Product design / development / engineering | Industrial automation | Product design and testing | Rules-based

Automating Mold Design and Toolpath Generation for Composites Manufacturing

BUSINESS PROBLEM

Project engineers will play a critical role as Re:Build Composite Resources (CR) pursues growth goals. The existing project engineer workstream consists of high-value decision-making and low-value repetitive tasks, including the design of molds for simple geometry parts. This internship project aims to automate mold design and toolpath selection for simple geometry composite parts. This will reduce lead times, increase project engineer capacity, reduce indirect labor costs, and standardize engineering outputs.

APPROACH

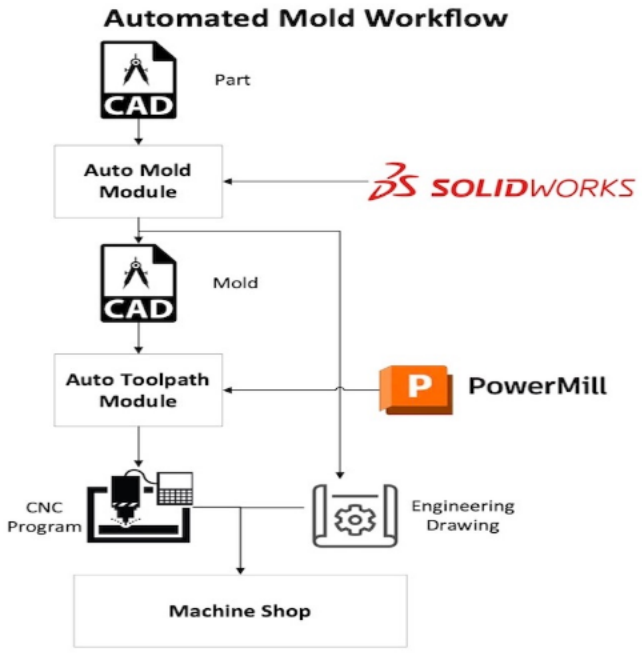
Historical parts were studied to qualitatively define in-scope parts based on geometric complexity. The manual mold design and toolpath selection processes were mapped. Using a combination of CAD/CAM API calls, engineering heuristics, and rules-based decision-making, a suite of C# and Python-based algorithms was iteratively developed to automate mold design and toolpath selection.

DATA SOURCES

Mold data was gathered by qualitatively analyzing CAD files. Toolpaths were characterized by scraping thousands of CAM files and extracting toolpath parameters. ERP entries were collected and analyzed via SQL queries. Engineer/ CNC programmer interviews were conducted to understand technical decision-making. Management interviews were conducted to understand the greater business context.

Data Types and Format

CAD/ CAM files, aggregate toolpath parameters, ERP data including work center processing times and PO frequency, and text from interview notes.



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IMPACT

Based on tests on historical parts, the automated mold design algorithm developed in this research could design molds for 12% of CR's parts. The automated toolpath generation algorithm created toolpaths for 18% of CR's parts. The algorithm's run time was typically 5 minutes or less. Lead times are projected to decrease from 8-10 weeks to 5-7 weeks for in-scope parts. The automated mold design algorithm, seamlessly integrated as a SolidWorks plug-in, is designed to enhance the existing project engineer workflow. Similarly, the automated toolpath generation tool, implemented as a PowerMill plug-in, offers an intuitive experience for CNC programmers. This user-friendly approach ensures that project engineers / CNC programmers can easily modify outputs from both algorithms, if required, without disrupting the workflow.

DRIVERS

Re:Build seeks to leverage digital manufacturing technologies as a competitive differentiator. This industry is competitive on lead times. CR is pursuing aggressive growth goals and seeks to win more business by reducing lead times. By automating up-front design work, production can start earlier, and lead times will be shorter. Automation will also play a critical role in decoupling revenue from headcount.

BARRIERS

This project encountered technical and human barriers, both of which were manageable. Technical barriers included learning new programming languages and using the CAD/CAM APIs to perform design tasks. Human barriers included healthy skepticism among company personnel. Concerns included wasting time on buggy/ ineffective automated tools and skepticism that design and toolpath generation could be automated robustly.

ENABLERS

Strong continuous improvement culture. Experts were willing and enthusiastic to share their knowledge. Recent growth has increased project engineer and CNC programmer workload and they are motivated to find ways to work more efficiently.

ACTIONS

The automated algorithms were developed in a highly iterative manner. A carefully crafted pilot program was launched with project engineer and CNC programmer champions. The pilot program was designed to add value while also collecting feedback on algorithm performance. A critical aspect of this pilot program was a streamlined workflow that included decision aids, special part numbering, and automated macros.

INNOVATION

Use of the SolidWorks API to automatically orient parts, perform draft analysis, place a parting surface, and generate a mold without human intervention. Through analysis of historical CAM files, determined that a majority of in-scope machining work could be completed using only three toolpaths that could be applied uniformly over all in-scope parts. This simplified and standardized CNC programming outputs.

IMPROVEMENT

Automated the mold design for 12% of parts and automated the toolpath generation for 18% of parts. For in-scope parts, lead time is projected to decrease from 8-10 to 5-7 weeks.

BEST PRACTICES

Study existing manual processes thoroughly to understand key decisions. Study parts to identify common features compatible with automation. From there, define a scope that makes the problem more manageable. Focus solely on in-scope activities and parts. Start with the simplest possible version of the problem and iteratively increase the complexity. Find resident experts who are interested in your work and build relationships.

OTHER APPLICATIONS

This research is a case study of the value of automating up-front engineering design work. Design automation is a productivity enhancer in high-mix, low-volume manufacturing environments. Design automation can reduce changeover costs and provide rapid prototyping capabilities to manufacturers. Similar automated design tools could be helpful in metallics manufacturing or any mold-based manufacturing process.