Industrial On-Demand Circularity in Apparel Manufacturing – The Production Twin as a Data Foundation for Demand-Driven Production and Circularity

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Abstract

Overproduction, markdowns and deadstock in the apparel industry are not merely end-of-life problems but consequences of upstream decisions concerning quantities, variants, materials and production organisation. This contribution develops the concept of industrial on-demand circularity: manufacturing is triggered by an actual order or a narrow demand-based replenishment signal, while product design, materials, capacity, quality and circularity are systematically connected.

Made-to-order alone does not ensure circularity. Inventory risks may shift to fabrics and trims, while missing product and process data can impede repair, replenishment, sorting and recycling. A digital twin consisting of a product twin and a production twin is therefore proposed as the connecting data architecture. The production twin links orders and product versions with material batches, operation sequences, machines, parameters, standard and actual processing times, quality inspections, rework and status. The product twin adds construction, material, care, repair and lifecycle information. Selected information can be transferred to the Digital Product Passport, while internal production data remain protected.

Based on a conceptual, practice-informed synthesis and a modelled target process for apparel manufacturing, a minimum dataset is structured into six domains: identifi cation, material, construction, manufacturing, quality and lifecycle. The model demonstrates how demand-driven production can be connected with traceability, measurable quality, repairability and circular value retention. The central proposition is that circularity does not begin with recycling. It begins with the decision to manufacture fewer unnecessary and more durable products – supported by a data architecture that makes this principle operational throughout production and the product lifecycle.

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