DESIGNING FOR COST / AFFORDABILITY : Developing A Total Cost Model For Plastic Injection Molded Parts

D. W. Merino , D. N. Merino , Ph.D. P. E.
Engineering Information Inc. / Stevens Institute of Technology
Hoboken, NJ

Introduction

Engineering design involves using scientific principles to provide economical solutions that satisfy technical requirements[3]. Increasing global competitiveness has made economical solutions even more important than it has been in the past. The need to Design for Cost or Design for Affordability has become dominant for many products in many industries.

Target Costs in Engineering Design

A new engineering design paradigm has emerged where global competitors set target costs for products before engaging in engineering design'. Target costs are the costs products must meet in order to realize a profit and create or penetrate a market. Defining Quality as meeting customers' specifications must now be amended to include the price the customer is willing to pay. A concurrent engineering approach with multi-disciplinary teams is used to design plastic parts that meet customer requirements including cost. While these teams use a variety of tools, there is a lack of cost prediction software packages for plastic parts. This paper discusses the development of an engineering economic model for injection molding.

Design for Cost/Affordability in Engineering Design

For engineering design teams to be effective they should continually assess cost tradeoffs and then use this information to constantly improve the cost estimates as they progress from feasibility to the final design. Initial estimates developed in the conceptual design phase are updated during the definition and scoping phases of the design. These design teams quickly learn what other industries already know. The accuracy of the cost estimate increases as the design cycle progresses (Figure 1). Typically a knowledgeable designer should be able to estimate the cost of a plastic part to within ± 30°/0 to ±50% at the initial feasibility stage. As the project progresses and the design team spends more time they can increase the accuracy of the estimate. Increased effort in engineering design and cost estimation results in increased accuracy.

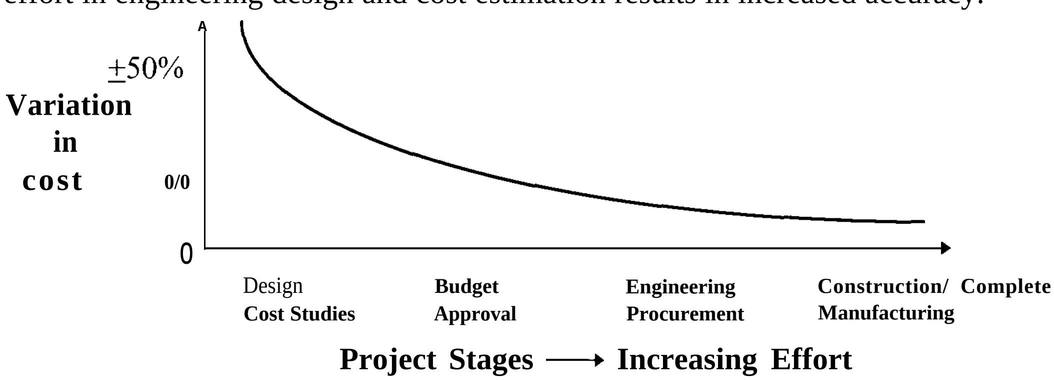

Figure 1 Trade offs in Cost Estimation : Accuracy vs. Effort

While the accuracy of the cost estimates increase with increasing engineering effort, the cost to change the design also increases exponentially. A number of companies have studied the cost to fix or correct defects or error at various stages of development. An IBM study indicated that the cost of fixing an error was $1 in R&D, $4 in manufacturing and $80 in the field. An AT&T executive stated that for switching technology the ratios were 1 - 100-1000. Both of these examples reflect the fact that making changes during the early design phase is a lot less expensive than in manufacturing or in the field. (Figure 2)

