unit cost model forproduct cost management

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contents

1.0	Abstract	03
2.0	Introduction	03
3.0	Cost Modeling	04
4.0	Why Unit Cost Models?	04
5.0	Costing Methodologies Used Parametric Modeling	04
6.0	Activity Based Costing (ABC) Also Known As Bottom-up Costing	04
7.0	Unit Cost Estimation	05
8.0	Case Study	05-06
9.0	Benefits of Unit Cost Models	06-07
10	Conclusion	07
11	References	08
12	Author Profile	08-09
13	About QuEST Global	09

Abstract

There is an increasing demand in aero-engine products for better efficiency and environmental performance while maintaining low product cost. Unlike performance, the theory behind cost effectiveness is not well understood. This white paper proposes a unit cost modeling methodology applied to an aero-engine part. An objective of the cost model is to allow engineers to understand the breakdown of product cost, identify "key cost drivers" and hence manage the product cost. A value driven design concept is outlined to understand cost impact of design decisions at the early design stage through Unit Cost Model.

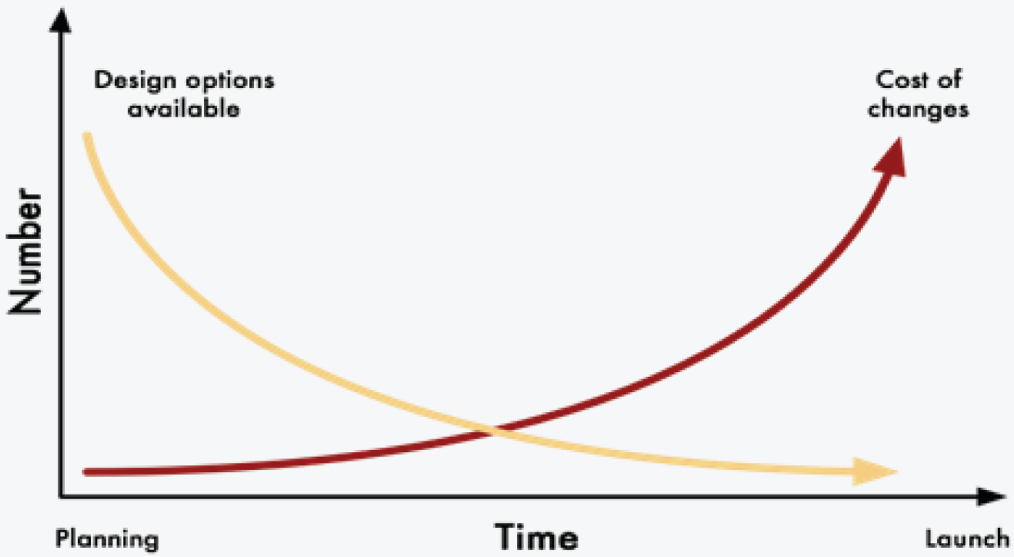
Introduction

Businesses in current scenario are influenced by many factors; a major factor being "cost effectiveness". Engineering usually makes design decisions without understanding their true cost impact. This can be overcome by adopting Product Cost Management (PCM) approach, which involves creating internal software for predicting, controlling, minimizing, recording, and sharing product costs. PCM approach also shortens lead time, which reduces the cost without compromising on quality by eliminating non-value-added objects.

PCM through Unit Cost Models may include one or more of the following processes:

- Evaluate unit cost of product / Should cost
- Analyze cost effectiveness of design alternatives
- Analyze cost effectiveness of manufacturing alternatives

The cost of change graph shown below explains the importance of unit cost model at the beginning of a project/product lifecycle, as these models dramatically



improve the speed, consistency and accuracy of the estimates at the planning (concept /early design) stage as cost of changes is minimal at this stage. These unit cost models permit designers to play around with the design options and envisage the cost impact of a particular design, thereby empowering the designer to make decision on the right design by evaluating its cost impact.

Cost Modeling

Cost modeling is a process of evaluating the cost of a product/activity through interpreting the historical data or knowledge by creating/using a cost model. Cost estimation as seen is largely based on experience. It's often difficult to get the standard information on costing as it requires the knowledge of various disciplines namely, manufacturing processes, materials, commercial drivers, etc,. Cost modeling uses historical knowledge base to store data of similar products in each model, making it readily available for estimating the cost of a new product, which in turn, eliminates factual errors while estimating.

Why Unit Cost Models?

Unit cost model adopts many costing methods as detailed below and would result in the benefits indicated. The model can be built using commercially available software such as Excel, VanguardTM, etc.

Activity Based Costing (ABC) : Breaks-up the total cost into estimates of (for) individual processes, activities, and resources.

Parametric Estimating: Uses historical data to identify statistical relationships between cost and design parameters through relevant equations.

