CATALOG-BASED CUSTOMIZATION

PhD. Dissertation
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U.C. Berkeley, 1997

Abstract

The latter half of the twentieth century has been witness to a fundamental paradigm shift in the manufacturing industry---from mass-production to mass customization. This thesis develops a new method for implementing mass-customization, namely, the customization around standard products, or catalog-based customization. The method addresses the customization requirements of a class of products that are complex in configuration, multi-functional and structurally similar. We formulate catalog-based customization as an optimization problem consistent with the manufacturer's goal of incurring minimal costs in the redesign of existing standard components, while meeting customer specifications and satisfying design constraints. The `catalog-based' nature of the formulation raises concomitant issues of constraint representation, cost function development and problem simplification/solution.

We use directed bipartite graphs to represent the design variables/constraints of catalog-based customization. The constraints of the optimization formulation are dynamic in that they depend on the infrastructure of the manufacturer and the set of customer specifications. Bipartite graphs permit the abstraction, from a comprehensive product model, of the design variables/constraints corresponding to a particular manufacturer and a particular set of customer specifications. We present algorithms to effect these abstractions.

The product cost function for the formulation is rarely available in closed-form. However, there is a wealth of information in the cost data of existing standard catalog products. Based on an analysis of existing cost structures, we identify the generational structure as best suited to exploit this information and construct a product cost function. The cost-estimation methods used by the generational structure in the construction are identified as weight-based ---for modeling the material costs, and methods based on similarity principles and regression analyses---for the production costs. The optimization formulation of catalog-based customization may be simplified by an a priori identification of a standard catalog design to base the customization on. This is accomplished with function costing---a cost-estimation hypothesis that uses product functionality to develop an approximate cost-estimate. The function-costing estimate is also used to abstract features from the standard base design into the optimization formulation. The preferred solution strategy for the optimization formulation is identified as genetic algorithms. Genetic algorithms accommodate several features of customization that make it intractable to other optimization techniques. The extendibility of genetic algorithms to improve solution efficiency for catalog-based customization is also discussed.

The domain of application of the customization method developed is Brushless D.C. Permanent Magnet (BDCPM) motors. We obtain optimal minimal cost custom designs

(from the standard designs of a family of BDCPM motors produced by motor manufacturer, for different sets of customer requirements. These customization scenarios offer valuable insights into the redesign of BDCPM motors. In particular, they provide evidence that supports the application of function-costing to BDCPM motors.