Chapter 6 Sheet Metal Forming Suranaree University Of

This book contains useful instruction and information for metal workers, from novice to intermediate and even advanced, on how to apply force and use good judgment, thorough planning, close observation, creativity, and restraint to create almost any metal part. With this book, simple to complex fabrication and metal forming tasks are within the reach of adept enthusiasts.

- Overview of materials and treatment aspects of manufacturability of sheet metal - Written by an industrial expert turned scientist - Concentrates on the formability of sheet metal, one of the fundamental form material is used in metalworking

Process Control for Sheet-Metal Stamping presents a comprehensive and structured approach to the design and implementation of controllers for the sheet metal stamping process. The use of process control for sheet-metal stamping greatly reduces defects in deep-drawn parts and can also yield large material savings from reduced scrap. Sheet-metal forming is a complex process and most often characterized by partial differential equations that are numerically solved using finite-element techniques. In this book, twenty years of academic research are reviewed and the resulting technology transitioned to the industrial environment. The sheet-metal stamping process is modeled in a manner suitable for multiple-input multiple-output control system design, with commercially available sensors and actuators. These models are then used to design adaptive controllers and real-time controller implementation is discussed. Finally, experimental results from actual shop floor deployment are presented along with ideas for further improvement of the technology. Process Control for Sheet-Metal Stamping allows the reader to design and implement process controllers in a typical manufacturing environment by retrofitting standard hydraulic or mechanical stamping presses and as such will be of interest to practising engineers working in metal-working, automotive and aeronautical industries. Academic researchers studying improvements in process control and how these affect the industries in which they are applied will also find the text of value.

This book is addressed to both research scientists at universities and technical institutes and to engineers in the metal forming industry. It is based upon the author’s experience as head of the Materials Science Department of the Institut für Umformtechnik at the University of Stuttgart. The book deals with materials testing for the special demands of the metal forming industry. The general methods of materials testing, as far as they are not directly related to metal forming, are not considered in detail since many books are available on this subject. Emphasis is put on the determination of processing properties of metallic materials in metal forming, i.e. the forming behavior. This includes the evaluation of stress-strain curves by tensile, upsetting or torsion tests as well as determining the limits of formability. Among these subjects, special emphasis has been laid upon recent developments in the field of compression and torsion testing. The transferability of test results is discussed. Some testing methods for the functional properties of workpieces in the final state after metal forming are described. Finally, methods of testing tool materials for bulk metal forming are treated. Testing methods for surface properties and tribological parameters have not been included. The emphasis is put on the deformation of the specimens. Problems related to the testing machines and measuring techniques as well as the use of computers are only considered in very few cases deemed necessary.

This book helps the engineer understand the principles of metal forming and analyze forming problems - both the mechanics of forming processes and how the properties of metals interact with the processes. In this fourth edition, an entire chapter has been devoted to forming limit diagrams and various aspects of stamping and another on other sheet forming operations.
Sheet testing is covered in a separate chapter. Coverage of sheet metal properties has been expanded. Interesting end-of-chapter notes have been added throughout, as well as references. More than 200 end-of-chapter problems are also included.

Over the last 15 years, the application of innovative steel concepts in the automotive industry has increased steadily. Numerical simulation technology of hot forming of high-strength steel allows engineers to modify the formability of hot forming steel metals and to optimize die design schemes. Theories, Methods and Numerical Technology of Sheet Metal Cold and Hot Forming focuses on hot and cold forming theories, numerical methods, relative simulation and experiment techniques for high-strength steel forming and die design in the automobile industry. Theories, Methods and Numerical Technology of Sheet Metal Cold and Hot Forming introduces the general theories of cold forming, then expands upon advanced hot forming theories and simulation methods, including: the forming process, constitutive equations, hot boundary constraint treatment, and hot forming equipment and experiments. Various calculation methods of cold and hot forming, based on the authors’ experience in commercial CAE software for sheet metal forming, are provided, as well as a discussion of key issues, such as hot formability with quenching process, die design and cooling channel design in die, and formability experiments. Theories, Methods and Numerical Technology of Sheet Metal Cold and Hot Forming will enable readers to develop an advanced knowledge of hot forming, as well as to apply hot forming theories, calculation methods and key techniques to direct their die design. It is therefore a useful reference for students and researchers, as well as automotive engineers.

