Automating Design-for-Manufacturing Workflows: Lessons from Composite Ply Kit Design

BUSINESS PROBLEM

Composite Resources (CR) manufactures a high mix of thermoset composites: in 2024, hundreds of unique laminate components were built. To prepare each new component for production, engineers at CR execute multiple design-for-manufacturing tasks, including ply kit design. In ply kit design, engineers synthesize customer requirements and knowledge of the manufacturing process to design 2D plies that can be layered into 3D components. Errors can lead to extra work in manufacturing, extended lead times, and scrap. This project focuses on automating the ply kit design process, to reduce engineering time and improve design quality.

DATA SOURCES

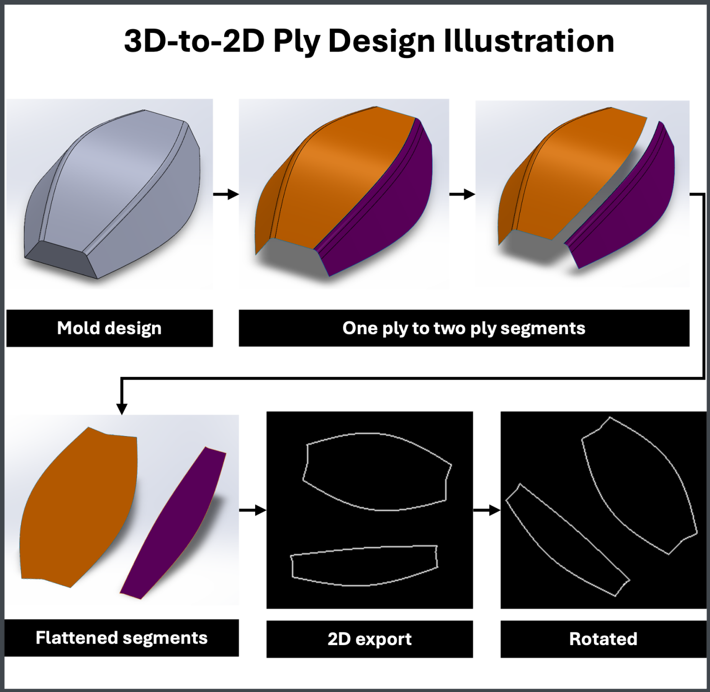
Baseline process data was collected via engineering and production observations, quality management system nonconformance records, and production file revision histories. Experimental data evaluating the tool included quantitative execution times and qualitative feedback comparing manual and automated outputs.

Data Types and Format

Categorical (nominal), Count (integer), Numeric, Relational Data, Spatial, Static, Structured, Text, Unstructured

APPROACH

First, the existing, manual ply kit design process was mapped. Downstream data was collected to assess how design decisions impact manufacturing efficiency and quality. Applying lessons from this analysis, a modular automation tool was developed. The tool, which operates as an add-in within existing CAD software, processes 3D models and tabular specifications to generate design options, evaluate manufacturing feasibility, and output standardized 2D production files. Performance was assessed via side-by-side experiments comparing manual and automated execution.



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IMPACT

The project delivered immediate improvements in engineering efficiency and lessons for future automation initiatives. The automation tool was tested under two usage scenarios: export-only and full automation. The export-only scenario tested the tool as an augmentation to engineers' manual design process. In this case, engineers manually complete the ply kit design; then the tool formats and geometrically orients cutting paths to meet equipment and customer specifications. The automated export was 45% faster than manual export for engineers. Additionally, the consistent formatting and orientation reduced downstream production setup time by 24%.

The full automation use case tested the tool across the entire ply kit design process, from initial 3D ply creation to final export. Full automation failed for 3 of 5 geometries tested and yielded no meaningful time savings. The failures revealed limitations in current manufacturing feasibility modeling within composites and algorithmic challenges in balancing competing objectives. These insights were used to develop an automation-readiness framework for assessing future automation opportunities within engineering workflows.

DRIVERS	Demand for composite materials is growing in innovative sectors such as aerospace and transportation. For many customers, reducing development lead times is critical to support rapid design iteration. In this context, ply kit design automation serves as an opportunity to accelerate new product introduction and enhance customer responsiveness.
BARRIERS	A challenge was current reliance on engineer intuition for manufacturing feasibility. Production observations were limited to approved designs, providing an incomplete dataset to inform automation logic. Technically, the project required mastering C# for custom add-in development and creating a robust algorithm to handle realistic geometries.
ENABLERS	The support and openness of stakeholders across engineering and production teams was a key enabler. Access to quality records, historical design files, and production data also provided a valuable mix of qualitative and quantitative evidence needed to understand the problem and guide solution development.
ACTIONS	Baseline performance was established using live time studies and internal data. Based on the baseline analysis and a review of off-the-shelf software capabilities, priorities were set for a new automation tool. The tool was created as a custom add-in for SolidWorks, the CAD software currently used at CR. Automated and manual design performance was then evaluated side-by-side under partial (export-only) and full automation scenarios.
INNOVATION	The project pioneered an attempt at automated, geometry-based segmentation within composites, drawing inspiration from automatic pattern making in other industries. Strategically, the project applied Lean manufacturing concepts like poka-yoke (mistake-proofing) and hidden factory reduction directly to engineering, optimizing the design-for-manufacturing value stream before production begins.
IMPROVEMENT	The new automation tool was evaluated against manual ply kit design. The most immediate improvements came from automating the export of production-ready cut path files. This partial automation was highly successful, accelerating the export task by 45%. Automation also reduced inconsistency in the exported files, which resulted in a 24% reduction in production setup time for new files.
BEST PRACTICES	The successes and failures of the automation tool provided insight on what makes an engineering process ready to automate. Two criteria were identified: inputs must be simple to define, and outputs must be easy to evaluate objectively. If these are not met, the process may be too reliant on human intuition and nuanced decision making to automate.
OTHER APPLICATIONS	For manufacturers focused on custom products or short product life cycles, design-for-manufacturing tasks within engineering may contribute substantially to overall lead times and costs. In these settings, applying value stream mapping to engineering workflows provides a structured path to accelerate new product introduction.