Tree Layout Structure: Vanguard's user interface overcomes the limitations of a typical spreadsheet in representing complex models by using a hierarchical tree layout. It allows one to work with meaningful cell names, plain-English formulae, and equation in standard math form.

Collaborative Modeling: Using component-based modeling technology, many individuals in an organization can work concurrently to build large models.

Custom Methods: Create new or hybrid costing methods.

Other Benefits:

- Data analysis using various charts
- Primitives and library models
- Sensitivity analysis and Monte-Carlo simulation
- Web publishing

Costing Methodologies Used Parametric Modeling

This technique involves developing cost estimates based upon the examination and validation of the relationships that exist between a products's technical, programmatic, and cost characteristics as well as the resources consumed during its development, manufacture, maintenance and/or modification.

Parametric cost estimation establishes a relationship between cost and input parameters that affect cost and this relationship can also be used to estimate the cost of new product for the same family of component where the design is not well defined. This can be done by adjusting the values of input parameters; however the model should be revisited to make sure that they are to the current standards and the input parameters still hold good for the new program.

Activity Based Costing (ABC) Also Known As Bottom-up Costing

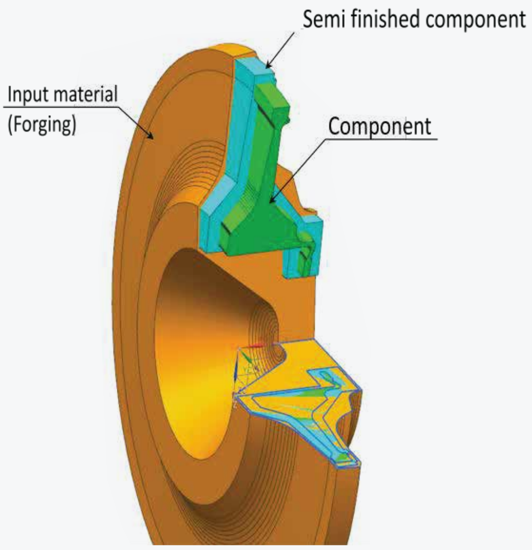
ABC is a methodology that identifies activities in an organization/process and assigns the cost of each activity with resources to all products and services according to the actual consumption. Methodology of ABC focuses on cost allocation in operational management and can account for indirect costs more realistically by costing the time and resources spent on each activity. This type of costing provides more detailed and accurate estimates and in addition it also helps in understanding and categorizing the value and non value items.

Unit Cost Estimation

A parameterized geometry unit cost model involves creation of feature based part geometry and manufacturing information that is scalable with the design definition. The main purpose of the flexibility and scalability in the cost model is to estimate the time required to manufacture a component based on design parameters that drives the manufacturing operation time and hence the cost. The flexibility and scalability will provide a robust unit cost solution at various levels of topology to be integrated as part of design iterations. The same has been illustrated with a generic case study in next section.

Case Study

Turbine Disc-Aero Engine Part



The case study was developed for “IP turbine disc”, one of the high impact Aero-engine components. The function of the component is the same for all variants listed in the table below. These components are characterized by commercial features such as low to medium volume, high manufacturing cost and long lead time. The implementation of design change is too costly because of the nature of the component.

The designer had a tough time when making a design decision as there is no tool available, which captures the historical cost and manufacturing data typical for this component and there is no mechanism available for the designer to know how the design change will impact the cost.

During this case study, a flexible – parametric unit cost model was prepared, which calculated the unit cost of component and had all the flexibility to accommodate the design changes as required by the designer.

The illustration below shows a conceptual baseline design along with three design alternatives and cost delta for alternative designs. The alternative designs are derived by varying the type of material, critical dimensions like outer diameter, bore diameter, web thickness, drive arm length, number of flange holes, number of fir-tree grooves, etc, from baseline concept.

The table contains major cost breakup and manufacturing process cost details. Negative value indicates cost savings over baseline design.

The administrative burdens and non recurring costs are not included in this analysis. (All values are in GBP)