Different aspects of metal forming, consisting of process, tools and design, are presented in this book. The chapters of this book include the state of art and analysis of the processes considering the materials characteristics. The processes of hydroforming, forging and forming of sandwich sheet are discussed. Also, a chapter on topography of tools, and another chapter on machine tools are presented. Design of a programmable metal forming press and methods for predicting forming limits of sheet metal are described.

Incremental Sheet Forming (ISF) exempts use of dies and reduces cost for manufacturing complex parts. Sheet metal forming is used for producing high-quality components in automotive, aerospace, and medical industries. This book covers the benefits of this new technology, including the process parameters along with various techniques. Each variant of this novel process is discussed along with the requirements of machinery and hardware. In addition, appropriate guidelines are also suggested regarding the relationship between process parameters and aspects of ISF process in order to ensure the applicability of the process on the industrial scale. This book will be a useful asset for researchers, engineers in manufacturing industries, and postgraduate level courses.

Thorough reference to numerical techniques used for simulating metal forming operations.

The collection of 282 peer reviewed papers aims to promote the interest for all types of materials and all topics connected to Material Forming. The papers are grouped as follows: Chapter 1: Formability of Metallic Materials Chapter 2: Forging and Rolling; Chapter 3: Composites Forming Processes; Chapter 4: Semi-Solid Processes; Chapter 5: Light Weight Design and Energy Efficiency in Metal Forming; Chapter 6: New and Advanced Numerical Strategies for Material Forming; Chapter 7: Extrusion and Drawing; Chapter 8: Friction and Wear in Material Processing; Chapter 9: Nano-Structured Materials and Microforming; Chapter 10: Inverse Analysis Optimization and Stochastic Approaches; Chapter 11: Innovative Joining by Forming Technologies;
In recent years, interest in developing statistical and computational techniques for applied manufacturing engineering has been increased. Today, due to the great complexity of manufacturing engineering and the high number of parameters used, conventional approaches are no longer sufficient. Therefore, in manufacturing, statistical and computational techniques have achieved several applications, namely, modelling and simulation manufacturing processes, optimization manufacturing parameters, monitoring and control, computer-aided process planning, etc. The present book aims to provide recent information on statistical and computational techniques applied in manufacturing engineering. The content is suitable for final undergraduate engineering courses or as a subject on manufacturing at the postgraduate level. This book serves as a useful reference for academics, statistical and computational science researchers, mechanical, manufacturing and industrial engineers, and professionals in industries related to manufacturing engineering.

Manufacturing, reduced to its simplest form, involves the sequencing of product forms through a number of different processes. Each individual step, known as an unit manufacturing process, can be viewed as the fundamental building block of a nation's manufacturing capability. A committee of the National Research Council has prepared a report to help define national priorities for research in unit processes. It contains an organizing framework for unit process families, criteria for determining the criticality of a process or manufacturing technology, examples of research opportunities, and a prioritized list of enabling technologies that can lead to the manufacture of products of superior quality at competitive costs. The study was performed under the sponsorship of the National Science Foundation and the Defense Department's Manufacturing Technology Program.

The numerical simulation of sheet metal forming processes has become an indispensable tool for the design of components and their forming processes. This role was attained due to the huge impact in reducing time to market and the cost of developing new components in industries ranging from automotive to packing, as well as enabling an improved understanding of the deformation mechanisms and their interaction with process parameters. Despite being a consolidated tool, its potential for application continues to be discovered with the continuous need to simulate more complex processes, including the integration of the various processes involved in the production of a sheet metal component and the analysis of in-service behavior. The quest for more robust and sustainable processes has also changed its deterministic character into stochastic to be able to consider the scatter in mechanical properties induced by previous manufacturing processes. Faced with these challenges, this Special Issue presents scientific advances in the development of numerical tools that improve the prediction results for conventional forming process, enable the
development of new forming processes, or contribute to the integration of several manufacturing processes, highlighting the growing multidisciplinary characteristic of this field.