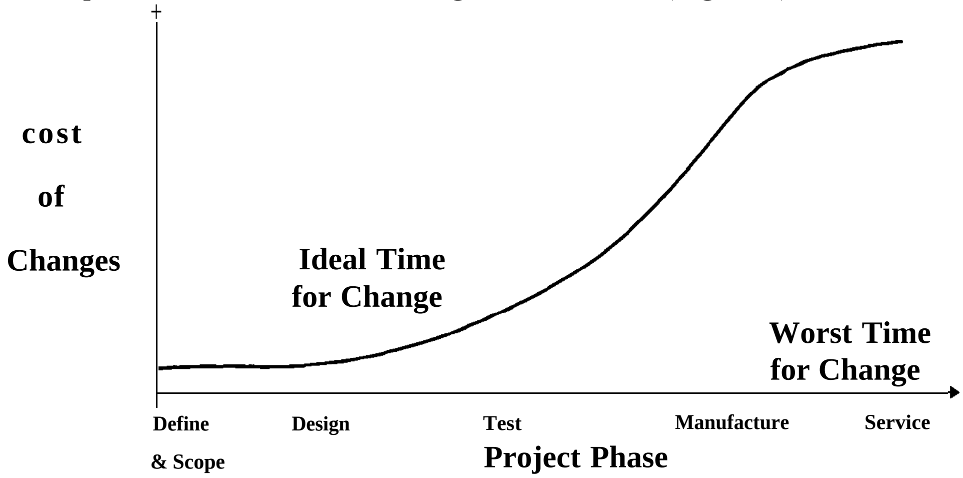

Figure 2 Cost of Changes by Project Phase

A tenet of concurrent engineering is to spend more time in the early stages of design, where the changes are less costly and reduce the need for change downstream when the cost grows. This is the opposite to the traditional sequential method. illustrated in Figure 4. One of the major reasons for redesigning the product at later stages is the need to reduce the cost of the product. This cost reduction redesign coupled with the annual cost reduction efforts drives the life cycle cost of the product up significantly.

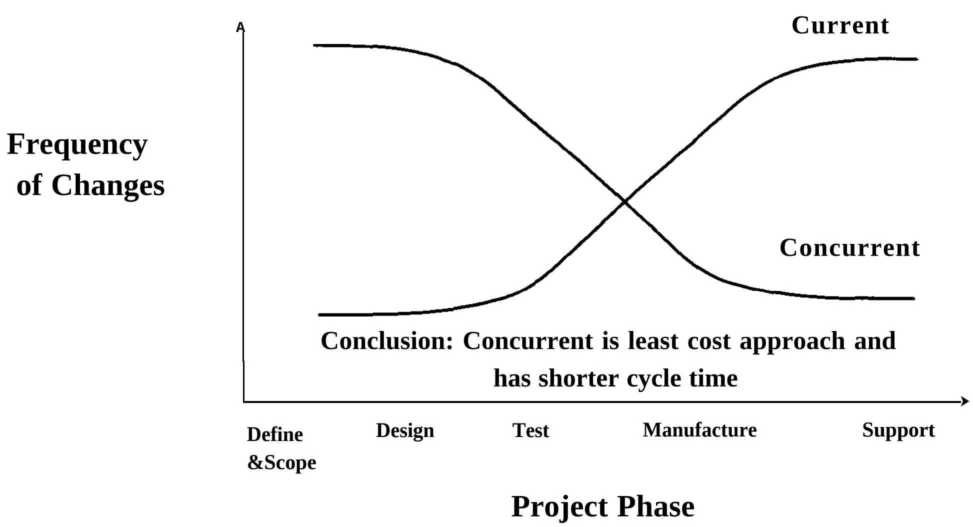

Figure 3 Frequency of Changes : Current vs. Concurrent Engineering Approach

Creating New Paradigms for Engineering Design

A robust engineering design process that includes meeting a predetermined cost is needed. For plastic - parts the old method of engineering design consisted of converting marketing and engineering characteristics into designs on drawings. These drawings were given to the molders and mold makers who determined the cost of the product. If this exceeded the cost that the customer was willing to pay, then the product was redesigned. Most companies employ a sequential design process similar to that in Figure 4. In addition to the feedback loop in the cost phase, there are many times when the design sequence is restarted either during or after the manufacturing phase. All of these feedback loops cost time and money. These iterations are much more costly than getting it right the first time.

