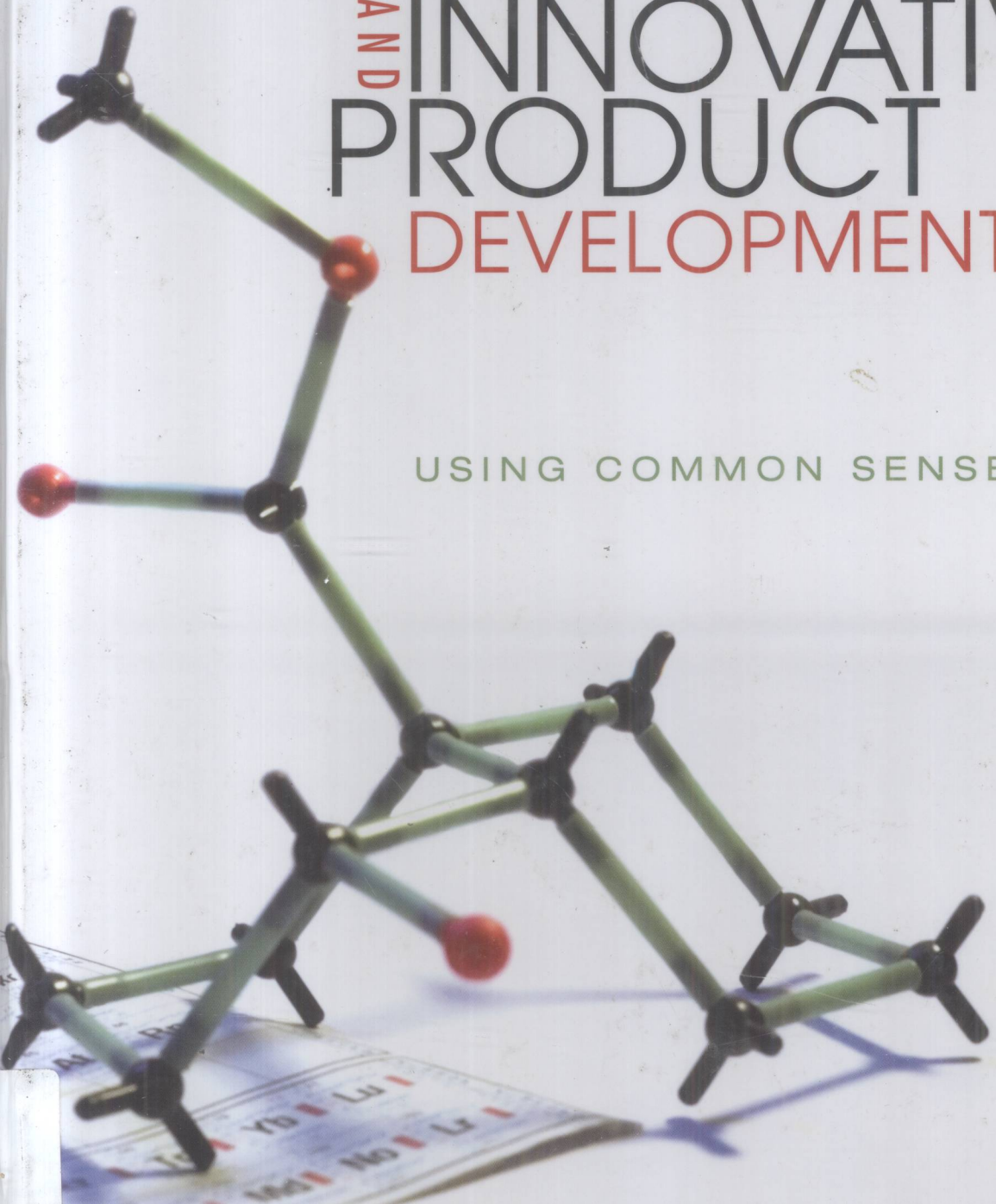
GERNOT H. GESSINGER

MATERIALS AND INNOVATIVE PRODUCT DEVELOPMENT

USING COMMON SENSE



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Using Common Sense

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Materials and Innovative Product Development

To my family

Preface

Always bear in mind that your own resolution to success is more important than any other one thing.

