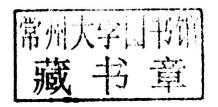


Sustainability in Engineering Design

An Undergraduate Text

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Sustainability in Engineering Design

Preface

Anthony Johnson and Andrew Gibson are engineers with extensive experience in several complementary fields.

Anthony started his career as an indentured apprentice with the U.K. Royal Navy. He worked in a commercial capacity as well as a design capacity in several industries, eventually managing a busy design office for a specialist plant manufacturer. Anthony has performed numerous engineering design consultancy projects during his career at the University of Huddersfield, where he has taught mechanics, dynamics, strength of materials, automotive design, computer-assisted design (CAD), and engineering design for 27 years.

Andrew has extensive expertise in customer-driven product development, technical sales, business strategies, export strategies, and legislation related to engineering. After graduating with degrees in engineering and German, Andrew worked in product development and as customer liaison, moving on to export sales and marketing and thence into the management of international subsidiaries of U.K.-based engineering companies. He subsequently developed a consultancy-based business, working with clients to penetrate new markets and focusing latterly on international trade training.

The raison d'être for the book was the result of several influences: a chance meeting with a sustainability entrepreneur, the need to teach sustainability for engineers in a higher education establishment, the embarkation of a post-graduate research program integrating sustainability principles with design methods, and the opportunity to take the message of practical engineering design out into the world.

This book is essentially a text that covers the formulative approach to mechanical engineering design but also combines methods and techniques that accommodate the principles of sustainability for use by practical design engineers performing their day-to-day work. Sustainability is an increasingly important environmental factor that is promoted by environmentalists, national governments, and commercial enterprises alike, and as such it is required by engineering institutions to be woven into the fabric of undergraduate and post-graduate engineering programs.

When new products are created, it makes sense to incorporate the principles of sustainability, but the *only* function in the product creation process that can deliver the principles of sustainability is the design function. This text promotes the total design control approach to sustainability and applies it at a practical level.

The material in the book has been drawn from extensive research as well as from the wide-ranging experience of both authors.



Foreword

Anthony Johnson and Andrew Gibson are both experienced engineers whose combined practical and advanced expertise spans some 86 years. Anthony has brought his extensive practical design experience to the book as well as his 27 years of experience in teaching several analytical subjects, along with engineering design, at the University of Huddersfield in the United Kingdom.

This book expands the normal approach to engineering design to accommodate the approach to modern CAD and analytical techniques, but more important, it incorporates the designer's approach to creating sustainably engineering products. Thus this book is hailed by several sources as a ground-breaking text.

During Anthony's Ph.D. research program, he extensively explored sustainability and its application and discovered that there was a dearth of literature covering practical application of sustainable principles for mechanical engineering designers. Anthony continuously asked the question, "How can practical designers apply the principles of sustainability to their newly designed products?" This book attempts to answer that question.

The book contains a methodical approach to design, taking into consideration Anthony's own practical design experiences and his involvement with various consultancy projects. Sustainability whole-product-life models are put forward, incorporating the six stages of a product's life, from sustainable sourcing through sustainable disposal. The approach to implementing sustainability within the design process has then been engaged within each of the elements.

Andy Gibson is head of a management training company, Segelocum Limited. Andy has strengths in production and process engineering and has particular skills in the fields of marketing-driven product development, and of the impact on companies of financial and legislative processes; these areas have been the focus of Andy's contribution.

The book seeks to address the forces that act on engineering designers and the businesses in which they are involved, including legislation, consumer pressure, and marketing opportunities. It describes in some detail the concepts of open and closed life-cycle loops and argues that the modern design must take into account impacts generated during the full life cycle but concentrate on where the correct selection of material or design modification can make the greatest impact. In that light, the book also looks in brief at some of the modeling methods currently used to measure the sustainability of machines and machine elements across the whole life cycle.

Prof Andrew Ball

Pro-Vice-Chancellor Research University of Huddersfield West Yorkshire United Kingdom

Book Synopsis

Earth's natural resources are becoming increasingly scarce, yet the drive for ever-newer products could not be greater. The strain on our natural resources is therefore increasing, but it is our contention that sustainable engineering design must be part of the solution rather than part of the problem.

Sustainable design incorporates the standard design process with the sustainable sourcing, use, reuse, and disposal of materials ensuring a minimum effect on the planet's resources. The normal design process merely selects materials for manufacture often with no thought as to the source of the material or the method of disposal after the products life has expired, let alone the possibility of renewed or extended life through easy maintenance. Sustainable design incorporates eco-sourcing at the beginning of the design process and eco-dismantling on the end of the design process. It also incorporates an improvement in product life cycle by designing-in ease of repair and renovation.

Central to this theme is the argument that the ultimate responsibility for sustainability in components, products, and systems belongs with the design function; just as Taguchi suggested the same function also controls quality.

If goods and products are to be produced to use resources efficiently and with low cost, then it is important that awareness, knowledge, and ability are generated in our new graduate designers, and this book proposes and details some useful tools and approaches that can be incorporated into a standard designer's armoury to ensure that their output moves the planet toward rather than away from a sustainable future.

Introduction

Traditionally, engineering designers designed and manufacturing engineers manufactured the design. In the late 1950s, engineer and statistician Genichi Taguchi suggested that quality should be placed in the hands of the designer. This revelation prompted a design and manufacturing revolution and was the catalyst that drove production techniques into quality mass production. Though production techniques had been pioneered by inventors and industrialists such as Samuel Colt and Henry Ford, quality of manufacture still largely remained the domain of craftsmen and artisans to produce and create quality goods.

There are a great number of demands placed on the modern design and production environment. Some of these are traditional demands, such as that of reducing cost. Newer demands, however, are becoming prominent, such as those that require reduced environmental impact when a new design is created. This relatively new discipline is *sustainable engineering design*.

Taguchi was one of the first proponents of placing the emphasis on designers and the idea that designers should take control and specify quality. The greater demands and expectations placed on new products effectively demand that designers take a greater role in specifying and controlling the new product, from its inception right through manufacture to packaging and even marketing. This is, effectively, Sustainable Engineering Design. The design function can no longer be compartmentalized, since it is the only function that can oversee and control the entire process of product creation from "cradle to grave."

It is within the designer's gift to apply sustainable design techniques for a long-life product. It is the designer and *only* the designer who has the overview of the whole design and manufacture process. This whole-life process involves the following elements:

- · Specifying sustainable materials
- · Designing for sustainability
- Designing for sustainable manufacture
- · Designing for sustainable use
- Designing for sustainable maintenance
- Designing for sustainable disposal

The designer must therefore take control of the whole-life process. This technique is termed *total design control*.

This book examines traditional design techniques and offers suggestions as to how these techniques can be incorporated into total design control. To achieve this goal, the traditional approach to design compartmentalization must change to a global design approach. Traditionally designers design and manufacturers manufacture, but the new methodology demands that these two major disciplines be combined and joined by several other disciplines. This means that designers' attitudes and approaches have to change to a global, whole-life design strategy. This book shows how to achieve that goal.

Anthony Johnson University of Huddersfield West Yorkshire United Kingdom

> Andrew Gibson Segelocum Ltd Retford Nottinghamshire West Yorkshire

> > January 2014

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