Book Reviews

Titanium Alloys: Modelling of microstructure, properties and applications

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This book owes its being to ten years of generously sponsored research, support which the authors gratefully acknowledge.

While many engineers know a fair amount about a few common titanium alloys, when in the solid useable state, far less is generally known of how titanium behaves when molten and semi-molten in the furnace. The authors are adamant that more needs to be known about thermomechanical processing and thermal treatment procedures – the nature and development of phase changes being all important. Areas of study specifically identified include: i) modelling of microstructure, ii) computer based modelling, iii) collaborative research, iv) Atomistic Simulation (γ/a2 interface and dislocations relevant to lamillar titanium aluminides, for example). Conventional titanium alloys and titanium aluminides are considered.

Following an introduction to titanium alloys and titanium aluminides in the Preface, the content is subsequently sympathetically split into four closely interrelated parts: i) Experimental techniques, ii) Physical models, iii) Neural network models, iv) Surface engineering products, the emphasis being on high temperature in situ, conditions throughout.

High temperature, in situ, microscopy, transmission electron microscopy and synchrotron radiation, X-ray diffraction and differential scanning calorimeters, are sub-headings which indicate the level of experimental sophistication employed. While the abundance of excellent micrographic reproductions does full justice to the art. On the other side of the coin readers, new to the analytic side of the subject, are shown how to use thermodynamic theory to construct physical models, there being a full chapter devoted to the Johnson-Mehi-Avrami method of isothermal transformation kinetics. It is probably fair to say that metallurgy, once the preserve of the less mathematically inclined, is now fully supported by the use of high grade finite element methods, couched in terms of space and time. FEA, in its liquid/fluid form, features strongly in Chapters 8 and 9, where the evaluation of β to α phase transformations and the lamillar structure of γ-Ti-Al alloys is pursued. NB: the observant reader will notice that data points on almost all graphs from this stage on lie exactly on the line, be it straight or curved. These highly precise graphs are, of course, state-of-the-art mathematical predictions which show close correlation with experimental results.

A method called cellular automaton is used to resolve the evolving microstructure of the alloy Ti-6Al-4V and this is followed in Chapters 10 and 11 by a study of titanium aluminides. Further computational methods, well supported (as elsewhere) by excellent electron microscope shots, are advanced in Chapter 12.

Neural network models (NN) are introduced in Part III – Chapters 13-15 – where the goal is to simulate and predict processing parameters and material properties that result. The text is explicit and implies that the reader who fully understands the text will have no need to refer to dedicated works on the subject. Topics discussed include: prediction of properties of existing materials, new alloy design, material selection and optimisation of processing parameters. Help is also given relating to the upgrade of software systems. Neural networks are further developed in Chapter 14, where β transus temperature and time-temperature-transformation (TTT) diagrams are discussed. The chapter also contains a training session in which (NN) system architecture and a Matlab coding example is explained. The correlation between processing parameters and mechanical properties of Ti-6Al-4V alloy forms the basis of Chapter 15. The blurb on the back cover refers to: 'the growing importance of titanium-based materials in aerospace, automotive, sport and medical sectors,' and an impressive list of almost 50 other titanium alloys which have also been tried and tested is included (page 410).

The excellent corrosion and sterile/inert properties of titanium and its alloys have made it a superb substitute material for diseased and worn bone, when implanted in the human body. But stem cells are likely to be used in future and a shortfall in other properties, namely the materials high cost, poor fretting fatigue, soft surface/poor wear resistance, high coefficient of friction and its susceptibility to fatigue failure, already restrict its wider use in mechanical engineering. All these problems relate to the surface of the material, which the authors have sought to improve. The abstract – page 413 – informs the reader that Part IV – Chapters 16-19 – is geared to experimental research into phase transformations that occur during gas/plasma nitriding, using all the techniques cited in Part 1. Chapter 19 is given over to the aluminising process in which nano surface layers are created. The process entails bombarding the surface of titanium with a mixture of hard balls and aluminium powder. The powder sticks, the balls do not. Hence a coating of aluminium is built up which is transformed to Al3-Ti when annealed at 600°C.

A list of 45 research papers by others used in the preparation of this book are acknowledged in the Preface.

The authors have penetrated deep into previously uncharted waters and claim a first for applying thermodynamic/mathematical modelling to the complex issue of inducing phase developments which lead to enhanced mechanical properties. It is to be hoped that these new findings will become more widely known and soon put to profitable practical use.

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Human Safety Under Accelerations (Biomechanical Analysis)

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This self-published textbook represents the work of Dr Rabinovich and his then-Soviet colleagues in some aspects of biomechanics published in the period 1966-2006. Based on 268 references that are assembled into a single list, Rabinovich reviews a body of knowledge essential for the complete aeromedical practitioner: the physics of acceleration and its effects on the body; basic biomechanics; the limits of tolerance for prolonged acceleration in each axis; and impact tolerance. (This book does not address vestibular physiology.)

Amidst the engineers' arcana of integral calculus, the book amuses the reader with background anecdotes, e.g., that the first structure to impose head-to-pelvis acceleration was a roller coaster that imposed up to 4G, designed by Nartov for the Russian Empress Elizabeth in 1752.

After his academic and inventing career as Professor at the Moscow Aviation Institute (25 of the 200 Russian language citations are

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