PREDICTING MANUFACTURING COST BY GENERATING A FACTORY SIMULATION FROM CAD GEOMETRY

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ABSTRACT

Analysis of a design is required to determine if the design meets specification. The cost analysis process requires information from multiple sources including results from other analysis. A framework is presented that combines component CAD geometry, dynamic factory simulation, manufacturing and cost knowledge, to reduce the time and improve the accuracy of cost analysis.

INTRODUCTION

In early design stages many different designs are required to be developed in a short space of time. To aid the design process multi-disciplinary teams are assembled to develop designs for groups of interlinked components. Designs are developed by the team, by analysing and improving on design iterations. Analyses of the designs are completed by utilising tools and techniques developed by specialised groups. Figure 1 shows the current process for an engine project in a large aerospace company. The engine project creates a component specification which the multi-disciplinary team will fulfil. Each specialised group analyses the design, but an analysis has multiple attributes that require consideration.

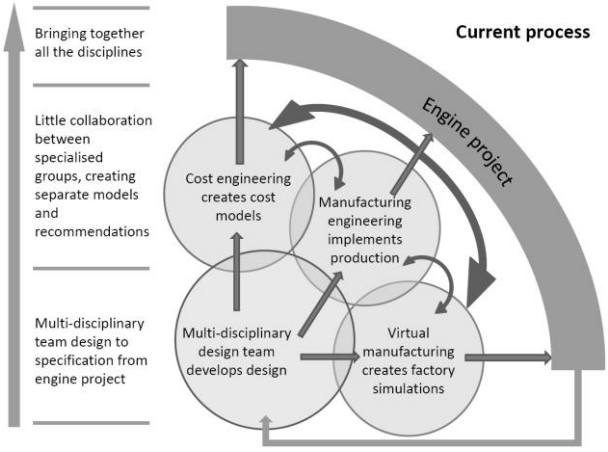

Figure 1: Flow of information through a project

In terms of cost analysis the design forms only part of the information required. Static information such as the amount and cost of material required can be retrieved from design and database information. Dynamic information such as the time taken to manufacture a component needs to be simulated or modified from similar designs. Figure 1 shows analysing departments share information to complete their own analysis, but the information being shared takes time to be generated.

Cost analysis is conducted by experienced engineers who have cost and manufacturing experience combined. The engineering experience combined with modelling techniques [1] helps reduce the need to receive information from other departments such as manufacturing engineering. But the requirement of skilled engineers to conduct the analysis, results in capacity issues which manifests itself as time required generating the analysis results.

Modelling techniques and historical information can reduce the need for generating dynamic information via simulation. These are no substitute for a simulation which can provide a prediction of the resources required and the time taken to manufacture a component [2, 3]. This paper presents a framework that automatically generates a dynamic factory simulation to improve the accuracy and reduce the time to conduct a cost analysis of a component, by combining manufacturing and cost knowledge, CAD geometry and dynamic factory simulation.

RELATED WORK: SIMULATION

Simulation mimics the behaviour of a system, which aids in understanding, thus allowing improvement to the system [4]. A dynamic system such as a factory can be simulated, allowing 'what if' scenarios to be run on the systems inputs. These scenarios allow a system to be understood, which can be used to find the boundaries or to optimise the inputs. This section reviews the latest developments and methods in simulation building to aid in understanding of manufacturing and cost estimation.

Simulation has many uses and has been proved to help in decision making and improving systems [2, 3, 5]. Chen [6] states that 'production simulation' is the most accurate method for predicting completion time in a semiconductor factory, but goes on to say that production simulation requires lengthy simulation time and requires large amounts of data. This has lead to developments in simulation building methods. Standridge [7] came up with seven laws to aid in performing factory simulations, and Zhou et al [8] introduced a common set of concepts to aid in conceptualisation of DES models. Other researchers have used spread sheets [9, 10] and databases [11, 12, 13, 14] to speed up the construction of simulations. Some researchers have extracted basic or predefined geometric data from CAD tools [15, 16, 17, 18] to aid in building simulations. Ingemansson et al [19] collects data from a manufacturing system automatically, which is used to construct a simulation model.

It has been shown that simulation can improve the accuracy of resource predictions, which in turn can improve cost estimations. But the time required to generate specific simulation models is unrealistic at early design stages, unless the models can be automatically created from design data.

THE PROPOSED FRAME WORK

The proposed framework reduces the time and improves the accuracy of resource prediction required for cost estimation, by automatically generating a factory simulation from component geometry directly from a CAD tool. Figure 2 shows a flow chart of the framework. The framework is split into 4 stages; geometry creation, component information, factory modelling and result publishing.