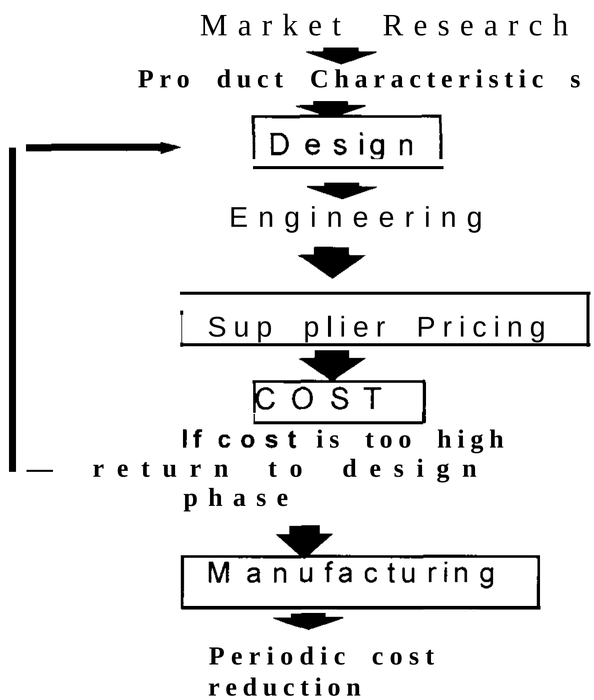

Figure 4 Current Desire Process

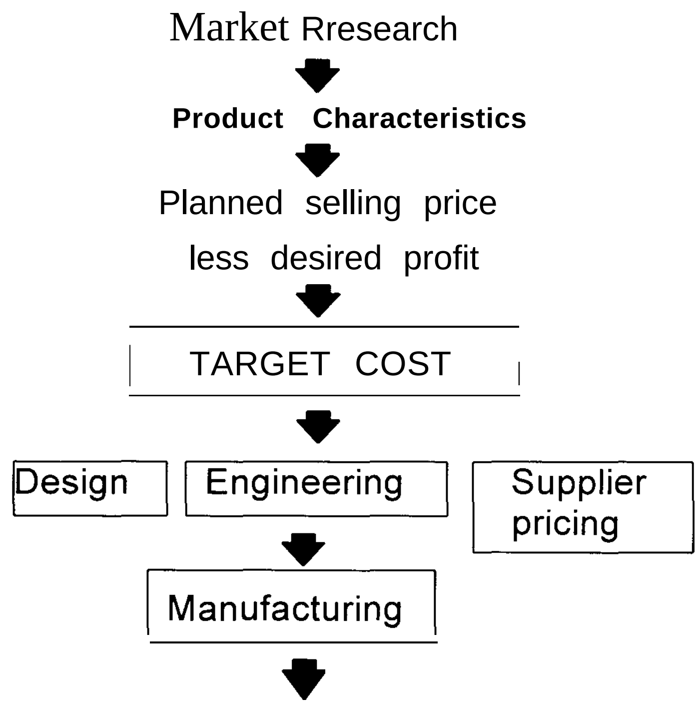

Figure 5 Desire for Cost - Concurrent Engineering Approach

In the new paradigm, marketing not only specifies the product characteristic, but also the cost ‘bogey’ of the product. Based on the TARGET COST, the design, engineering and supplier pricing is done concurrently with the goal of meeting the customers needs and price as shown in Figure 5. In order to accomplish this new design paradigm it is critical to have individuals with a corporate memory of product development costs or have a computer model that will help the designers determine the critical cost tradeoff early in the design[5] stage.

