Genetic Algorithm Optimization of a Filament Winding Process

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Abstract. This paper describes a research effort to improve the efficiency of a filament winding process by combining the simulation capabilities of the WITNESS modeling program with the search capabilities of a genetic algorithm. Results show that the genetic algorithm is able to reduce the cost of producing filament wound mandrels used in the defense industry.

1 Introduction

This paper describes an effort to use a genetic algorithm to enhance the modeling and optimization capabilities in a specific simulation environment, WITNESS – a well-known simulation environment designed by AT&T and Istel that is generally geared toward industrial engineering applications.

The current work represents an expansion of an earlier work completed by the authors [2]. This previous effort focused on a very simple optimization problem in which only the production costs of a filament winding operation were considered. In the current work, the total cost (production cost, materials cost, labor costs, etc.) are considered.

2 Filament Winding Model

The filament winding process is an assembly process used by the advanced composites industry to make composite material filaments. It involves taking composite fibers, winding them around mandrels, hardening them, and then cutting and assembling them into a finished product. Products produced using the filament winding process include rocket-motor cases, helicopter blades, piping, tubing, and drive shafts. For the purpose of this research, the same filament winding model formerly used by the authors [2] is once again addressed. The objective of the current effort is to use a genetic algorithm to minimize the cost of producing a composite mandrel. The production process is simulated in the WITNESS environment. Figure (a) shows a schematic of the filament winding

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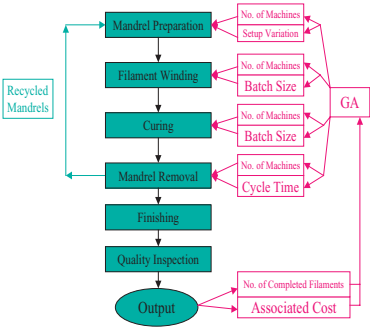
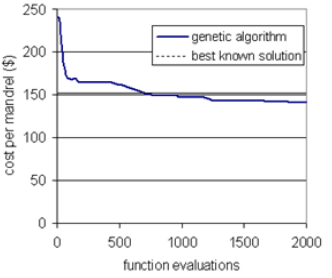
model, along with the means by which the genetic algorithm interacts with the filament winding model.



(a) Filament Winding Model



(b) Genetic Algorithm Performance

3 Results

The optimization problem involved determining two parameters for each workstation. Thus, the problem solved is actually a 10 parameter optimization problem. Minimizing the total cost of mandrel production involved material costs, labor costs, operation costs, and market value of the product. In addition, penalties were incurred if the products were not delivered on time. The exact objective function used here can be found in the thesis by Wilson [1].

For the purpose of the current study, the best solution determined by the genetic algorithm ($140.70) was compared to the best know solution as determined by process engineers addressing the problem ($152.10). Figure (b) indicates that the genetic algorithm clearly located a more cost-effective layout for the filament winding process.

References

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