Rapid Prototyping Technology Principles and Application on Selective Laser Sintering (SLS)

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Abstract: The purpose of this book is to provide an introduction to the fundamental principles and application area in Rapid Prototyping (RP) technology. The book traces the development of RP in the arena of Advanced Manufacturing Technologies and explains the principles underlying each of the RP technologies.

It also covered the most dominant RP processes and their specifications, in particular of selective laser sintering (SLS) process. The material in this book has been used and revised several times for professional courses conducted for academia since 2008. Certain materials were borne out of research conducted in the School of Mechanical Engineering at the University of Leeds. To be used more effectively for graduate or final year undergraduate student in Manufacturing Engineering.

Keywords: Fundamental principles, application, Rapid Prototyping, Advanced Manufacturing Technologies

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CONTENTS

PREFACE

The purpose of this book is to provide an introduction to the fundamental principles and application of Rapid Prototyping (RP) technology. The book traces the development of RP in the arena of Advanced Manufacturing Technologies and explains the principles underlying each of the RP technologies. It also covers the most dominant RP processes and their specifications, in particular Selective Laser Sintering (SLS) process.

The material in this book has been used and revised several times for professional courses conducted for academia since 2008. Certain materials were borne out of research conducted at the The School of Engineering (Mechanical Department), University of Leeds, United Kingdom. It is to be used more effectively for graduate or final year undergraduate student in Manufacturing Engineering.

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LIST OF ABBREVIATIONS

AM	:	Additive Manufacturing
3DP	:	Three dimensional printing
CAD	:	Computer aided design
FDM	:	Fused deposition modelling
FFF	:	Freeform fabrication
LOM	:	Laminated object manufacturing
MJM	:	Multi Jet Modelling
RP	:	Rapid prototyping
SEM	:	Scanning electron microscopy
SFF	:	Solid freeform fabrication
SLA	:	Stereolithography
SLS	:	Selective laser sintering

Chapter 1

INTRODUCTION

1.1 PROTOTYPE FUNDAMENTALS

1.1.1 Definition of a Prototype

A prototype is an important and vital part of the product development process. In any design practice, the word "prototype" is often not far from the activities involving designers. In most dictionaries, it is defined as a noun, e.g. the Oxford Advanced Learner's Dictionaries of Current English (Hornby et al, 2000) defines it as;

> *'The first design of something from which other forms are copied or developed'*

However, in design, it often means more than just an artifact. It has often been used as a verb, e.g. prototype an engine design for engineering evaluation, or as an adjective, e.g. build a prototype printed circuit board (PCB). To be general enough to be able to cover all aspects of the meaning of the word prototype for use in design, it is very loosely defined here as;

> *'An approximation of a product (or system) or its components in some form for a definite purpose in its implementation'.*

Chapter 2

RAPID PROTOTYPING TECHNOLOGY

2.1 INTRODUCTION

Rapid prototyping technologies are also often referred to as layer manufacturing (LM) technologies (Levy et al., 2003). This is because the first major application area for layer manufacturing was RP. Such technologies are also known as freeform fabrication (FFF), solid freeform fabrication (SFF) and additive processes (Debasish et al., 2001). A universally agreed terminology for these technologies is Additive Manufacturing (AM), is the official industry standard term (ASTM F2792) for all application of the technology.

2.2 BASIC PRINCIPLES

Basically, all rapid prototyping systems consist of a combination of a CAD system with a machine to perform the fabrication of layers under the instruction from a computer (Choi et al., 2002). Figure 2.1 shows an example of the basic procedure for rapid prototyping process. The procedure can be divided into five steps (Pham, 2002):

Chapter 3

SELECTIVE LASER SINTERING

3.1 INTRODUCTION

An introduction to the SLS process has been given in section 2.3.2. This section will describe in detail the processing parameters, materials, and the current development in SLS technology.

3.2 IMPORTANT PROCESSING PARAMETERS

In the SLS process, there are many parameters involved, both controllable and non-controllable. Each parameter, as shown in Figure 3.1, has some effect on either the rate of sintering during the formation process or the feature definition of the complete SLS object (Nelson, 1993).

Chapter 4

BENCHMARKING OF SLS PROCESS

4.1 INTRODUCTION

This chapter presents the results of SLS process benchmarking carried out on a commercial SLS machine using a commercial Duraform PA material. Mechanical properties, surface quality and dimensional accuracy of the material and the process currently in use were identified. As the material properties were expected to be orientation-dependent due to the fabrication method used, different fabrication orientations have been defined, as shown in Figure 4.1. The effects of different fabrication orientations of specimens on the material properties were determined by the isotropic/anisotropic behaviour of the process.

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