

# Preface

The concept of *virtual manufacturing* has been developed in order to increase the industrial performances, being one of the most efficient ways of reducing the manufacturing times and improving the quality of the products. *Numerical simulation* of metal forming processes, as a component of the virtual manufacturing process, has a very important contribution to the reduction of the lead time. The finite element method is currently the most widely used numerical procedure for simulating sheet metal forming processes. The accuracy of the simulation programs used in industry is influenced by the *constitutive models* and the *forming limit curves models* incorporated in their structure. From the above discussion, we can distinguish a very strong connection between *virtual manufacturing* as a general concept, *finite element method* as a numerical analysis instrument and *constitutive laws*, as well as *forming limit curves* as a specificity of the sheet metal forming processes. Consequently, the *material modeling* is strategic when models of reality have to be built.

The book gives a synthetic presentation of the research performed in the field of sheet metal forming simulation during more than 20 years by the members of three international teams: the Research Centre on Sheet Metal Forming—CERTETA (Technical University of Cluj-Napoca, Romania); AutoForm Company from Zürich, Switzerland and VOLVO automotive company from Sweden.

The first chapter presents an overview of different Finite Element (FE) formulations used for sheet metal forming simulation, now and in the past. The objective of this chapter is to give a general understanding of the advantages and disadvantages of the various methods in use. The first section is dedicated to some of the necessary ingredients of the fundamentals of continuum mechanics for large deformation problems. These are needed for a better understanding of the forthcoming FE-formulations.

A more extended chapter is devoted to the presentation of the phenomenological yield criteria. Due to the fact that this chapter is only a synthetic overview of the yield criteria, the reader interested in some particular formulation should also read the original paper listed in the reference section. We have tried to use the symbols adopted by the authors, especially in the mathematical relationships defining

the yield stresses and the coefficients of plastic anisotropy. This decision has been made in order to facilitate the reading of the original papers. Of course, under these circumstances, the coherency of the notations cannot be preserved. As one may see in the list of symbols, several identifiers have different meanings. The reader should take this aspect into account. This chapter gives a more detailed presentation of the yield criteria implemented in the commercial programs used for the finite element simulation (emphasizing the formulations proposed by the CERTETA team—BBC models—implemented in the AutoForm commercial code) or the yield criteria having a major impact on the research progress. To improve the springback prediction a novel approach to model the Bauschinger effect has been developed and implemented in the commercial code AutoForm. Consequently, an extended section of this chapter has been dedicated to the modeling of the Bauschinger effect, especially in the AutoForm model.

The sheet metal formability is discussed in a separate chapter. After presenting the methods used for the formability assessment, the discussion focuses on the Forming Limit Curves (FLC). Experimental methods used for limit strains determination and the main factors influencing the FLC are presented in detail. A section is dedicated to the use of Forming Limit Diagrams in industrial practice. Theoretical predictions of the FLCs are presented in an extended section. In this context, the authors emphasize their contributions to the mathematical modeling of FLCs. A special section has been devoted to present an original implicit formulation of the Hutchinson–Neale model, developed by the authors of this chapter, used for calculating the FLCs of thin sheet metals. The commercial programs (emphasizing the FORM CERT program) and the semi-empirical models for FLC prediction are presented in the last sections of the chapter.

The aspects related to the numerical simulation of the sheet metal forming processes are discussed in the last chapter of the book. The role of simulation in process planning, part feasibility and quality, process validation and robustness are presented based on the AutoForm solutions. The performances of the material models are proved by the numerical simulation of various sheet metal forming processes: bulge and stretch forming, deep-drawing and forming of the complex parts. A section has been devoted to the robust design of sheet metal forming processes. Springback is the major quality concern in the stamping field. Consequently, two sections of this chapter are focused on the springback analysis and Computer Aided Springback Compensation (CASP).

The authors wish to express their gratitude to Dr. Waldemar Kubli, founder and CEO, Dr. Mike Selig, CTO and Markus Thomma, CMD of AutoForm Company, for their support of the book project. They have created favorable conditions for the AutoForm team in order to make this book possible. The authors also wish to thank Dr. Alan Leacock from University of Ulster (UK) for his help in proofing the English of the manuscript. Prof. Banabic wishes to express his thanks to his former PhD students Dr. L. Paraianu, Dr. P. Jurco, Dr. M. Vos, Dr. G. Cosovici and his current PhD students G. Dragos and I. Bichis for their help in preparing and editing this book.

The book will be of interest to both the research and industrial communities. It is useful for the students, doctoral fellows, researchers and engineers who are mainly interested in the material modeling and numerical simulation of sheet metal forming processes.

Cluj-Napoca, Romania  
December 2009

Dorel Banabic