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Preface

Usually one seeks out a career, and, although I chose my career, I never realized how that choice was to impact my life. Although I chose heat treatment as a career, I did not make a conscious choice for nitriding; the subject of nitriding chose me.

In 1960, I was a final-year apprentice at DeHavilland Propellors, Lostock, United Kingdom. My project with a colleague was to evaluate the nitriding process for the DeHavilland Aircraft Group. It was at that time that the subject of nitriding chose me.

No matter where I have been, in the United Kingdom, South Africa, and now the United States, the subject of nitriding has followed me. Yet each time that I have researched the subject, I have found very few resource materials available. Unlike carburizing, for example, the subject of nitriding has had very few reference books or “cook books” written on the subject. A few books include a chapter or two on nitriding, and some conference papers are available in proceedings volumes. Up to now, however, there has not been a practical “how to” or “why to” book available on the subject.

In 1991, Rodney Allwood of the ASM Education Department urged me to present a one-day class on nitriding and somehow got me to agree. Despite feeling that I did not know enough to pull it off, to my surprise I was able to put together the notes for that course. This was the foundation for a book on nitriding. Mrs. Veronica Flint of the ASM Reference Publications Department challenged me to write such a book and, with her tremendous patience and persistence, forced me to find the time to put pen to paper.

Many books are dedicated to husbands, wives, children, or even dogs and cats (we have 8!). I can only dedicate this book to the young heat treater or metallurgist who is coming into the industry and to my colleagues who have, without exception, given me tremendous encouragement.

I want to remember my colleagues in South Africa, where to a large extent I learned my trade. Without that 20 years experience in South Africa, I could not do what I am doing today. I also want to remember my
colleagues at DeHavilland Propellors with whom I worked from 1956 to 1963, especially Wally Simms, our foreman (now deceased), who had the foresight and tenacity to fight to bring apprentices into the world of heat treatment and the DeHavilland Propellers (now British Aerospace) apprentice program; Bill Oddey, our heat treatment superintendent; Joe Aspinal, our metallurgist; and Alex Thexton, our chemist (who sold me his briefcase, which I still have), who is now somewhere in Australia. We will always be grateful to Paul Huber at Seco Warwick, who brought my family and me to the United States, and I thank my other colleagues there. I would also like to dedicate this book to all those who have gone before me whose work in the field of nitriding has brought the process to maturity. I stand humbly before all of them and thank them for this opportunity.

For help and growth in the field of pulsed plasma nitriding, I give thanks to Dr. Siegfeid Stramke in Germany. I especially would like to recognize Dr. Reinar Grun, who has put up with me, debated with me vigorously, and helped me learn the subject. He is a man whom I hold in great respect in the field of plasma physics.

I would like to acknowledge both George Totten and Maurice Howes for being mentors to me and for their very positive encouragement. Their support has been a privilege and continues to be a very rewarding experience.

I would like also to acknowledge Grace Pye. She always believed that I was capable of "going on my own."

It took my wife Lynn to push me to the successful completion of this and other goals. She said to me, "You have a dream. Don’t keep dreaming; live the dream." I could not have accomplished what I have without her patience, dedication, and support. This book could not have come together without her. She typed the original manuscript from my almost illegible handwriting and "chicken scratching." Thank you for your support of me and for listening to my heat treatment and furnace stories. You really are a gift to me.

I also would like to recognize Valerie Sales, my mother-in-law (deceased) who interpreted my hand drawn sketches and turned them into illustrations, and Robin Maloney, who also helped with the illustrations. Thank you for being patient with me.

I would like to thank all the reviewers who gave freely of their time and efforts to reviewing the manuscript. I would also like to acknowledge the editorial contribution of Joseph R. Davis, Davis & Associates, who helped polish the chapters and prepare them for the production process.

**Purpose**

Nitriding and ferritic nitrocarburizing in some ways can be seen as Cinderella processes in comparison to the other surface modification techniques, as it was around but often ignored. Though the beginning of nitriding can be traced to Adolph Machlet who applied for a patent in
1908 followed by Dr. Adolph Fry’s patent in 1922, it was considered in many areas as “a new process” when Drs. Wehnheldt and Berghaus developed the ion nitride process in 1932. Many fine metallurgists have contributed to the growth in our knowledge of the subject of nitriding. I have attempted to bring together all of their work by capturing the accumulated knowledge about the process in a book that will contribute to the continued growth of the nitriding process. The bell has not struck midnight on the subject of nitriding, however. Its technology, the refinement of its control, and most of all, our understanding of the process and methods will continue to grow. I expect the technology will be adapted for application to nonferrous metals, such as aluminum and the refractory metals.

This book is intended to assist all of the practitioners of the technology in the day-to-day process operation of nitriding and ferritic nitrocarburizing. The contents are based upon my lifetime of experience and the knowledge gained from my peers. I hope that you, the reader, will gain some useful knowledge about the subject of nitriding and its derivative process techniques.

The chapters in this book address many important questions related to the nitriding process:

- Of the many nitriding methods, which one is for you? There are many different and valid reasons for choosing each relevant nitriding process technique, be it the reduction in thickness of the compound zone, the elimination of the compound zone, deep case formation, shallow case formation, high wear resistance, or corrosion resistance.
- Of the many different nitridable steels that can be chosen to manufacture the component in question, which one should be chosen?
- What hardness should the steel have prior to nitriding?
- How much surface stock should be removed prior to nitriding, and what problems are caused if the appropriate amount of stock is not removed?
- Which furnace should be used?
- How should the process be controlled?
- How should the steel be prepared?
- How should the steel be handled after nitriding?

Up to now, many of the answers have been determined mostly by personal experience (“what works for you”) and possibly by the age old method of trial and error.

This book is a practical approach to the subject and not an academic or scientific work, although the subject is of a scientific nature. As with any other surface treatment process, such as carburizing or carbonitriding, the process of nitriding draws on many disciplines such as physics, chemistry, mechanical engineering, and electrical engineering. The “art” of nitriding
also requires individual ingenuity and dogged determination, tempered with patience to accomplish the process and produce a metallurgically sound part. The process cannot be guessed. It can offer many metallurgical benefits, but it needs to be managed and controlled in order to produce the desired and acceptable surface metallurgy. While it is a very simple process, there is little widespread understanding of it. This book is my attempt to help remedy this situation.

Over the years of heat treating and the years in the furnace industry, many examples of material selection for varied applications, process techniques, and failure evaluations have been both seen and experienced by myself and shared by others. My years as a consultant have exposed me to many industrial problems and process techniques. All of these experiences contributed significantly to this publication.

There are many, many steels available to the engineer who designs the part and chooses the steel. The problem that the engineer is faced with is “How do I source my information on steel and metallurgical processing techniques?” The simple answer (which may sound glib) is “With great difficulty.” It is hoped that this publication will provide the reader, who might be a heat treater, metallurgist, or design engineer, with a clearer insight into the techniques, material selection, equipment, control, testing, evaluation, and trouble shooting.

The analogy of an iceberg can be used to consider the factors that influence process costs related to nitriding. Nine-tenths of an iceberg is below the surface of the water. The top one-tenth could be likened to representing both the material cost and the process cost. However, inappropriate material selection and a lack of understanding of process techniques (and their results) can greatly inflate these costs. The submerged nine-tenths of this iceberg is the labor cost, machining costs, equipment costs, and time that is lost if the part does not function properly and must be scrapped because of improper heat treatment procedures and material selection.

The combination of steel selection and choice of heat treatment can therefore “make or break the product.” This book is offered to help you “make the product” and not “break the product.”

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