NC STATE
Wilson College of Textiles

JTATM
Journal of Textile and Apparel, Technology and Management

Special Issue 1: ITMA, 2023

The Smart Textile Factory: Digital Transformation, Defect Detection, and the Data Revolution ITMA 2023

Jeanine Fry,
Textile and Apparel, Technology and Management,
Wilson College of Textiles, NC State University,
Raleigh, NC, USA

Introduction

A Smart Factory is an interconnected network of machines capable of computing and communicating data. These machines are equipped with advanced technologies such as artificial intelligence **AI** and machine learning **ML** to analyze data, drive automated processes, and learn throughout production. Smart factories and smart manufacturing are part of the technological transformation, Industry 4.0, declared the 4th industrial revolution. Each prior industrial revolution evolved from an innovative technology that upended the status quo of work operations and manufacturing: the steam engine, the assembly line, and the computer. Digital transformation and intelligent automation are the catalysts of Industry 4.0.

Embedded sensors enable the interconnected network through the Internet of Things **IoT,** allowing machines to send and receive data. These sensors allow real-time data, such as energy consumption, to be automatically recorded and input into Enterprise Resource Planning **ERP** systems. This real-time accurate data eliminates manual operations of capturing (potentially faulty) data that is then able to reveal the *hidden factory*, the most efficient version of the factory, detected through inefficiencies in the data.

While automated machines and systems merely follow a set of instructions, those powered by AI can learn from these interactions to improve performance and efficiency. Through the incorporation of AI, computer systems are able to perform tasks that have previously required human intelligence, such as data analysis, visual perception, speech recognition, and decision-making. Machine learning **ML** and deep learning **DL** are specific subsets of AI. ML uses algorithms trained on data to produce models capable of performing various complex tasks. DL is a subset of ML using neural networks that mimic the human brain to perform some of the most complex ML tasks autonomously.

Digital Transformation

At ITMA 2023, many companies presented customizable digital transformation services for data transparency through Manufacturing Execution Systems **MES**, Enterprise Resource Planning **ERP**, and Product Lifecycle Management **PLM**. These companies offer access to real-time data for performance optimization, reduced utility costs, improved product quality, and reduced time to market throughout the textile supply chain.

These platforms can create a *digital twin*, a virtual model of a physical object, such as a weaving machine, or a system, such

as a factory floor, updated with real-time data captured from the sensors on the machine. These systems can translate this data into a simulated virtual model of the factory floor layout, as seen in images 1 and 2, as well as graphs and spreadsheets depicting the data. This data, in tandem with ML, can more accurately guide decision-making.

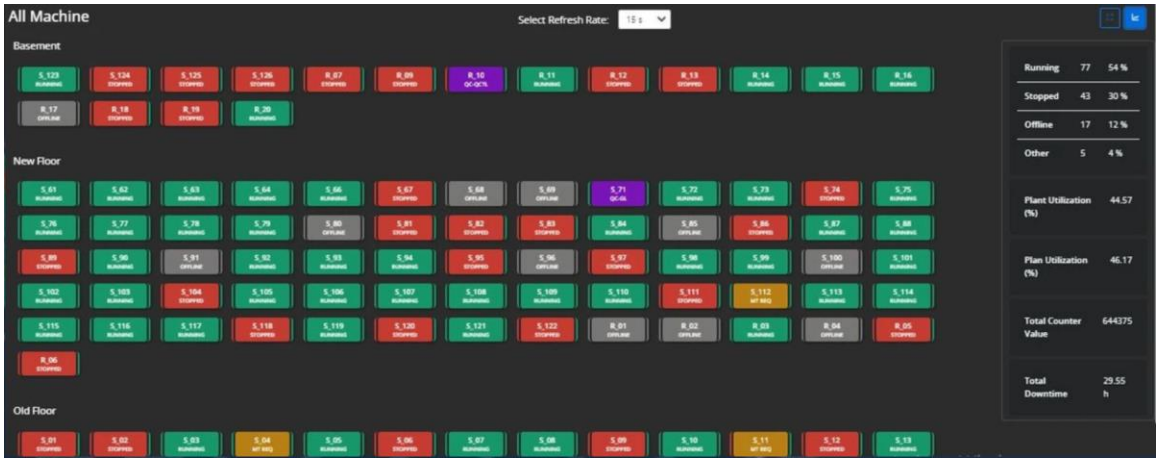

Image 1: Machine Floor Line View Dashboard with summary data (XdotO)

Image 2: Machine Floor Tile View Dashboard with production parameters (XdotO)

For example, a cable can connect a weaving machine outfitted with sensors to the IoT, or a machine can be updated with additional hardware if necessary. The data collected can include machine efficiency, planned and unplanned stops, room humidity, picks per inch, predictive maintenance, etc. While Picanol and Itema offer brand-specific digital platforms, PicConnect and MyWeave, respectively, third-party systems can connect any machine to the IoT. A computer installed at each machine can display the machine data, while remote devices can also access the data from anywhere. One difference between the systems was whether the stationary computer connected to the machine was specific to the company providing the system or if the machine could connect to any computer.

