

¹School of the Arts, English and Drama, Loughborough University, Loughborough, UK;
²Textile Engineering and Materials Research Group, De Montfort University, Leicester, UK
³Wolfson School of Manufacturing and Mechanical Engineering, Loughborough University,

INTRODUCTION

Demand for efficient, environmentally sustainable and quick-to-market textile and fashion goods has increased demand for flexibility and responsiveness within manufacturing systems and supply chains [1,2]. In a shift from advance bulk ordering, responsive systems can produce goods to order according to demand, thereby reducing stockholding and subsequent waste. Digital technologies can facilitate agility in supply chains [3] by allowing late-stage design flexibility without complicated or costly set up.

Lasers provide a digitally-led, energy efficient processing tool. *Laser Peri-Dyeing* is a laser dye fixation method for textiles, that allows the dye reaction and diffusion to take place at the point of laser material interaction [4]. It provides efficient, targeted coloration and surface patterning of textiles. The non-contact CO₂ laser allows precision detail on three-dimensional textile surfaces, such as finished garments.

AIM

After industrial interest in *laser peri-dyeing* for manufacturing and customisation of textile goods, this research aimed to identify new opportunities to implement the technique and assess its commercial suitability within different sectors of the textile industry and their associated supply chains, building a business case for further investment into the *laser peri-dyeing* technique for apparel, sportswear and textile components.

CONCLUSION

- *Laser peri-dyeing* proven to be a controllable, transferable coloration and surface design process for textiles with relevance across multiple textile sectors (Table 2).
- Economic and sustainability benefits through significant reduction of resources and subsequent textile waste.
- As an agile, DTG manufacturing system, *laser peri-dyeing* may facilitate a more precise, responsive approach to market demands potentially reducing waste stock and enabling a more efficient distribution of textile goods.



Fig. 1. Direct-to-Garment customisation on blank panel swim shorts.

FINDINGS

1. Consultation across the textile industry identified opportunities to implement *laser peri-dyeing* within the supply chain to facilitate responsive production, technical innovation and areas for environmental improvement (Fig 2).
2. *Laser peri-dyeing* was able to apply precision coloration and pattern with laser controlled depth of shade to multiple fabric constructions including woven narrowband textile components and knitted sportswear textiles (Fig 3).
3. Prototype swimshorts with blank panels were *laser peri-dyed* Direct-to-garment (DTG), showcasing the on-demand customisation opportunities afforded by the technique (Fig 1).
4. The permanence and durability of the coloration process was assessed through material performance testing procedures, which met with commercial standards across all conducted tests (Table 1).
5. Lifecycle Assessment was conducted comparing *laser peri-dyeing* to a conventional dyeing and printing process [5]. Results showed a significant reduction in the environmental impact of *laser peri-dyeing* at lab-scale (Fig 4), with further improvements predicted on development of custom built *peri-dyeing* machinery.

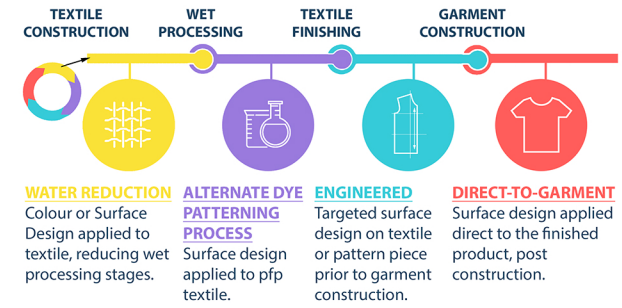


Fig 2. Opportunities to introduce *peri-dyeing* within the production cycle.

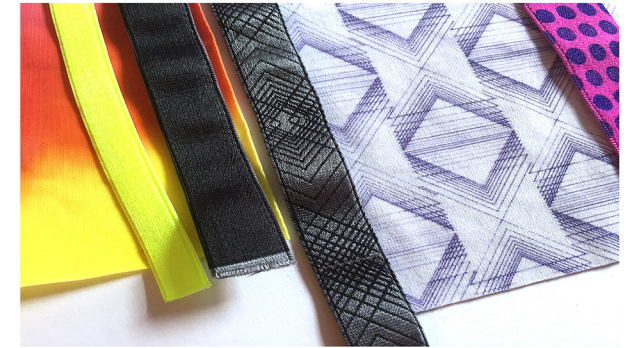


Fig 3. Laser *peri-dyed* design and coloration on a variety of textile constructions.

Table 1. *Peri-dyed* Nylon performance testing results.

Test	Pass Score	Peri-Dyed Nylon
Colour fastness to washing	4+	4/5
Colour fastness to rubbing	4+	5
Washing durability	3	5
Chlorine durability	3	3
Washing Stability (% shrinkage)	-3+	-2.3
Stretch Modulus (gf)	800-1000	940

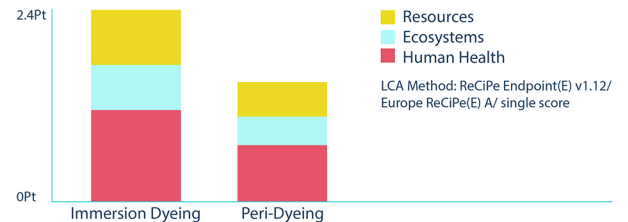


Fig 4. Environmental Impact Score comparing *peri-dyeing* and immersion dyeing of 1Kg of nylon textile component.

Table 2. Benefits of *Peri-Dyeing* for design, manufacture, application, sustainability.

MANUFACTURE	DESIGN
Resource efficiency. On-demand production benefits. Repeatable, responsive, accurate. Whole garment processing.	Targeted dyeing with accurate laser-defined colour values. Digital precision for tonal and multicolour design effects.
APPLICATION	SUSTAINABILITY
Durable, targeted dye fixation on natural and synthetic substrates. Customisation opportunities DTG on finished textile goods.	Water, dye and energy efficiency. reduced environmental impact. Flexible processing to minimise waste and over-production.



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