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Building up Mathematical Modeling Using Spot Welding Parameters and Prediction Weld Nugget by Minitab

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Abstract

In serial production, problems are constantly encountered in the selection of welding parameters due to the excess of welding parameters and variations. In order to compensate for these variations, mostly high energy flux is used. In this study, an approach developed in order to estimate weld nugget diameter in determining the welding parameters for sheets with a thickness of 0.6–3 mm is introduced. Sheet is an iron-based material that has been given certain mechanical and chemical properties in standards, turned into sheets from thick plates by rolling processes. Minitab statistical program was used to create experimental data and mathematical operations. First of all, 7 source parameters were selected and experimental study was carried out for 64 experiments using the ½ partition factorial method of disegn of experiments(DOE) in Minitab software. With the experiments, real weld nugget diameters were obtained. These results were transferred to the Minitab software and the mathematical model of the system was established. Weld nugget diameter estimation procedures were carried out using the datas of factorical disegn of experiments(DOE). Test and prediction data were transferred to Minitab software, regression graph was drawn and R-Sq and R-Sq (adj) values were calculated. In addition, samples were created with randomly selected data for verification and comparison was made by transferring them to Minitab. According to the results of this study, remarkable accuracy rates have been achieved in the weld nugget diameter estimation with Minitab.

Keywords: Resistance spot welding, weld nugget prediction, design of experiment, regression analysis, Minitab.

1. INTRODUCTION

Today, 7-12 thousand spot welding is used when a car is being produced. Electric Resistance Welding (ERW) is generally done by computer controlled robots. The quality of ERW is an extremely important issue in the automotive industry. The accuracy and consistency of parameter settings made with manual welding parameter calculations, operator experience and technician expertise may not be appropriate.

Welding parameter setting of each machine and point is a difficult process due to many sensitive factors. It takes a lot of trials with a large number of materials to find the optimum value of each spot to be spot welded, which cannot be done as it is very costly. In order to achieve the final standard welding quality, different sheet thicknesses such as electrodes etc. The process of adjusting the parameters in each different welding machine model by changing it is quite costly. Therefore, in the ERW spot welding process, it is important to be able to meet the weld quality improvement requirements with efficiency estimation and appropriate parameter optimization.

When the literature is examined in general, it is seen that studies are carried out on a single sheet thickness by taking only the welding time, current and force. Different approaches can be seen for estimation methods.

In another method, welding current, electrode force and welding time other welding parameters can be kept constant. Welded joints can be subjected to tensile-shear tests to determine shear force and absorption energy values. In the study, parameter optimizations can be performed by using the surface methodology based on Box-Behnken design to generate a quadratic response model regression from Yue et al. [1].

There are also approaches to applying data mining techniques to estimate the weld nugget diameter in the ERW resource. With a relatively simple and straightforward approach, it can accurately estimate the diameter of a spot from easily measured signals during the welding process by Boersch et al. [2].

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Mathematical Modeling With Minitab

Yan Bai

Mathematical Modeling With Minitab:

   Mathematical Modeling with Minitab William P. Fox,1987 Mathematic Modeling with MINITAB is designed for individuals who wish to use their MINITAB software to support a wide range of mathematical modeling applications The book allows instructors to use their department s existing software to support their teaching of a wide range of mathematical modeling applications For students the book provides computer support for any text on mathematical modeling Modeling principles covered in this book include proportionality model fitting and least squares high and low order polynomial fitting cubic splines and dimensional analysis techniques   **Mathematical Modeling** Mark M. Meerschaert,2007-06-18 Mathematical Modeling Third Edition is a general introduction to an increasingly crucial topic for today s mathematicians Unlike textbooks focused on one kind of mathematical model this book covers the broad spectrum of modeling problems from optimization to dynamical systems to stochastic processes Mathematical modeling is the link between mathematics and the rest of the world Meerschaert shows how to refine a question phrasing it in precise mathematical terms Then he encourages students to reverse the process translating the mathematical solution back into a comprehensible useful answer to the original question This textbook mirrors the process professionals must follow in solving complex problems Each chapter in this book is followed by a set of challenging exercises These exercises require significant effort on the part of the student as well as a certain amount of creativity Meerschaert did not invent the problems in this book they are real problems not designed to illustrate the use of any particular mathematical technique Meerschaert s emphasis on principles and general techniques offers students the mathematical background they need to model problems in a wide range of disciplines Increased support for instructors including MATLAB material New sections on time series analysis and diffusion models Additional problems with international focus such as whale and dolphin populations plus updated optimization problems