—Abraham Lincoln

Materials can always be seen as components of engineering systems, forming the basis of new products and leading to innovation. For many companies and particularly those engaged in the aerospace, energy, transportation, construction, "high-tech," or consumer electronic industries, the ability to innovate and produce a stream of new materials-based products is key to the continued growth and profitability of the organization. New materials-based products frequently also serve as a driver to create startup companies. Although, in hindsight, there is always a logical evolution of innovative products, there is no certain method for ensuring innovation. In many cases, recognizing and supporting the "ideas" person and ensuring that the straightjacket of company bureaucracy does not stifle creative instincts is important in establishing an appropriate innovative environment.

Experience has shown that, early on, a focus on a still unclear target is most important and rules and guidelines obtained from business schools may be helpful but are insufficient to ensure success. The role of intuition, pattern thinking, and the ability to make fast decisions are often more important than the application of rational but time-consuming thought processes.

Nevertheless, certain formal processes can be used to encourage the generation of ideas and development of innovative products, and the purpose of this book is to present some of these formalisms in the context of the management of an R&D program in a large diversified company. The content is based on the material presented by me in a course given at the Swiss Federal Institute of Technology in Zurich since 2005. The course was initiated in response to the proposal by Professor Ludwig Gauckler, head of the Laboratory of Nonmetallic Materials, to introduce a focus area on the topic of Materials and Economy and the idea was to take advantage of my experience in managing the corporate R&D program at ABB. It is a frequent criticism of the R&D fraternity that there is insufficient awareness of the costs involved when developing new products, and it was judged that an early introduction to the economics of materials usage would be advantageous.

The book is aimed at graduate and postgraduate students and those early in a research career. In this context, an important feature is the inclusion of case studies from mostly newly established companies in the United States, Canada, Russia, Switzerland, and Finland and my own experience of managing the R&D process to ensure the emergence of new and improved products. Thus, the case studies provide real-world examples of innovation and new product development and bring to life some of the concepts described in the formal chapters. The individual chapters describe the critical phases in product development, including some

of the models that can be used to guide the creation and application phases of the dynamics of innovation. Chapters on R&D management, accounting, and market characteristics and requirements provide the reader with the background necessary to understand potential obstacles to be overcome in the introduction of new products.

Most existing management books take a top-down view, based on a statistical evaluation of a large number of case studies, supposedly proving management theories. The approach in this book is bottom up. Although referring to important conclusions from existing management literature, it tries to bring the reader into the real world, where work is done, showing the present and a look into the future. The following points may differentiate this book further.

- The importance of ethical, social, environmental, and sustainability considerations.
- The need to use common sense and intuition.
- The courage to work against all outside resistances and obstacles.
- An analogy between management and mountaineering.

With the emergence of the global economy, the emphasis in the developed countries of Europe and North America in particular is on the production of high value-added products and equipment with a high input of skill and originality in design and production. The information in the book may not ensure an ability to innovate, but it may provide a bridge between academic and professional life and the inspiration to drive the innovative process.

ORIGINS AND ACKNOWLEDGMENTS

The course on Materials and Economy evolved after discussions and input from

- Professor Ludwig Gauckler, who started out his career at the Max Planck Institute, from which he moved to work in an industrial research center of an aluminum company and then became professor of ceramics at the ETHZ, keeping his focus on application-driven basic research.
- Dr. G. Schröder, a leading researcher in metal forming, who held various positions at ABB and later obtained an MBA.
- Dr. W. Hofbauer, an electrical engineer, at one time responsible for ABB's newly created surge arrester business. He taught a somewhat related course to electrical engineers at the ETHZ, providing me with his manuscript, and co-authoring Chapter 7.

From discussions with Gauckler, it quickly became clear that a series of case studies would be of great help to bring real-life experiences to students.

The idea to write this book came during one night in February 2006. I had just completed my first course. I asked the students for their feedback, and they criticized the dominance of too many slides: "Why don't you provide us with some notes as well?"

Many people influenced me during my studies and my subsequent career. Although it is impossible to list them all, I want to give credit to a select few:

- Dr. W. Kaltenegger, who taught me mountain climbing in a constructive way, as if he were my manager.
- The late Prof. F. V. Lenel of Rensselaer Polytechnic Institute, who helped generate my interest in powder metallurgy and its many potential applications.
- Prof. G. Petzow, my first boss at the Max Planck Institute in Stuttgart, for his constructive support.
- Dr. Claus Schüler, my first boss at BBC (later ABB), who led by his interest in my work, including numerous suggestions about my course.
- Dr. Craig Tedmon, CTO at ABB, who taught me the importance of making quick and still good decisions.

