Chapter two: design

2. 1 Chapter Overview

This chapter presents a summary of the the review of literature regarding the subject of design and captures various aspects and thoughts on this. Various thoughts, process and research particularly related to the design process are explored. This chapter encompasses the definitions, characteristics, discussions and applications of design. It is intended that this chapter should give some clear background on the understanding of the design process and its development in today's world of design research.

While the literature review provides a useful background of current research in the material, process and RM systems, the literature available on the design aspect for RM products is severely limited. First a review of the literature for definition of the term ' design' is presented. A discussion of the act of designing then follows. Next, the type of knowledge associated with design has been discussed. Finally, various thoughts of process of design have been reviewed. This introduction should provide the reader with a context for interpreting the remaining chapters of this report. The full version of this chapter can be referred to Appendix 3.

2. 2 Chapter Summary

Design is a complex activity, involving artefacts, people, tools, process, organisations and the environment in which this takes place. This chapter has explored and discussed the subject of design and captures various aspects and thoughts on this. Various thoughts, process and research particularly related to the design are explored. However, the assumption that there exists a set of universally accepted design process is an area that can be further explored. Conclusively, design is seen as a possible but subjective

process. This leads to different sets of interpretation being used by different researchers.

Whilst there may be some dispute about the precise definition of the term ‘ design’, it is recognized as a purposeful and creative activity. In summary, design seeks to create things with the purpose of satisfying certain requirements in new ways that improves the quality of lives. In product design, a variety of requirements must be considered ranging from functionality and usability to pleasure. However, design is more than just translating a set of requirements into a product. Also, and more importantly, it involves finding new requirements. Thus, design involves finding problems and solutions simultaneously, and this is where creativity is important.

Designing a product involves a constant decision making process that includes problem solving in a sequential fashion and analysis of constraints at each step. Product designers conceptualize and evaluate ideas, making them tangible through products in a more systematic approach. The role of a product designer encompasses many characteristics of the marketing manager, product manager, industrial designer and design engineer. The role of the product designer combines art, science and technology to create tangible three-dimensional goods. This evolving role has been facilitated by digital tools that allow designers to communicate, visualize and analyze ideas in a way that would have taken greater manpower in the past. (This appears in identical form in Wikipedia!)

A number of formal structures and frameworks to better understand the design process have been suggested from many different disciplines by

many researchers. Most of them have converged upon the general form proposed by Pahl and Beitz's. Pahl and Beitz (1996) outline a model of the design process for mechanical design that considers not only the sequence of stages, but also what the output of each stage. They divided the design process into four phases that includes planning and clarification of the task, conceptual design, embodiment design and detail design.

However, this research is concern with the understanding of the design process for Rapid Manufactured products. One of the objectives is to understand how the design process works and how it is learned and performed by professional and expert designers. The aim of the research is to support the design process with the aid of computers. Finally, this chapter has given some background on the understanding of the design process and its development in today's world of design research.

Chapter Three: Computer Support Tools for Design

3. 1 Chapter Overview

This chapter presents an overview of various tools to generate CAD models for RM processes and the decision support systems, tools and techniques used to support the design process. The full document of this chapter can be referred to Appendix 4.

3. 2 Chapter Summary

Computational tools play an essential role in providing support for the designer, because of their speed and capability for handling huge amounts of information at fairly low costs. There are various methods to aid designer to generate CAD models such as CAD softwares, reverse engineering and haptic devices. CAD traditionally refers to computer tool to visualize,

describe, edit and test manufactured artefacts, which are now an essential part of all manufacturing and production processes. CAD systems often involves more than just shapes. CAD has evolved to incorporate several other applications of computer integration with engineering, manufacturing and simulation. CAD now offers the capability of freeform surface modelling and solid modelling operations that allows user to create almost any complex geometry and photo realistic rendered images.

Reverse engineering is an important tool to generate CAD models. To reverse engineer a part, the part is measured by a coordinate measuring machine (CMM) or a 3D laser scanner. The use of reverse engineering technology not only increases the overall accuracy, but also improved the productivity of manufacturing process.

There are various areas of applications of haptics devices. In manufacturing, haptics can assist design for assembly and for rapid design and prototyping. In computer-aided design, designers can experience real time details with their hands, such as wanted or unwanted artefacts of a design which are difficult to display visually. It is also possible to assess human maintainability of complex systems before they are built .

The increasing power of computer has lead to the development of software, tools and techniques to support the design activity particularly to make design decisions. Most of the decision support tools are related to the knowledge base systems or often called as expert system. Expert systems are computer programs that are derived from a branch of computer science research called Artificial Intelligence (AI). AI’s scientific goal is to understand

intelligence by building computer programs that exhibit intelligent behaviour (Boyle 1989). It is concerned with the concepts and methods of symbolic inference, or reasoning, by a computer, and how the knowledge used to make those inferences will be represented inside the machine. The main characteristics of the Expert Systems can be briefly described as: reduced decision making time, enhancement of problem solving capabilities, a capture of limited expertise and its diffusion, an increased output, productivity and quality; accessibility to knowledge, ability to work with incomplete information and provision of training(Ziemian, Crawn 2001).

There are several methods used to support the decision making process such as Case-Based Reasoning (CBR), fuzzy logic, Artificial Neural Network, Rule Base System and Ontology. CBR is a problem solving technique based on the adaptation of previous examples that are similar to the current problem(Maher, Balachandran & Zhang 1995). An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information (Moridis, Economides, 2009). Fuzzy are developed using the method of fuzzy logic, which deals with uncertainty. This technique, which uses the mathematical theory of fuzzy sets, simulates the process of normal human reasoning by allowing the computer to behave less precisely and logically than conventional computers (Shu-Hsien Liao 2005).

Rules are probably the most common form of knowledge representation and they are present in most Artificial Intelligence (AI) applications such as Expert Systems and Decision Support Systems (Obot, Uzoka 2009). Rule base system uses rules as the knowledge representation for knowledge

coded into the system i. e. knowledge is stored as rules. Rules typically take the form of if – then statement.

Ontology in both computer science and information science is a formal representation of a set of concepts within a domain and the relationships between those concepts (Shu-Hsien Liao 2005). Ontology is a system of vocabulary, which is used as a fundamental concept for describing the task/domain knowledge o be identified. This vocabulary is used as a communication basis between domain experts and knowledge engineers.

On the other hand, there are a number of selection tool for RP system has been developed since 1993 (Masood, Soo 2002). The selection of the most suitable RM process is dependent on factors such as build envelope, accuracy, material, build speed and other machine related parameters.

This chapter has explored and discussed the general overview of the various tools to generate CAD models for RM processes and the decision support systems, tools and techniques to support the design process. Various CAD data development systems and tool have been explored. Furthermore, various expert systems technologies that support the decision making process have also been explored. Conclusively, CAD and reverse engineering technology are the most well known CAD data development systems. In addition, expert systems are the most well known decision support tool that have been used for various applications. Having become widely used for a broad range of applications, some elements of an expert system could be considered to have the capability to be a design aid tool that could realise the DfRM tool.

In the context of design support systems for RM technologies, due to the direct manufacturing of products from CAD data, the cost and time are low mainly because complex objects can be generated without the use of conventional machines. So far within the RM field little attention has been given to the product design phase, emphasis is normally on the development of the technology itself (processes, materials, building strategies, system selection, manufacturing parameter optimisation etc). On the other hand the operation and choices which take place during the design phase are crucial for the quality of the product produce.