   Advanced Mathematical Modeling with Technology William P. Fox,Robert E. Burks,2021-05-19 Mathematical modeling is both a skill and an art and must be practiced in order to maintain and enhance the ability to use those skills Though the topics covered in this book are the typical topics of most mathematical modeling courses this book is best used for individuals or groups who have already taken an introductory mathematical modeling course This book will be of interest to instructors and students offering courses focused on discrete modeling or modeling for decision making   *Numerical Methods and Analysis with Mathematical Modelling* William P. Fox,Richard D. West,2024-08-07 What sets Numerical Methods and Analysis with Mathematical Modelling apart are the modelling aspects utilizing numerical analysis methods to obtain solutions The authors cover first the basic numerical analysis methods with simple examples to illustrate the techniques and discuss possible errors The modelling prospective reveals the practical relevance of the numerical methods in context to real world problems At the core of this text are the real world modelling projects Chapters are introduced and techniques are discussed with common examples A modelling scenario is introduced that will be solved with these techniques later in the

chapter Often the modelling problems require more than one previously covered technique presented in the book Fundamental exercises to practice the techniques are included Multiple modelling scenarios per numerical methods illustrate the applications of the techniques introduced Each chapter has several modelling examples that are solved by the methods described within the chapter The use of technology is instrumental in numerical analysis and numerical methods In this text Maple Excel R and Python are illustrated The goal is not to teach technology but to illustrate its power and limitations to perform algorithms and reach conclusions This book fulfills a need in the education of all students who plan to use technology to solve problems whether using physical models or true creative mathematical modeling like discrete dynamical systems **Nonlinear Optimization** William P. Fox,2020-12-08 Optimization is the act of obtaining the best result under given circumstances In design construction and maintenance of any engineering system engineers must make technological and managerial decisions to minimize either the effort or cost required or to maximize benefits There is no single method available for solving all optimization problems efficiently Several optimization methods have been developed for different types of problems The optimum seeking methods are mathematical programming techniques specifically nonlinear programming techniques Nonlinear Optimization Models and Applications presents the concepts in several ways to foster understanding Geometric interpretation is used to re enforce the concepts and to foster understanding of the mathematical procedures The student sees that many problems can be analyzed and approximate solutions found before analytical solutions techniques are applied Numerical approximations early on the student is exposed to numerical techniques These numerical procedures are algorithmic and iterative Worksheets are provided in Excel MATLAB and MapleTM to facilitate the procedure Algorithms all algorithms are provided with a step by step format Examples follow the summary to illustrate its use and application Nonlinear Optimization Models and Applications Emphasizes process and interpretation throughout Presents a general classification of optimization problems Addresses situations that lead to models illustrating many types of optimization problems Emphasizes model formulations Addresses a special class of problems that can be solved using only elementary calculus Emphasizes model solution and model sensitivity analysis About the author William P Fox is an emeritus professor in the Department of Defense Analysis at the Naval Postgraduate School He received his Ph D at Clemson University and has taught at the United States Military Academy and at Francis Marion University where he was the chair of mathematics He has written many publications including over 20 books and over 150 journal articles Currently he is an adjunct professor in the Department of Mathematics at the College of William and Mary He is the emeritus director of both the High School Mathematical Contest in Modeling and the Mathematical Contest in Modeling **Mathematical Models in Biology** Valeria Zazzu,Maria Brigida Ferraro,Mario R. Guarracino,2015-11-26 This book presents an exciting collection of contributions based on the workshop Bringing Maths to Life held October 27 29 2014 in Naples Italy The state of the art research in biology and the statistical and analytical challenges facing huge masses of data collection are treated in this