These systems also include a fabric inspection application. This application allows for the documentation of defects post-

production of the textile. While there are machines that use AI to auto-detect defects post-production based on ML using data of how the fabric should look along with uploaded images of prior defects, such as Agteks Quality Bar, manual inspection is currently a standard method of defect detection. While manual detection is tedious, both manual and automatic post-defect detection are essentially ineffective. At this point, the detector can only give a defect a score designating how *bad* the defect is. The amount and quality of defects will then impact factory margins and create extra textile waste during later product development, as seen in image 3.

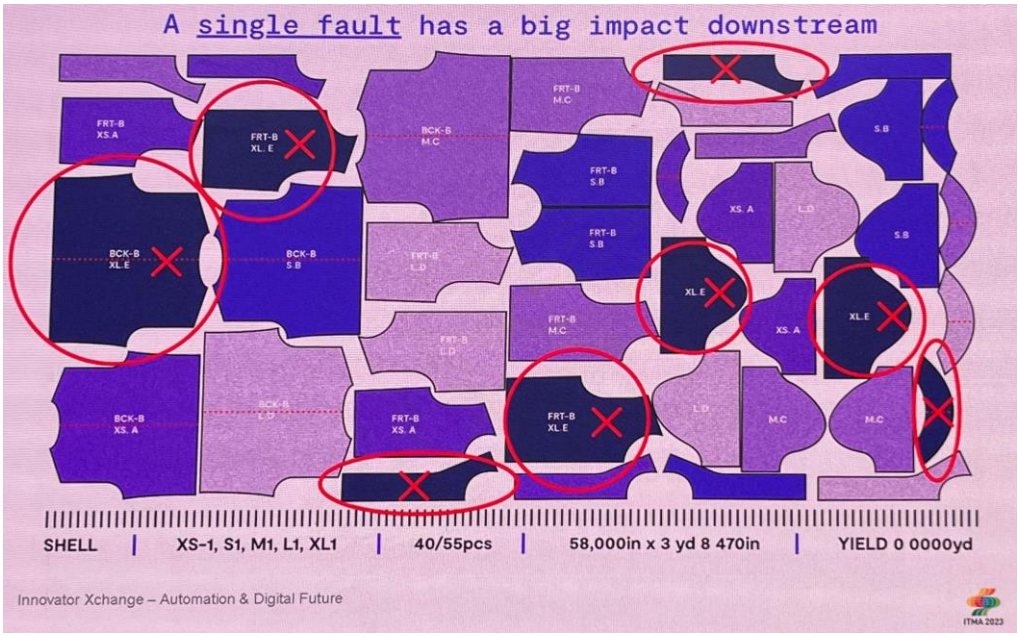

Image 3: Apparel Cutting Marker Layout showing potential fabric waste from defects (Smartex)

Defect Detection

Given the impact of the limitations of post-production defect detection, a few companies are using computer vision and intelligent automation to solve this problem.

BMS Vision, a company that has been around for 50 years, is an MES provider offering auto defect detection technology. BMS Vision has been at the forefront of AI and real-time auto defect detection for woven textiles. During the production of the fabric, an on-loom camera can detect a defect, triggering an autostop of the machine and allowing for the correction of the defect. Customers have primarily used this technology for technical fabrics. The initial version, Cyclops, has been in use for approximately 15 years and can be used for uniform dobby weave structures. Cyclops uses a moving camera system, seen in image 4, to detect warp, filling, and point defects, examples seen in image 5. Cyclops can also be used for Kevlar and carbon fabrics with a unique camera head to accommodate the reflective properties of the textile. A more recent development, Argus detects defects in uni-color jacquard weaves, including one-piece woven products like airbags, with an option for front and back inspection. Argus uses a scanner consisting of an array of fixed cameras and a LED illumination bar, seen in image 7, to detect defects, examples seen in image 8. This ITMA, BMS Vision, presented their newest concept, a universal system in development to detect defects during the production of any woven or knit fabric, as well as detect issues during the warp-beaming process.

