

ABSTRACT

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Title: Performance Informed Technical Cost Modeling for Novel Manufacturing

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Inaccurate cost estimates contribute to lost implementation opportunity of novel manufacturing technologies or lost revenue due to under-bidding or loss of an over-bid contract. High-volume, long-term orders, such as those the automotive industry begets, are desired as they lock in revenue streams for months into years. However, high-rate composite materials and their manufacturing processes are novel among the industry and traditional costing methods have not advanced at a proportional rate. This research effort developed a method to reduce the complex composite manufacturing systems to fungible, upgradable, and linkable individual processes that derive their manufacturing parameters from the performance part design process. Employing technical cost modeling, this method accurately quantifies the value of pursuing composite manufacturing by integrating impregnation, solidification, heat transfer, kinetics, and additional technical data from computer-aided part design simulation tools to deliver an accurate cost estimate.

Cost modeling provides a quantitative result that weighs heavily in the decision making process for adoption of a new manufacturing method. In this thesis three case studies were investigated for three different management decision cases: part production management, in-house manufacturing management, and global manufacturing management.

Part production management is the decision making process for selecting a certain manufacturing method. A case study with a Tier 1 Part Producer was conducted to provide a comparison of two emerging novel preforming systems versus their in-use, metals based high-rate manufacturing line in manufacturing a structural automotive part. Determining material usage was the primary cost driver focus. Equipment Supplier A's process operated by seaming single layers of thermoplastic tape into rolls and then stacking prior to consolidation and resulted in a scrap rate of 23-28% with a cost of \$32.87-36.01 per kilogram saved depending on the input tape width. Equipment Supplier B's layup process, essentially a multi-head automatic tape layup machine,

resulted in scrap rate of 20-27% with a cost of \$34.48-36.67 per kilogram saved depending on the input tape width. This exceeded the Tier 1 Part Producer's requirement of \$6.6-11 per kilogram saved and led to them to abandon this application as a feasible project and instead look for a different part with a higher return regarding cost for weight saved.

In-house manufacturing management is the decision making process governing manufacturing operating procedures. A case study for the Manufacturing Design Laboratory's (MDLab) hybrid molding line was undertaken to determine the manufacturing cost for a composite test coupon. Processing parameters were obtained from three sources: performance design computer aided engineering (CAE), common industry transfer estimation times, and a calculated preform layup time. Compared to a similarly shaped test coupon made of aluminum, highly-automated manufacturing realizes weight savings of 46.25% and cost savings of 16.5%. Low-automation manufacturing captures the same weight savings, but has a cost for weight saved penalty, cost increase, of \$9.48 per kilogram, showing how influential the labor contribution is to manufacturing cost.

Global manufacturing management is the decision making process governing manufacturing location. Various manufacturing cost drivers are location dependent, thus a dataset was developed to alter these parameters for the U.S. states. Global comparisons are accomplished through indexing of global cost of living allowances and labor rates. Within the U.S., high-automation manufacturing costs in the West Coast/Pacific are 20.1% greater compared to the Midwest and similarly, low-automation costs are 21.2% greater. Globally, high-automation manufacturing costs in North America are 52.1% greater compared to Asia while low-automation costs are 115.7% greater. These variations highlight why we see geographically clustered manufacturing centers within the states and major manufacturing relocations due to cost sensitive and labor sensitive production.