Cost Modelling and Design Optimisation

This article may be found at
http://www.soton.ac.uk/~cedc/posters.html

Abhijit R Rao
Computational Engineering and Design Centre
School of Engineering Sciences
University of Southampton
Southampton SO17 1BJ
UK
Tel: +44 (0)23 8059 3392
Email: arr@soton.ac.uk

Prof. Andy J. Keane
(Academic Supervisor)
Tel: +44 (0)23 8059 2944
Fax: +44 (0)23 8059 3230
Email: ajk@soton.ac.uk

CEDC UTP for design

The total cost of making a product comprises direct manufacturing costs, material costs, procurement transportation costs and other indirect business costs (overheads) associated with the product. Cost control is a major concern in engineering design and critical decisions made in design have a huge influence on total product cost, Fig.1

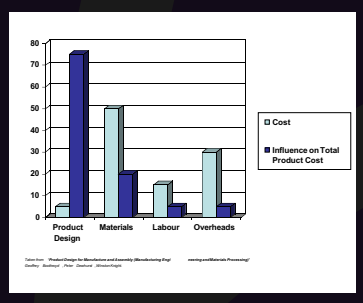

Fig.1 product cost categories and their influence on total cost

How Does Cost Fit Into Design Optimisation?

Traditionally Design Optimisation tends to ignore cost and focuses primarily on performance and structural integrity. In a few cases it has been included as a function of the weight of the component. But this can be grossly misleading as high manufacturing cost can easily overwhelm any incentive to improve the design. Though it is a widely accepted fact that 75-80% of cost is committed in the concept design stage (Fig.1), optimisation using cost in the objective function has been elusive in the past because of two prime reasons;

- Lack of accurate methods for determining the cost of manufacture at the concept design stage.
- Difficulty in modelling manufacturing cost in terms of typical parameters and design variables used in design optimisation processes.

Objective

This project aims to demonstrate optimisation of design parameters using a manufacturing cost model, stresses and the weight of a component. The work until now has focussed on developing a system which will utilise the feature based approach to accurately estimate the cost of manufacturing of a proposed design and further to optimise cost against performance to converge on the most economical and structurally feasible design. The framework of the system is shown in Fig.2

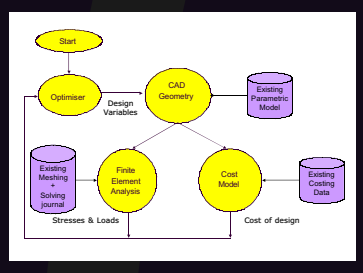

Fig. 2 System Specifications

Feature Based Manufacturing

A feature is a geometric form having an appearance which emerges out of a manufacturing activity carried out on it. Every component can be subdivided into the constituent features present in it. The entire manufacturing process of the component is a summation of the processes needed to make the features. Machined parts were chosen here to demonstrate feature based cost estimation. Machining cost is proportional to the machining time which changes proportionately with change in the design variables. CATIA V5 is the application used to parameterise the geometry and calculate the machining time. Fig. 3 and 4 depict the machining simulation of two features in CATIA V5.

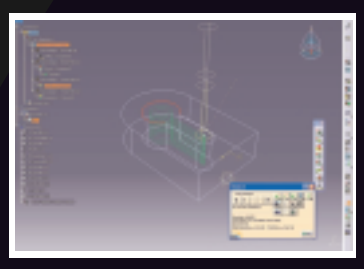

Fig.3 Pocket milling (Machining time is displayed in the window –bottom right)

Fig. 4 Contour Milling

Structural Analysis and Optimisation

Cost analysis cannot be used in isolation. Cost must be balanced against performance, here represented by weight and strength. As shown in Fig.2, finite element analysis will be used to calculate the resultant stresses on the design, which are an important constraint in final optimisation process. It is interesting to note the relationship between cost and strength. Simplification of a part may reduce the processing cost but increase the material costs and also the strength. Reduction in strength may not reduce the material costs but increase processing costs and scrap rate. Clearly the search for a good design depends on accurately modelling complex relationships between the various parameters and the existing trade-offs.

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Future work

Future work is aimed at the development of a complete prototype model based on the system described in previous sections. The component studied will be a Rolls-Royce turbine disc modelled in CATIA.

DecisionPro

DecisionPro is a dedicated cost modelling software tool which combines features of artificial intelligence tools, math applications, and spreadsheets. Methods such as decision tree analysis, Monte Carlo simulation, forecasting, optimization, expert systems, statistical analysis, and others are available in this application. DecisionPro supports advanced programming techniques enabling it to build and simulate complex systems. It has the feature for running cost models in a web browser and there is a possibility of converting it into a web service.

The cost model will be built in DecisionPro or CATIA V5 (which will become clearer as the research into these applications continues). Structural analysis will be performed in ANSYS. The OPTIONS toolkit in MATLAB will be used for optimisation. This whole model can be wrapped in a MATLAB script to be run automatically in a batch mode. The skeleton is shown in Fig. 5

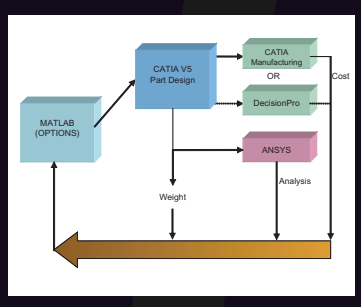

Fig. 5

University of Southampton