Image 4: Cyclops (BMS Vision)

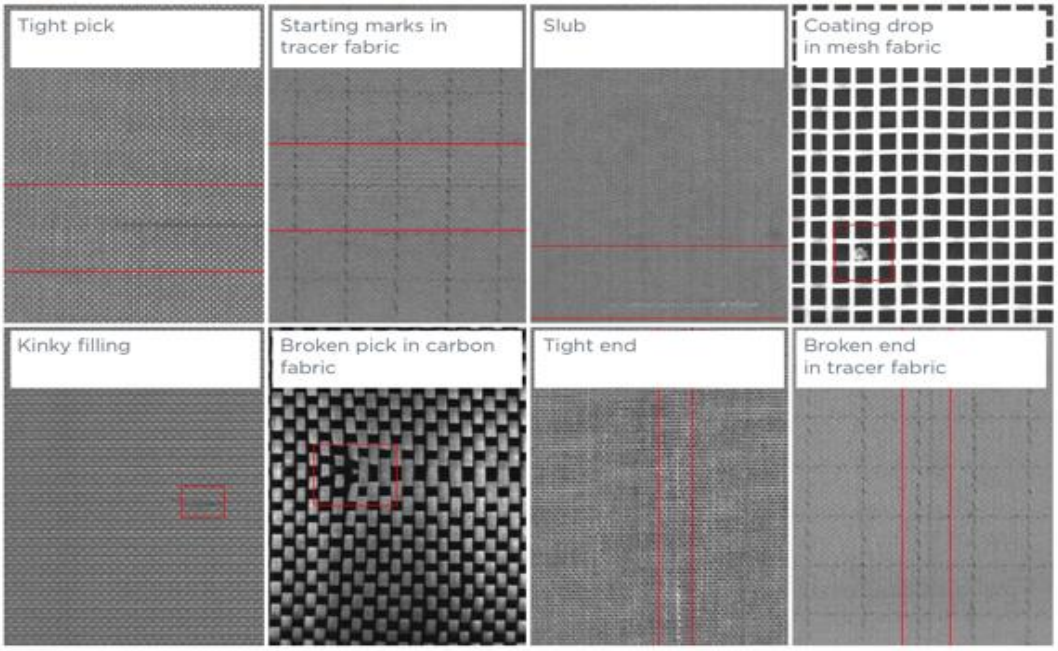

Image 5: Cyclops captured defect images (BMS Vision)

Image 6: Argus (BMS Vision)

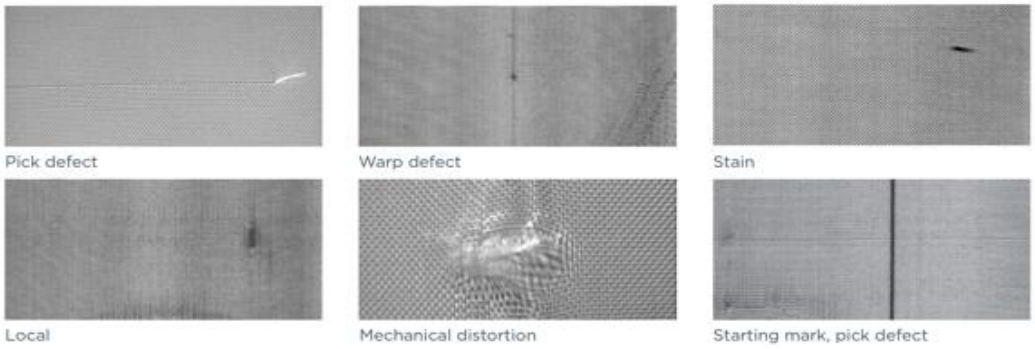

Image 7: Argus captured defect images (BMS Vision)

Smit presented two prototypes for their Guard One quality control system. The first prototype has a high-definition camera on a sliding bar that runs across the entire width of the fabric, capable of detecting pore size variations for technical fabrics made of simple dobby weaves. Their second prototype consists of a scanner bar system that is adaptable to the width of the fabric and capable of detecting general defects with the potential for use on jacquard fabrics. These prototypes can detect and identify breaks in real time. The system maps the defect along the fabric, categorizes the defect, and stores pictures of the defects in the cloud.

Smartex is a start-up that currently only detects defects during circular knitting production, but they are working on developing systems for flat knitting and weaving. Smartex stands out because the system also incorporates a heat set QR code onto the finished fabric roll for data documentation of defects and other product info to track throughout the following production processes. The QR code can then be passed along to the customer for product information, as seen in images 8 and 9. This heat-set QR code can withstand any of the fabric finishing processes. Partners and investors of Smartex include Gucci, Balenciaga, and Tommy Hilfiger, to name a few.