Many more people deserve credit. I worked with them, they worked for me, or they were consultants, and I learned a lot from their skills and their patience and enthusiasm: Martin Müller, Erwin Schönfeld, Rolf Lüthi, Dr. C. Corti, Dr. M. Bomford, Dr. C. Buxbaum, Dr. G. Schröder, Dr. P. S. Gilman, Dr. C. R. Boër, Dr. C. Verpoort, Willy Kuhn, Karin Batke, Dr. H. Rydstad, Prof. A. Speiser, Prof. J. Carlsson, Prof. H. Gleiter, Prof. P. Gudmundson, Dr. T. Duerig, Dr. K. Melton, Dr. O. Mercier, Dr. W. Hoffelner, Dr. E. Bakke, Prof. R. Singer, Prof. H. F. Fischmeister, Prof. E. Hornbogen, Denise Riedo, Elisabeth Egli, and Frank Sharp.

As mentioned before, a lot of original information for this book came from case studies. I owe many thanks to Prof. L. Gauckler, Dr. F. Filser, Dr. W. Rieger, S. Jud, Dr. M. Santi, N. Winterberger, P. Keisänen, Prof. J. Pylkkänen, Dr. J. MacDonald, Dr. T. Duerig, Dr. D. Stöckel, B. Zider, Prof. J. C. Palmaz, Dr. H. R. Zeller, Prof. K. Ragaller, Dr. W. Paul, W. Schmidt, M. Hagemeister, and Dr. V. Samarov.

Special thanks go to Dr. T. Gibbons, who spent valuable time to review and improve the manuscript.

Introduction

There are books on materials science, books on processing materials, books on innovation, and books on economics and management. No book combines all these topics from a point of view of the person who starts the innovation process, often a materials engineer but perhaps a physicist, chemist, or anyone with an engineering background.

Innovation is a complex phenomenon. Success requires the combination of many skills, but each situation is so novel that what is needed most often is common sense, the ability to see the bigger picture and quickly decide when to steer into a new direction, how to manage new risks (which appear all the time) and keep looking for newly opened opportunities that may suddenly change the course of the whole process.

This book is an attempt to explain some of the fundamentals, often outside your field of experience but highly important to be successful. You may consider it a personal view of how things are done, which also explains frequent references to the companies Brown Boveri, Asea, and ABB. Much of the information can be found in more detail in the specialized literature, but the purpose of this book is to focus on the essentials, trying to make it interesting by connecting everything to real-world examples. Case studies show what has been learned by actually going through the innovation process or trying to solve a problem. Some of the learning experiences from the case studies are similar, but there is no attempt to develop "theories" around them. With a few exceptions, these case studies do not go into specific technical and financial details, so the focus invariably is at the higher level of decision making and learning experiences. As you will recognize, there is a heavy emphasis on experiences.

ANALYSIS OF AVAILABLE LITERATURE

Numerous textbooks cover the whole range of materials, their properties, methods of processing them, and their applications [1–5]. In the case of mature technologies, the information is compiled in handbooks, often reaching out to cover the interdisciplinary aspects of engineering or economics [6–10]. The value of these books often is based on complete information about the composition, properties, design rules, and applicable economical principles of established materials.

Individual processes, like innovation management, strategic planning, technology roadmapping, financial management, and new ventures, have been covered by many excellent textbooks [11–17].

WHO SHOULD READ THIS BOOK?

To be successful in creating an innovative product, a wide range of skills is necessary. The first glimpse of reality in science comes with the thesis, then working in industry confronts the engineer with the reality of the business world. It is a mistake to believe that an MBA education at such an early stage would help shorten the way to successful innovation. Most likely, the opposite will happen, because the focus on economic and managerial issues is too early. This book is intended to reach both graduates and people in the R&D field, also engineers in small- and medium-sized companies in just about any position.

By definition, any book that offers information about skills that still need to be acquired will be used sooner or later by those who need them. To serve their purpose, such books have to be as interdisciplinary as possible, which often does not happen. This book will not make you a designer of specialized products nor an accountant or a manager. Without realizing it, you would lose interest if too much specialized information were provided, which may just cost you too much time to absorb. The main purpose of this book is to serve as a *bridge from academic, specialized training to professional life*, to widen your horizon and make you aware of what else counts. Experience shows that focused workshops and short-term training courses also do a better job in filling this need than in-depth specialization.