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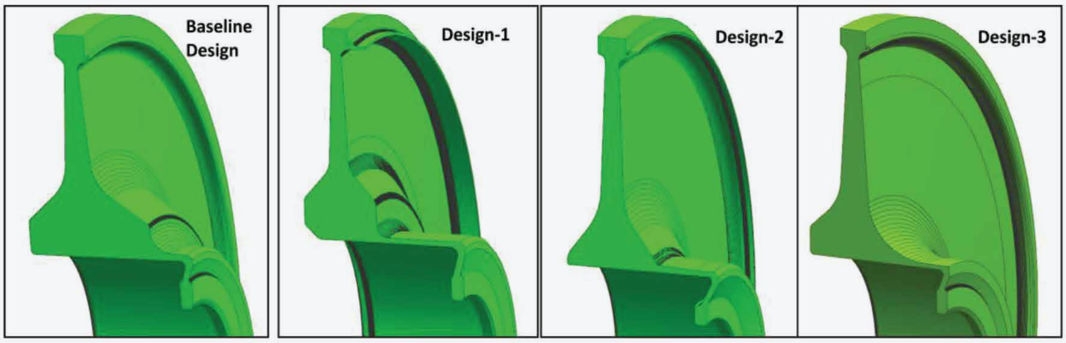
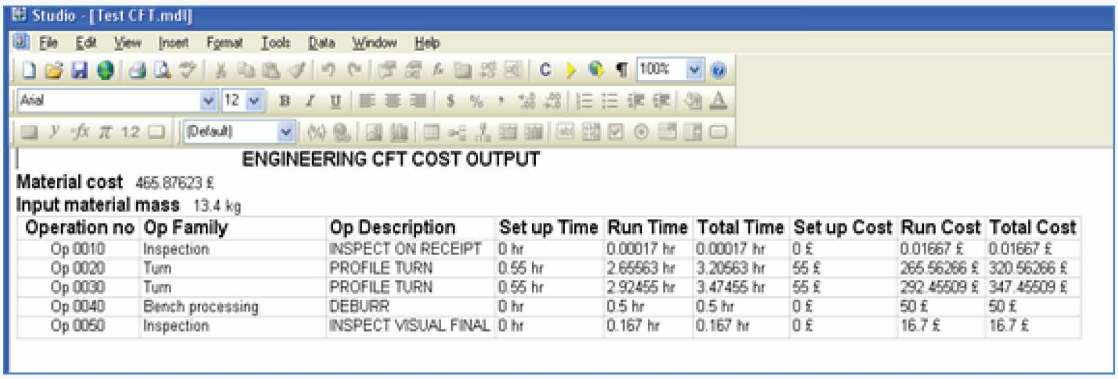


Cost delta	Design option - 1	Design option - 2	Design option - 3
Material	**Udimet**	**Waspaloy**	**Udimet**
Component mass	-54.1	-37.6	3.4
Input material mass	-144.8	-141.1	-75.3
Cost delta			
Total cost	-22,224.8	-36,231.9	-11,163.2
Material cost	-10,195.2	-23,588.0	-3,384.1
Process cost	-12,587.6	-13,917.5	-9,805.4
Subcontract	1,002.0	1,734.0	1,747.3
Scrap	-444.1	-460.4	279.0
Process cost details			
Turning cost	-9,076.4	-10,153.7	-9,079.8
Milling cost	-152.7	-135.7	-50.9
Drilling cost	-339.3	-680.4	111.6
Bench processing cost	-8.5	464.8	161.2
Broaching cost	-2,346.3	-2,837.8	-921.0
Surface treatment cost	77.9	198.3	9.6
Inspection cost	-841.9	-777.2	-129.9
other	99.5	4.1	93.8