Work Specific topics explored in depth surround the sessions and special invited sessions of the workshop and include genetic variability via differential expression molecular dynamics and modeling complex biological systems viewed from quantitative models and microscopy images processing to name several In depth discussions of the mathematical analysis required to extract insights from complex bodies of biological datasets to aid development in the field novel algorithms methods and software tools for genetic variability molecular dynamics and complex biological systems are presented in this book Researchers and graduate students in biology life science and mathematics statistics will find the content useful as it addresses existing challenges in identifying the gaps between mathematical modeling and biological research The shared solutions will aid and promote further collaboration between life sciences and mathematics   Advanced Problem Solving Using Maple William P Fox,William Bauldry,2020-11-09 Advanced Problem Solving Using MapleTM Applied Mathematics Operations Research Business Analytics and Decision Analysis applies the mathematical modeling process by formulating building solving analyzing and criticizing mathematical models Scenarios are developed within the scope of the problem solving process The text focuses on discrete dynamical systems optimization techniques single variable unconstrained optimization and applied problems and numerical search methods Additional coverage includes multivariable unconstrained and constrained techniques Linear algebra techniques to model and solve problems such as the Leontief model and advanced regression techniques including nonlinear logistics and Poisson are covered Game theory the Nash equilibrium and Nash arbitration are also included Features The text s case studies and student projects involve students with real world problem solving Focuses on numerical solution techniques in dynamical systems optimization and numerical analysis The numerical procedures discussed in the text are algorithmic and iterative Maple is utilized throughout the text as a tool for computation and analysis All algorithms are provided with step by step formats About the Authors William P Fox is an emeritus professor in the Department of Defense Analysis at the Naval Postgraduate School Currently he is an adjunct professor Department of Mathematics the College of William and Mary He received his PhD at Clemson University and has many publications and scholarly activities including twenty books and over one hundred and fifty journal articles William C Bauldry Prof Emeritus and Adjunct Research Prof of Mathematics at Appalachian State University received his PhD in Approximation Theory from Ohio State He has published many papers on pedagogy and technology often using Maple and has been the PI of several NSF funded projects incorporating technology and modeling into math courses He currently serves as Associate Director of COMAP s Math Contest in Modeling MCM   Encyclopedia of Business Analytics and Optimization Wang, John,2014-02-28 As the age of Big Data emerges it becomes necessary to take the five dimensions of Big Data volume variety velocity volatility and veracity and focus these dimensions towards one critical emphasis value The Encyclopedia of Business Analytics and Optimization confronts the challenges of information retrieval in the age of Big Data by exploring recent advances in the areas of knowledge management data visualization interdisciplinary communication and others Through its critical approach

and practical application this book will be a must have reference for any professional leader analyst or manager interested in making the most of the knowledge resources at their disposal   *The Three Circles of War* Heather Gregg,Hy S. Rothstein,John Arquilla,2010-07 A comprehensive military textbook for our times our wars   **Geographic Information Systems, Spatial Modelling and Policy Evaluation** Manfred M. Fischer,Peter Nijkamp,2012-12-06 Geographical Information Systems GIS provide an enhanced environment for spatial data processing The ability of geographic information systems to handle and analyse spatially referenced data may be seen as a major characteristic which distinguishes GIS from information systems developed to serve the needs of business data processing as well as from CAD systems or other systems whose primary objective is map production This book which contains contributions from a wide ranging group of international scholars demonstrates the progress which has been achieved so far at the interface of GIS technology and spatial analysis and planning The various contributions bring together theoretical and conceptual technical and applied issues Topics covered include the design and use of GIS and spatial models AI tools for spatial modelling in GIS spatial statistical analysis and GIS GIS and dynamic modelling GIS in urban planning and policy making information systems for policy evaluation and spatial decision support systems   **Advances in Computational Methods in Manufacturing** R. Ganesh Narayanan,Shrikrishna N. Joshi,Uday Shanker Dixit,2019-10-17 This volume presents a selection of papers from the 2nd International Conference on Computational Methods in Manufacturing ICCMM 2019 The papers cover the recent advances in computational methods for simulating various manufacturing processes like machining laser welding laser bending strip rolling surface characterization and measurement Articles in this volume discuss both the development of new methods and the application and efficacy of existing computational methods in manufacturing sector This volume will be of interest to researchers in both industry and academia working on computational methods in manufacturing   Free Space Optical Communication A. Arockia Bazil Raj,2015-12-18 Recent progress in ICT has exceeded our expectations for meeting the requirement of multimedia society in the 21st century The FSOC is considered to be one of the key technologies for realizing very high speed multi GbPs large capacity terrestrial and aerospace communications In FSOC the optical beam propagation in the turbulent atmosphere is severely affected by various factors suspended in the channel Wavefront aberration correcting with continuous beam alignment are the key requirements for a successful installation of an FSOC system which are the main contributions in our book Establishment of FSOC setups development of accurate weather station measurement of atmospheric attenuation Att and turbulence strength $Cn2$ development of new models to predict the Att and $Cn2$ design of Response Surface Model and Artificial Neural Network based on controller implementation of neural controller in FPGA and attaining the BER of 6 4x10 9 during different outdoor environments All the original contributions newness findings and experimental results etc are reported in the book Subject of work Wireless Optical Communication The content of the book can be referred by various application designers and or academicians for working on FSOC transceiver design