This publication has been written to honour the contribution to science and education made by the Distinguished Professor Emeritus Professor Schey on his eightieth birthday. The contributors to his book are among the countless researchers who have read, studied and learned from Professor Schey’s work, which includes books, research monographs, invited papers, keynote papers, scientific journals and conferences. The topics include manufacturing, sheet and bulk metal forming and tribology, amongst others. The topics included in this book include: John Schey and value-added manufacturing; Surface finish and friction in cold-metal rolling; Direct observation of interface for tribology in metal forming; An examination of the coefficient of friction; Studies on micro plasto hydrodynamic lubrication in metal forming; Numerical simulation of sheet metal forming; Geometric and mechanics model of sheet forming; Modelling and optimisation of metal forming processes; The mathematical modelling of hot rolling steel; Identification of rheological and tribological parameters; Oxide behaviour in hot rolling; Friction, lubrication and surface response in wire drawing; and Modelling and control of temper rolling and skin pass rolling.

By an engineer with decades of practical manufacturing experience, this book is a complete modern guide to sheet metal forming processes and die design – still the most commonly used methodology for the mass-production manufacture of aircraft, automobiles, and complex high-precision parts. It illustrates several different approaches to this intricate field by taking the reader through the “hows” and “whys” of product analysis, as well as the techniques for blanking, punching, bending, deep drawing, stretching, material economy, strip design, movement of metal during stamping, and tooling. While concentrating on simple, applicable engineering methods rather than complex numerical techniques, this practical reference makes it easier for readers to understand the subject by using numerous illustrations, tables, and charts.


Manufacturing and Design presents a fresh view on the world of industrial production: thinking in terms of both abstraction levels and trade-offs. The book invites its readers to distinguish between what is possible in principle for a certain process (as determined by physical law); what is possible in practice (the production method as determined by industrial state-of-the-art); and what is possible for a certain supplier (as determined by its production equipment). Specific processes considered here include metal forging, extrusion, and casting; plastic injection molding and thermoforming; additive manufacturing; joining; recycling; and more. By tackling the field of manufacturing processes from this new angle, this book makes the most out of a reader's limited time. It gives the knowledge needed to not only create well-producible designs, but also to understand supplier needs in order to find the optimal compromise. Apart from improving design for production, this publication raises the standards of thinking about producibility. Emphasizes the strong link between product design and choice of manufacturing process Introduces the concept of a “production triangle” to highlight tradeoffs between function, cost, and quality for different manufacturing methods Balanced sets of questions are included to stimulate the reader's thoughts Each chapter ends information on the production methods commonly associated with the principle discussed, as well as pointers for further
This book gives a unified presentation of the research performed in the field of multiscale modelling in sheet metal forming over the course of more than thirty years by the members of six teams from internationally acclaimed universities. The first chapter is devoted to the presentation of some recent phenomenological yield criteria (BBC 2005 and BBC 2008) developed at the CERTETA center from the Technical University of Cluj-Napoca. An overview on the crystallographic texture and plastic anisotropy is presented in Chapter 2. Chapter 3 is dedicated to multiscale modelling of plastic anisotropy. The authors describe a new hierarchical multi-scale framework that allows taking into account the evolution of plastic anisotropy during sheet forming processes. Chapter 4 is focused on modelling the evolution of voids in porous metals with applications to forming limit curves and ductile fracture. The chapter details the steps needed for the development of dissipation functions and Gurson-type models for non-quadratic anisotropic plasticity criteria like BBC 2005 and those based on linear transformations. Chapter 5 describes advanced models for the prediction of forming limit curves developed by the authors. Chapter 6 is devoted to anisotropic damage in elasto-plastic materials with structural defects. Finally, Chapter 7 deals with modelling of the Portevin-Le Chatelier (PLC) effect. This volume contains contributions from leading researchers from the Technical University of Cluj-Napoca, Romania, the Catholic University of Leuven, Belgium, Clausthal University of Technology, Germany, Amirkabir University of Technology, Iran, the University of Bucharest, Romania, and the Institute of Mathematics of the Romanian Academy, Romania. It will prove useful to postgraduate students, researchers and engineers who are interested in the mechanical modeling and numerical simulation of sheet metal forming processes.