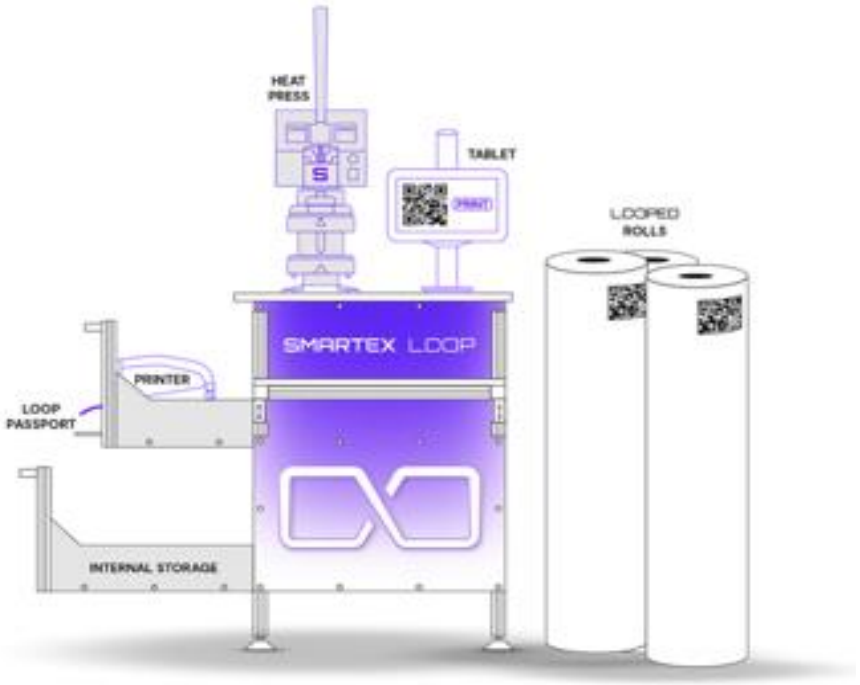

Image 8: Heat-set QR code system (Smartex)

Image 9: Heat-set QR code (Smartex)

Data Revolution

Moving forward, climate regulation and legislation will reinforce and necessitate the implementation of accurate and efficient MES, ERP, and PLM systems. Specifically, the EU Green New Deal sparked conversations at ITMA about industry solutions for adapting to future requirements.

The primary goal of the EU Green New Deal is to be the first climate-neutral continent by 2050. This legislation contains sustainable product policy and ecodesign sustainable regulation that will require the implementation of Digital Product Passports for tracking product lifecycle. The expected content of the Digital Product Passport will include materials and chemicals utilized, material origin, recycled content, CO_2 and H_2O footprint, manufacturing history, and instructions for repair and disposal.

According to the European Environment Agency Report "Textiles and the environment in a circular economy," the global textile industry, valued at $3B, is the 3rd most polluting industry, produces 10% of global CO_2 emissions, is the 2nd largest consumer of water, and causes 20% of freshwater pollution. These statistics show that the textile industry is a significant target of the EU Green New Deal and should expect to be impacted heavily by this legislation.

Currently, the rollout of the first products with digital passports is expected in 2026. These product passports will require machine data, process data, and product data. Accurate and efficient MES, ERP, and PLM systems will be necessary once this legislation goes into effect and digital product passports are mandatory for each good produced. Innovations such as Smartex's heat set QR code will also be essential in sharing the data throughout the product lifecycle. While most conversations discussed the use of cloud-based platforms, Paper Tale presented public blockchain as an option to create product lifecycle transparency tracking from cradle to grave.

The requirements of digital product passports and similar legislation will mandate all textile manufacturers to digitally transform the way they do business leading to the data revolution for a more accountable textile industry.

Sources

Argus: Automatic on-loom inspection for jacquard fabrics. (2022). BMS Vision. Retrieved July, 2023, from https://bmsvision.com/machines/argus

AURIGAA MDS. (2023, June). XdotO Concepts. Retrieved July, 2023, from https://www.xdoto.io/aurigaa-mds

Cyclops: Camera based automatic on-loom fabric inspection. (2023). BMS Vision. Retrieved July, 2023, from https://bmsvision.com/machines/cyclops

A European Green Deal. (n.d.). European Commission. Retrieved July, 2023, from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Manshoven, S., et al. (2019). ETC/WMGE Report: Textiles and the environment in a circular economy (6/2019). European Environment Agency.

Products. (n.d.). Smartex. Retrieved July, 2023, from https://www.smartex.ai/product