

Preface

If the lifestyles of up-and-coming and also developed societies are shaped in the future by the existing, currently predominating technologies, then the resource consumption at play will exceed every accountable environmental, economic and social boundary known to man. The dynamics of global competition and cooperation can be utilized for lending wings to processes of innovation and mediation towards the ultimate goal and necessity of *sustainability* on our globe. A special focus lies in condensing engineering to *sustainable manufacturing*, thus specifically addressing artefact generation shaping human living.

Abstract, intangible concepts and goals, such as *sustainability*, overburden human beings, engineers and researchers in different ways. To date, it constitutes an overwhelming task to consistently apply a full, balanced view and critical cross-assessment of the full range of relevant dimensions, such as the environment (incl. climate, resources and all other natural systems), the economy and society—the classical three pillars of the modern understanding of sustainability. Furthermore, conducting such assessments on different levels of abstractions creates a personal feeling of powerlessness. Researchers, however, take on the challenge of investigating both laws of interdependence and the underlying core mechanisms in order to provide new systemic views of the challenging concepts and goals of *sustainability*. Engineers, in addition, attempt to derive methods, processes and technologies to help society and companies in finding holistic, specific and proactive solutions for *sustainability*. In that mission, *sustainability* gets broken down into controllable elements within an overall system network: products with their functions and behaviours, material selections, production systems, factories, enterprises, logistic elements, value creation networks, patterns of use behaviours, labour and payroll systems, welfare, health and so forth.

The editors of this book and all contributing authors are of the belief that it is now high time to provide tangible solution sets to address various levels of “system driven realization and delivery oriented” sustainability. Yet what does that actually entail? Unlike the rather general (but necessary) discussions surrounding a “complete enough set” of sustainability development goals, such as the 17 goals agreed by the United Nations in September 2015, a critical urgency is attached to work on

“how such goals need to be realized, and which solutions have to be made available for them.” Manufacturing and its potential to deliver wealth and intelligent solutions to societies and human beings has been selected as a first prime route for investigating which changes are necessary for reaching a true state of *sustainability* in the future.

Sustainable manufacturing in this sense represents a manufacturing engineering’s approach to coping with these challenges. Manufacturing technology is developed in the direction of economic competitiveness, of environmental compatibility with natural global frame conditions of resource availability and of social welfare with different societal frame conditions to suit the different human communities around the globe. This multidimensional goal system can be balanced by developing adequate economic, environmental and social criteria, with analysis of their interdependencies and application of that analysis for guiding technological innovation in respective economic, environmental and societal frameworks.

Before stepping up and striving for a position from which to set up a “circular economy”—an economy where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimised—it is necessary to determine which elements need to be integrated into such a “system circle.” Hence, the underlying new mind-set of this book assumes that the overall values of *sustainability* and those specific to *sustainable manufacturing* can no longer just be driven by assessment factors and goals of the three dimensions environment, economy and society. Instead, it has become necessary to fundamentally change core and specific mechanisms and elements of the following “interacting system of systems”:

- The earth system with its natural resources and all associated ecological, biological and climatic sub-systems
- The societal system(s) and related behavioural patterns which are highly influenced by cultural, religious and ethnic values
- The economic system(s) originally driven by a profit theory based on the traditional production factors, such as land, work and capital, funds which was just recently however hugely impacted by new business model innovations, e.g. caused by the digital transformation

Research efforts in this book have investigated both specific technical approaches for ushering in changes to specific mechanisms (“the technical depth”), and on rather generic terms, overarching theories and methodologies on how value creation and its technical solutions can be variously influenced by specific earth and economic boundary conditions, i.e. the breadth of the overall approach.

The rather limited predictive capability of the timely progression of evolutionary or revolutionary changes to the solution set of *sustainable manufacturing* remains the first generic challenge of research in this field. This is the reason why system dynamic models are deemed to be appropriate candidates for overcoming such a research dilemma.

The second generic challenge in *sustainable manufacturing* deals with the contradiction between

- the desire to analyse the different aspects of the lifecycle behaviour of a product as narrowly as possible, and
- the obligation to provide a rather lean set of data, information and digital models for the design and determination of a product solution in the “Begin of Life” (BOL) phase of the lifecycle.

The right mix of both is decisive in the pursuit of enhancing the probability of influence on “smart and comprehensive decisions” as part of the engineering process of sufficiently sustainable products.

The ambition behind and need for driving changes from the different development levels of society and economy within both the highly developed and industrialized countries as well as from the perspectives and demands of the less developed and emerging countries represent the third overall challenge in *sustainable manufacturing*. Positive impact of the manufacturing sector on sustainability will thus only be possible if all participants actively involved think *locally and globally*.

This book is unique in its comprehensiveness in tackling research and engineering approaches in *sustainable manufacturing* and its global value creation mechanisms. It is the desire and intention of the editors that this book may serve to truly help researchers, industrial experts, politicians and interested members of society in the process of fully comprehending and further developing new solutions for driving and realizing *sustainability* with the help of manufacturing solutions. It is therefore an obligation for editors to stay in close contact with the growing community of sustainability oriented researchers, planners, engineering, managers, politicians and responsible individuals in all societies across the world.

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Sustainable Manufacturing

Challenges, Solutions and Implementation Perspectives

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