This comprehensive book offers a clear account of the theory and applications of advanced metal forming. It provides a detailed discussion of specific forming processes, such as deep drawing, rolling, bending extrusion and stamping. The author highlights recent developments of metal forming technologies and explains sound, new and powerful expert system techniques for solving advanced engineering problems in metal forming. In addition, the basics of expert systems, their importance and applications to metal forming processes, computer-aided analysis of metalworking processes, formability analysis, mathematical modeling and case studies of individual processes are presented.

Automotive and aerospace components, utensils, and many other products are manufactured by a forming/drawing process on press machines of very thin sheet metal, 0.8 to 1.2 mm. It is imperative to study the effect of all involved parameters on output of this type of manufacturing process. This book offers the readers with application and suitability of various evolutionary, swarm, and bio-inspired optimization algorithms for sheet metal forming processes. Book initiates by presenting basics of metal forming, formability followed by discussion of process parameters in detail, prominent modes of failure, basics of optimization and various bioinspired approaches followed by optimization studies on various industrial components applying bioinspired optimization algorithms. Key Features: • Focus on description of basic investigation of metal forming, as well as evolutionary optimization • Presentation of innovative optimization methodologies to close the gap between those formulations and industrial problems, aimed at industrial professionals • Includes mathematical modeling of drawing/forming process •
Discusses key performance parameters, such as Thinning, Fracture, and Wrinkling • Includes both numerical and experimental analysis

The book presents a compilation of research on meso/microforming processes, and offers systematic and holistic knowledge for the physical realization of developed processes. It discusses practical applications in fabrication of meso/microscale metallic sheet-metal parts via sheet-metal meso/microforming. In addition, the book provides extensive and informative illustrations, tables, case studies, photos and figures to convey knowledge of sheet-metal meso/microforming for fabrication of meso/microscale sheet-metal products in an illustrated manner. Key Features • Presents complete analysis and discussion of micro sheet metal forming processes • Guides reader across the mechanics, failures, prediction of failures and tooling and prospective applications • Discusses definitions of multi-scaled metal forming, sheet-metal meso/microforming and the challenges in such domains • Includes meso/microscaled sheet-metal parts design from a micro-manufacturability perspective, process determination, tooling design, product quality analysis, insurance and control • Covers industrial application and examples

Processes and Design for Manufacturing, Third Edition, examines manufacturing processes from the viewpoint of the product designer, investigating the selection of manufacturing methods in the early phases of design and how this affects the constructional features of a product. The stages from design process to product development are examined, integrating an evaluation of cost factors. The text emphasizes both a general design orientation and a systems approach and covers topics such as additive manufacturing, concurrent engineering, polymeric and composite materials, cost estimation, design for assembly, and environmental factors. Appendices with materials engineering data are also included.

The 33 papers presented in this book were selected from amongst the 97 papers presented during the sixth edition of the International Conference on Integrated Design and Manufacturing in Mechanical Engineering during 28 sessions. This conference represents the state-of-the-art research in the field. Two keynote papers introduce the subject of the Conference and are followed by the different themes highlighted during the conference.

Mechanics of Sheet Metal Forming

This book is a comprehensive presentation of the fundamental concepts and applications of metal fabrication technology. Designed primarily for undergraduate and postgraduate students of mechanical engineering and production engineering, the book will also be useful for students of engineering diploma programmes in the above fields and certificate courses in metal fabrication and erection, as well as for practising engineers and consultants involved in welding, fabrication, erection, production planning, testing and design. The initial chapters of the book provide an overview of the metal fabrication industry, as well as an exhaustive discussion of the properties of the various engineering materials, heat treatment processes, and frame analysis. The focus then shifts to production planning and control, production line design, as well as drawing, marking and layout. The ensuing chapters explain elaborately the various metal cutting processes, metal forming methods, and manufacturing processes. Assembly and erection, joining and welding, fault analysis and inspection, and metal finishing are covered subsequently. The various systematic guidelines for erection as well as the different prohibited welding methods and welding defects are elucidated. The final chapter of the book is devoted to health and safety issues relevant to fabrication and erection. The book contains numerous illustrations that enable the students to gain a thorough understanding of the subject matter. The review questions at the end of each chapter help to test their comprehension of the underlying concepts.