Research started at the Design and Manufacturing Institute (DMI) of Stevens has led to the development of a computer model for economic analysis of plastic parts’”. The Cost Estimation System (CES)[7] and the later version COSTQUICK$_{TM}$ are models that provide an interactive environment that allows the designer to examine the cost of a part at the different project phases. First, a multi attribute analysis much like the popular Quality Functional Deployment (QFD) method must be developed so that the customers requirements can be analyzed. Next, at a very early stage of design, an engineering economic model is used in such a way that the designer will know what area of the process (tool cost, material cost, processing cost, set-up cost post-processing costs) is the largest contributor to parts' overall cost. In later stages of the design the part cost can be broken down into sensitivity factors that include material type, part complexity, part - dimensions, wall thickness, tolerancing etc. Lastly, once the design is settled and the mold is designed, a machine based cost model can be used (Figure 6).

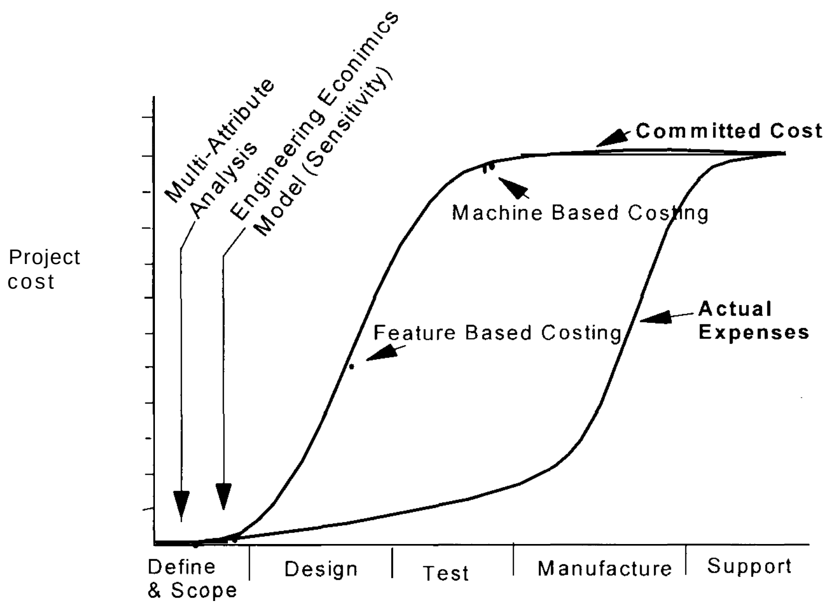

Figure 6 Part Cost by Project Stage

Model features

In the first part of this research product it was decided that the engineering economics and feature-based-costing model would be developed. To make this model useful to the designer a number of features must be present. They include:

- automatic sensitivity analysis for all inputs
- automatic ranking of variables by sensitivity
- automatic machine selection based on part size
- automatic cavity optimization based on 'least cost'
- separation of costs by major cost areas : (mold, material, process, set- up and post processing)
- estimates for cycle times, mold and material costs
  (calculated for attributes via formulas or overridable via exogenous inputs)
- inputs consistent with designer's vocabulary
- ability to display costs on a spreadsheet
- ability to display answers graphically

After-tax economic analysis consistent with industry standards.

COSTQUICK$_{TM}$: MODEL LOOK AND FEEL

Figure 7 is the master screen for COSTQUICK$_{TM}$ the engineering economics model developed for estimating the cost of plastic parts. This will be demonstrated at the conclusion of the talk.