FOLLOWING THE FLOW OF INNOVATION

The book describes all the important aspects that have to be considered, from idea creation to development of an innovative product. These aspects cover the *sources of innovation*, the *people* involved in defining the needs and providing the required knowledge base. To manage innovation, the flow of an *organization* is needed and, as one moves from the initial phase of idea creation into product development, an increasing level of *structure in terms of objectives, strategic planning, and time and cost targets* are required.

The chapters in the book are arranged as much as possible to follow this flow, although due to the multifaceted aspects, a simple time-based approach is not possible.

Chapter 1 describes the first phase, in which ideas evolve from different possible sources of innovation, both outside and within an enterprise. The wide and increasingly interdisciplinary field of materials is described. Twelve case studies, which in the course of this book are discussed in detail, are introduced briefly. The case study CERCON® serves as an example of the convergence of skill sets necessary for a successful innovation.

Chapter 2 introduces the structure and various types of organization of a company. As we will see, there has been a gradual shift away from traditional

mechanistic to organic organizations. Five possible ways of departmentalization of companies are described. The process of vision, mission, objectives, and strategic planning is the tool to reach product and business targets.

Chapter 3 focuses on the first part of the creation/application spectrum. The creation phase encompasses research and development. Over time, the well-known linear model of R&D has been replaced by a more-open two-dimensional view, a mix of basic and market-driven applied research. The dynamics of innovation is described by a model exhibiting interdependent rates of product and process innovation over time. Existing innovations invariably experience replacement by a new one within a company or a disruptive process coming in from outside a company. Various models and tools to follow the innovation process are discussed. The case study ZnO varistors addresses several issues: in-house R&D in a technology-oriented but still fairly hierarchically organized company and licensing the same technology by a more market-oriented company.

Chapter 4 deals with application, the second part of the creation/application spectrum. We learn that we have to think backwards from an anticipated product design and define product requirements or specifications for the material to be developed. This includes making the right choice of production engineering and manufacturing. Two case studies address the issue. The first one, on isothermal forging of Ti-alloy impellers, teaches how to compare the manufacturing costs of two existing processes and a new one, still under development. This case also shows the importance of early critical interaction among the various functions involved—R&D, engineering, production, and marketing—which was not done properly here and led to the ultimate failure of this project. The second case study deals with the successful implementation of design-software for hot-isostatic pressing of precision components, overcoming a multitude of initial barriers by relentless interaction among all the potential players.

Chapter 5 describes the challenges involved in managing R&D technology, the first function involved in dealing with new ideas. Many of the comments apply to other functions as well, such as portfolio management, financial commitments, and human aspects needed to successfully support innovation. The case study on managing several corporate research labs at ABB shows you in hindsight, that continuous improvement is needed to keep up to date with worldwide progress in management and be open to new ideas at any time.

Chapter 6 teaches you to understand that any function, R&D included, has to understand the processes and work flows necessary to move forward fast and efficiently. We continue to use ABB as a case study. Initially, PIPE, a new Lotus Notes software program, was developed to continuously manage the work flow of research projects, making it possible to accept new ideas at any time. The Stage-Gate process is an important step forward to integrate all the functions in a large global organization in the decision-making process. Knowledge management, although a bit overemphasized when it became known, shows a new way to distinguish between tacit and explicit knowledge and how it can affect management thinking.

Chapter 7, on the financial management of a company, addresses two major issues. Financial accounting teaches you which tools are available to look at a company's financial status at different points of time: the balance sheet pinpoints financial status at the end of an accounting period—where are we now? The profit and loss account or the income statement shows the results of a company's operations over a period of time in hindsight—where have we been? In budgeting, the same terms are used, but this time to take a look into the future—where are we going? Managerial accounting and investment decisions are the most important tools to be used when developing a product or operating a business.

Chapters 8 and 9 teach you the various ways to develop or grow a business: market penetration for a given product, new product development within an established market, and diversification, where both the product and the market are unknown. Several case studies show that smaller companies, especially start-ups, are more willing to take big risks to succeed with an innovation. What has to be understood, however, is that the likelihood to fail with a new venture is always very large as well.

Chapter 10 shines some light on the human aspects of management. Many tools, also called *psychometric instruments*, measure our capabilities and preferences. Some of them are discussed in more detail. You will learn why you think and act your way and why others may think and act in a totally different way. This allows you to view leadership issues, creativity, and human relations from a new angle. A special emphasis is placed on the importance of intuition as opposed to exclusive rational decision making, as some of the case studies have shown beyond any doubt.

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