Stage 1 – geometry creation consists of the user selecting a component part by navigating through the CAD tool menus; a GUI prompts the user for information about the dimensions of the part, and the user is then allowed to modify the part within the CAD tool. When the user is happy with the design geometry the user starts stage 2 – component information, by selecting a command button within the CAD tool. Stage 2 checks the geometry and any additions to the part; the data from the CAD tool is sent to and stored within a database, which links to extra information about the part and manufacturing process stored within the database. The user is then prompted for information concerning the manufacture of the component. Stage 3 – factory modelling starts the simulation environment and a factory model is built to comply with the information in the database. The simulation is run and

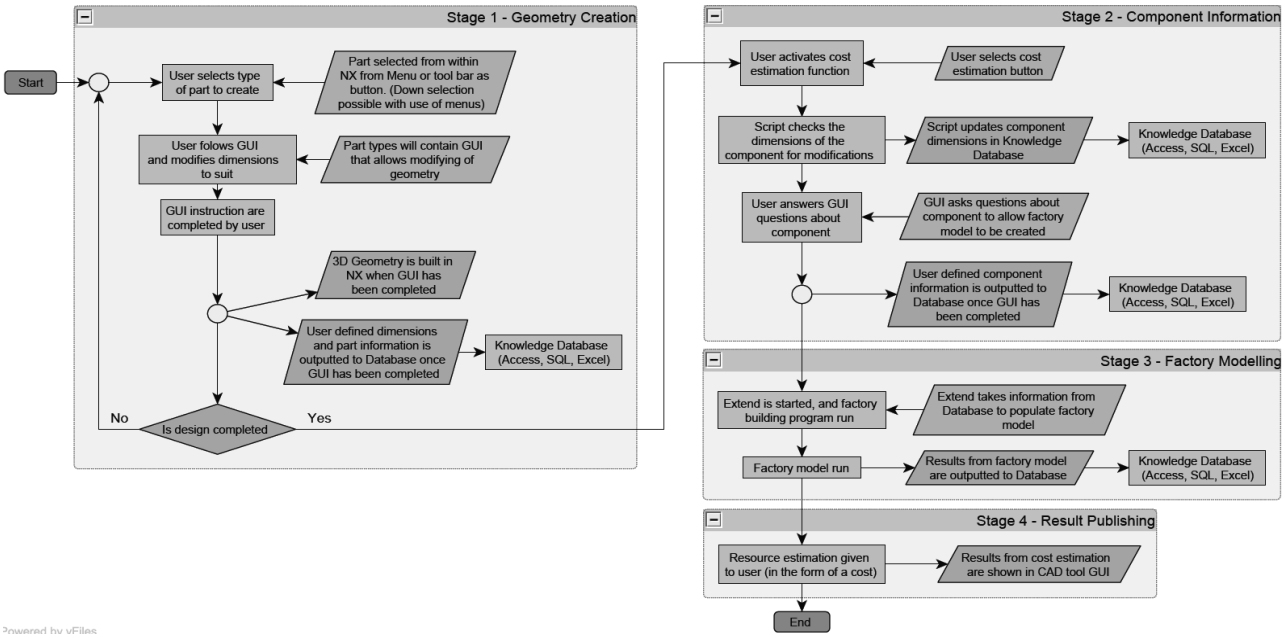

Figure 2: Framework flow diagram

the results are sent to the database. Stage 4 – results publishing, uses the results from the simulation to create a cost model and estimate the unit cost of the component. The unit cost is shown in the CAD tool for the user to review. If necessary the user is able to review a breakdown of the cost and manufacturing process to determine the design drivers.

A system to implement the framework is in preliminary construction. The system is being designed with a powder Hot Isostatic Pressing (HIP) process case study in mind. This process can manufacture components in a Near Net Shape (NNS) form, thus keeping machining and waste material to a minimum. The NNS attributes of this process pose significant benefits in terms of unit cost for components. A case study utilising a component manufactured by the HIP process will prove the fundamentals of the framework.

SUMMARY

A framework that combines CAD, and factory simulation, to reduce the time required to analyse the cost of a component in a production environment is presented. A case study is being implemented for a cylindrical component manufactured using the powder HIP process. The case study will show how the user interacts with the system and how the tools are interlinked. The case study will prove the system can implement the framework, which will allow the system to be extended to a real component case study.

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