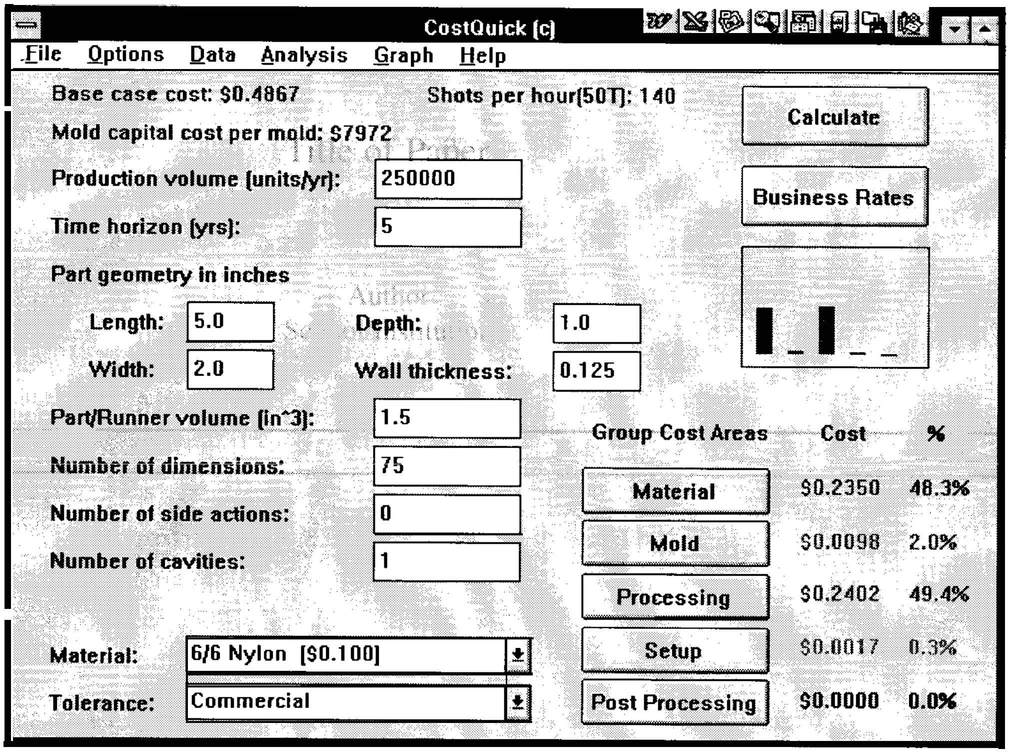

Figure 7 Master Screen for CostQuick$_{TM}$

Model development

The authors have completed the working prototype for DMI that was demonstrated to industry participants in 1993/94. Thirteen industry experts from nine Fortune 500 companies had the opportunity to test the new software. Results from the demonstration indicated that the users found the model easy to use and a significant improvement in the state of the art. Further development by the authors based on industry feedback has resulted in a comprehensive model called COSTQUICK$_{TM}$.

Acknowledgments

The authors would like to thank the following organizations: Design and Manufacturing Institute (DMI) at Stevens Institute of Technology, US Navy, Great Lakes Composite Corporation (GLCC), and the US Army. Special thanks go to the 3M Corporation that provided a summer fellowship to D. W. Merino to visit their best of breed mold makers and injection molders and obtain data for the cost estimation models.

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Authors' Profile :

DONALD N. MERINO, Ph. D., P.E. is a tenured full time Professor of Department of Engineering Management and Management at Stevens Institute of Technology. Dr. Merino was principal investigator for DMI for the development of the CES model. Dr. Merino received an ASEE Centennial award in Engineering Economy and in Engineering Management for his significant contributions to these fields. He is co-author of " The Selection Process for Capital Projects" by John Wiley, has authored over 40 technical reports and 20 referred journal articles. In the decade he has been in academe. For the prior 25 years Dr. Merino held positions of increasing executive responsibility at Standard Brands, Exxon, Mobil and Carousel. He is a registered professional engineer in Industrial engineering.

DONALD W. MERINO, M.S. is Vice President of Operations and Quality for Engineering Information Inc. (EI) located at Stevens Institute of Technology, NJ. D. Merino is a graduate of the US Naval Academy at Annapolis and spent 6 years in the Navy before coming to Stevens to complete a Ph. D in Concurrent Engineering. D. Merino was employed as a Resident Engineer at DMI and did the research that led to the development of the CES and CostQuick $_{TM}$ models.