Benefits of Unit Cost Models

Customized reports with each model



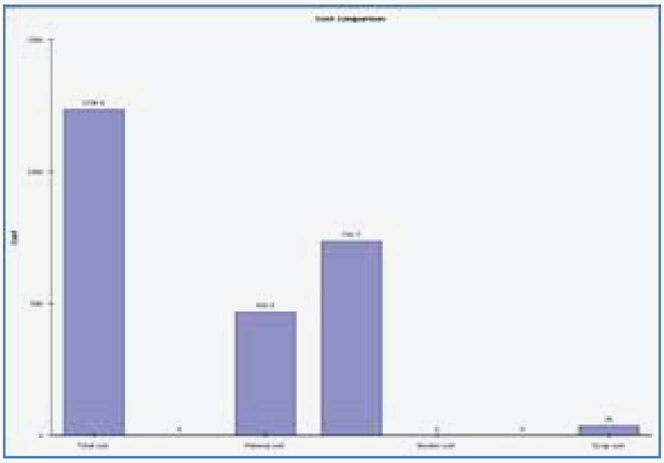
ENGINEERING CFT COST OUTPUT

Material cost 465.87623 £

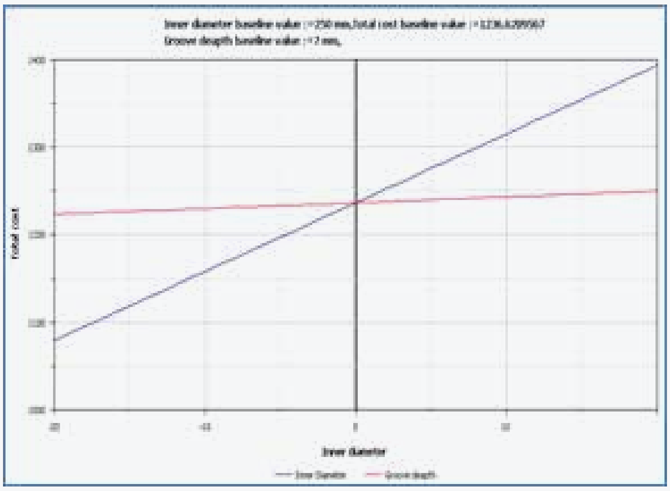
Input material mass 13.4 kg

Operation no	Op Family	Op Description	Set up Time	Run Time	Total Time	Set up Cost	Run Cost	Total Cost
Op 0010	Inspection	INSPECT ON RECEIPT	0 hr	0.00017 hr	0.00017 hr	0 £	0.01667 £	0.01667 £
Op 0020	Turn	PROFILE TURN	0.55 hr	2.65563 hr	3.20563 hr	55 £	265.56266 £	320.56266 £
Op 0030	Turn	PROFILE TURN	0.55 hr	2.92455 hr	3.47455 hr	55 £	292.45509 £	347.45509 £
Op 0040	Bench processing	DEBURR	0 hr	0.5 hr	0.5 hr	0 £	50 £	50 £
Op 0050	Inspection	INSPECT VISUAL FINAL	0 hr	0.167 hr	0.167 hr	0 £	16.7 £	16.7 £

Graphs: Standard charts (Bar /Pie /Line) available for report generation and further analysis. These charts help to find the area to focus for further evolutions.



Sensitivity Analysis: Sensitivity analysis examines the effect of changes on individual inputs to cost outputs. This allows you to emphasize on the factors that have a significant impact on the overall cost estimate and points out which factors needs to be refined. As shown in graph two inputs are analyzed for their cost sensitivity with respect to "Total cost" and feature dimension. Graph shows how inputs are sensitive to total cost output.



Collaboration: Many individuals simultaneously can contribute to a modeling effort by building blocks, easily combine their knowledge, assumptions, and historical data into one complete model.

Reusable model library: One doesn't have to re-invent the wheel with each new costing effort. Simply search the model library to find similar or related models that can be updated or linked, in real time.

Roll up / Drill down: Roll-up the analysis to see high-level views, or drill down into specific areas of the model for greater detail and understanding.

Instant web reports: Models are equipped to generate interactive Web reports and can be accessed from anywhere, fully exercise the models in real time, and distribute the results to everyone who needs them.

Easy integration: Cost models can be easily integrated directly with existing business systems such as databases, enterprise applications, and even spreadsheets.

Conclusion

This paper has discussed the importance of understanding cost drivers for a component at the early design stage, which helps in design

decision making. This in turn reduces the life cycle cost of component and lead time as the design process will become more robust with respect to cost effectiveness.

This will also drive a sense of cost ownership in the Design and Manufacturing community, which is lacking currently. Once cost ownership is established at the early life cycle of the component, it will result in better product cost management.

Overall this methodology has many advantages (as listed in benefits section above) over traditional costing methodology as these individual models will be a live document of cost and can be used throughout the lifecycle of the product.

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Author Profile

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Sreekanth D N is the Project Lead for ME Cost Engineering (Rolls Royce Centre) at QuEST. He has been with QuEST since April 2008, and his total experience spans over a decade and half in Manufacturing Engineering ranging from Process Planning to Cost Estimating

Author Profile

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Lokesh.P has rich Manufacturing Engineering knowledge ranging from process planning, costing and estimations of auto and aero engine components to assembly of special purpose machineries. His total experience spans over a decade and touched various mechanical industry verticals. He has been part of the team and later led the team to develop the methodology for Product Cost Management

About QuEST Global

QuEST Global is a focused global engineering solutions provider with a proven track record of over 17 years serving the product development & production engineering needs of high technology companies. A pioneer in global engineering services, QuEST is a trusted, strategic and long term partner for many Fortune 500 companies in the Aero Engines, Aerospace & Defence, Transportation, Oil & Gas, Power, Healthcare and other high tech industries. The company offers mechanical, electrical, electronics, embedded, engineering software, engineering analytics, manufacturing engineering and supply chain transformative solutions across the complete engineering lifecycle.

QuEST partners with customers to continuously create value through customer-centric culture, continuous improvement mind-set, as well as domain specific engineering capability. Through its local-global model, QuEST provides maximum value engineering interactions locally, along with high quality deliveries at optimal cost from global locations. The company comprises of more than 7,000 passionate engineers of nine different nationalities intent on making a positive impact to the business of world class customers, transforming the way they do engineering.

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