Applied Metal Forming: Including FEM Analysis describes metal forming theory and how experimental techniques can be used to study any metal forming operation with great accuracy. For each primary class of processes, such as forging, rolling, extrusion, wiredrawing,
and sheet-metal forming, it explains how FEA (Finite Element Analysis) can be applied with
great precision to characterize the forming condition and in this way optimize the processes.
FEA has made it possible to build very realistic FEM-models of any metal forming process,
including complex three-dimensional forming operations, in which complex products are
shaped by complex dies. Thus, using FEA it is now possible to visualize any metal forming
process and to study strain, stresses, and other forming conditions inside the parts being
manufactured as they develop throughout the process.
This book describes different types of rubber-pad forming processes currently being studied for
their experimental and numerical advantages and disadvantages. Rubber forming adopts a
rubber pad contained in a rigid box in which one of the tools (die or punch) is replaced by the
rubber pad. Up to 60% of all sheet metal parts in aircraft industry such as frames, seat parts,
ribs, windows and doors are fabricated using rubber-pad forming processes. Key process
parameters such as rubber material, stamping velocity, rubber-pad hardness and thickness
and friction conditions are investigated. The potential role of rubber as a flexible punch in metal
working processes is to give insight to engineers about different parts that can be produced
using this process The procedure of suitable die design for each process is presented in detail
Full defect analysis is undertaken with a thorough report presented to optimize rubber-pad
forming processes
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Chapter 11: Innovative Joining by Forming Technologies; Chapter 12: Multiscale &
Continuum Constitutive Modelling; Chapter 13: Incremental and Sheet Metal Forming;
Chapter 14: Sheet-Bulk-Metal Forming; Chapter 15: Heat Transfer Modelling; Chapter
16: Structures, Properties and Processing of Polymers; Chapter 17: Non-Conventional
Processes; Chapter 18: Machining and Cutting; Chapter 19: Integrated Design,
Modelling and Reliability Assessment in Forming (I-DMR); Chapter 20: Finite Element
Technology and Multi-Scale Methods for Composites, Metallic Sheets and Coating
Models; Chapter 21: Intelligent Computation in Forming Processes.
Sheet metal fabrication--from fins and fenders to art--with all the necessary information
on tools, preparations, materials, forms, mock-ups, and much more.
CD-ROM contains: Power Point presentations -- Video clips -- Quicktime movies.
Sheet forming is the most common process used in metal forming and is therefore
constantly being adapted or modified to suit the needs of forming composite sheets.
Due to the increasing availability of various types of fibre reinforced polymeric sheets,
especially with thermoplastic matrices, the scope of use of such materials is rapidly
expanding in the automobile, building, sports and other manufacturing industries
beyond the traditional areas of aerospace and aircraft applications. This book contains
twelve chapters and attempts to cover different aspects of sheet forming including both
thermoplastic and thermosetting materials. In view of the expanded role of fibre
reinforced composite sheets in the industry, the book also describes some non-
traditional applications, processes and analytical techniques involving such materials. The first chapter is a brief introduction to the principles of sheet metal forming. The next two chapters introduce the various forms of materials, manufacturing techniques and the fundamentals of computer simulation. Chapter 4 describes the different aspects of thermoforming of continuous fibre reinforced thermoplastics and the following chapter studies the shear and frictional behaviour of composite sheets during forming. Chapter 6 explores the possibility of applying the grid strain analysis method in continuous fibre reinforced polymeric sheets. The next two chapters address fundamental concepts and recent developments in finite element modelling and rheology. Chapter 9 introduces the theory of bending of thermoplastic composite sheets and shows a novel way of determining both longitudinal and transverse viscosities through vee-bend tests. A significant expansion in the usage of composite materials is taking place in biomedical areas. Chapter 10 discusses the thermoforming of knitted fabric reinforced thermoplastics for load bearing and anisotropic bio-implants. The final chapter introduces roll forming, a commonly used rapid manufacturing process for sheet metals, and discusses the possibility of applying it economically for continuous reinforced thermoplastic sheets.

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