



Automation Trends in Apparel Manufacturing

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Introduction and Literature Review. Apparel manufacturers assemble garments in low-wage countries to take advantage of the low labor costs of manual mass production. However, mass production doesn't cater to the personalization of garments for particular consumers beyond the selection of a handful of stock sizes (Gupta & Eremenko, 2017). Mass customization provides consumers with unique products, when, where, and how they want them at an affordable price. In mass customization, each product is manufactured as a unique item for each customer. Rapid technological advances in 3D body scanning and autonomous sewing assembly lines have the ability to achieve consistency in various aspects of garment construction that affect sizing and fit. Recent research into the mass customization process and technology in the apparel industry indicate the importance of the brands to tap into this age of the high-speed technology to develop new garment production methods (Nayak et al., 2015). There is a lack of literature to describe how these technological advances can develop new approaches of doing business and impact apparel brands' current production models.

Patents are a natural candidate for measuring technological progress and frequently serve as a function of innovation. According to a study by Mann and Puttmann (2017), patents were classified as automation patents if their texts described a device that carries out a process independently of human intervention. Furthermore, automation involves physical inventions (such as robots) as well as immaterial or conceptual inventions (such as software) (Mann & Puttmann, 2017) Thus, this study conducted a content-analysis of U.S. and WTO utility patents to examine the current state of automation in apparel manufacturing in order to identify key emerging trends that can impact existing product development and production processes.

Methodology. The authors obtained 50 US and International patents, filed between 2015 – 2020, related to the research topic by searching key words (e.g., sewing automation, apparel manufacturing automation, and apparel) on search engines such as Google Patents, USPTO, and The World Intellectual Property Organization (WIPO). This research ended up having a sample of 30 relevant utility patents. A thematic analysis was conducted of all collected utility patents to classify emerging themes from apparel related innovations and disclose those fields that are under development and implementation in the apparel industry.

Findings and Discussion. There were three critical themes identified for customization and automated systems: (1) innovative software systems, (2) autonomous componential inventions, and (3) autonomous systems. User customization is apparent and plays a critical role in software and autonomous componential systems.

Innovative software systems refer to patents claiming computer-based technology used in apparel manufacturing that will synchronize customizable design specifications directly from a customer, via computing device, directly to a receiving digital design engine that will modify a core design spec to define that of the custom design product. The Ram Group, of Milwaukee,

WI, has developed such a system that incorporates a digital design engine that streamlines the process of receiving customized design orders, patterns design modification, printing, and cutting (Marino & Demeyer, 2019). On the other hand, Levi Strauss and Co. has designed a system focusing on user experience that allows them to preview a desired wear pattern on jeans. This system is able to provide feedback to the users on how their garments can look virtual storefront that projects a 3D preview created by light projection techniques (Schultz et al., 2019).

Autonomous componential inventions are defined as devices or a system which focuses on a specific segment of the manufacturing processes. The patents included in this category describe functions such as, fluorescent ink printing, fabric feeding, transport devices, continuous laser cutting of textiles, and a pneumatic pump to generate suction to pull cut fabric panels. Softwear Automation Inc. was granted three componential patents, between 2015 and 2020, which describe a processing device, a feed mechanism that advances fabric, and a conveyance system that can transports fabric (Dickerson, 2015, Dickerson, 2018a). The processing device and configured logic is described to instruct the sewing module to sew the garment material based on counting threads of the garment material (Dickerson, 2018b). Similarly, Amazon Technologies Inc has patented an automated fabric picking device system comprised of a transport tube and a textile hopper arm located above a fabric cutting and assembly tabletop (Aminpour, 2019). The flexible transport tube picks up fabric panels using suction delivered from a pneumatic pump and is directed by a computing device identifies and tracks the textile panels on the surface of the tabletop (Aminpour, 2019). Furthermore, Amazon Technologies Inc is using ultraviolet (UV) light sources to capture reflections from fluorescent ink printed onto cut fabric panels which can be referenced by automated sewing systems to identify sewing assembly instructions (Aminpour, 2017). Levi Strauss & Co. has developed a method to make the fabric which includes spinning, dyeing, and weaving yarns in such a way to obtain the desired enhanced response characteristics for laser finishing (Schultz et al., 2019). **Innovations with claims to an autonomous system** consider patents that describe manufacturing systems that include stages from user product customization through garment assembly without requiring further substantive manual intervention or touch labor. Apparel organizations such as 3D Tech, had designed a network system for the automated manufacture of a personalized custom using 3D body scanning and a manufacturing system. Far Eastern Apparel LTD filed an international patent in 2018 which encompasses components similar to that of Softwear Automation Inc. but have incorporated the sewing assembly processes laying claims to subcomponents reliant on the manufacturing process (Zhao and Wang, 2018). Amazon Technologies Inc. has taken customization to an interactive level with *on demand* apparel manufacturing (Aminpour et al., 2015). This process includes a textile printer, textile cutter, and a computing device that is configured to process aggregating orders for products, organizing the orders according to a productivity factor, and arranging textile panels for products ordered. On the same topic of customization and user experiences, Jeanologia and Levi Strauss developed a Co- Mobile garment center that can laser a wear pattern onto the fabric of a jean (Sights et al., 2018). The mobile container includes wet processing abilities and claims to finish a custom garment in less than an hour (Sights et al., 2018).

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