laser cutting laser metrology laser surgery beam focusing pointing beacon positioning and coupling etc Further all necessary MATLAB and VHDL codes are also given on appropriate pages for the readers quick clear understanding **An Integrated Approach to Modeling and Optimization in Engineering and Science** Melih Savran,Levent Aydin,2024-12-30 An Integrated Approach to Modeling and Optimization in Engineering and Science examines the effects of experimental design mathematical modeling and optimization processes for solving many different problems The Experimental Design Method Central Composite Full Factorial Taguchi Box Behnken and D Optimal methods are used and the effects of the datasets obtained by these methods on mathematical modeling are investigated This book will help graduates and senior undergraduates in courses on experimental design modeling optimization and interdisciplinary engineering studies It will also be of interest to research and development engineers and professionals working in scientific institutions based on design modeling and optimization **Basic Statistical Methods and Models for the Sciences** Judah Rosenblatt,2017-07-12 The use of statistics in biology medicine engineering and the sciences has grown dramatically in recent years and having a basic background in the subject has become a near necessity for students and researchers in these fields Although many introductory statistics books already exist too often their focus leans towards theory and few help readers gain effective experience in using a standard statistical software package Designed to be used in a first course for graduate or upper level undergraduate students Basic Statistical Methods and Models builds a practical foundation in the use of statistical tools and imparts a clear understanding of their underlying assumptions and limitations Without getting bogged down in proofs and derivations thorough discussions help readers understand why the stated methods and results are reasonable The use of the statistical software Minitab is integrated throughout the book giving readers valuable experience with computer simulation and problem solving techniques The author focuses on applications and the models appropriate to each problem while emphasizing Monte Carlo methods the Central Limit Theorem confidence intervals and power functions The text assumes that readers have some degree of maturity in mathematics but it does not require the use of calculus This along with its very clear explanations generous number of exercises and demonstrations of the extensive uses of statistics in diverse areas applications make Basic Statistical Methods and Models highly accessible to students in a wide range of disciplines **Discontinuity and Complexity in Nonlinear Physical Systems** J. A. Tenreiro Machado,Dumitru Baleanu,Albert C J Luo,2013-12-04 Discontinuity in Nonlinear Physical Systems explores recent developments in experimental research in this broad field organized in four distinct sections Part I introduces the reader to the fractional dynamics and Lie group analysis for nonlinear partial differential equations Part II covers chaos and complexity in nonlinear Hamiltonian systems important to understand the resonance interactions in nonlinear dynamical systems such as Tsunami waves and wildfire propagations as well as Lev flights in chaotic trajectories dynamical system synchronization and DNA information complexity analysis Part III examines chaos and periodic motions in discontinuous dynamical systems extensively present in a range of systems including

piecewise linear systems vibro impact systems and drilling systems in engineering And in Part IV engineering and financial nonlinearity are discussed The mechanism of shock wave with saddle node bifurcation and rotating disk stability will be presented and the financial nonlinear models will be discussed   *Proceedings of the Second International Conference of Innovative Textiles and Developed Materials-ITDM'2; 05-06 May 2023; Tunisia* Saber Ben Abdessalem,Mohamed Hamdaoui,Ayda Baffoun,Adel Elamri,2024-03-01 This book includes selected articles from the 2nd International Conference on Innovative Textiles and Developed Materials ITDM 2 held in Monastir Tunisia on May 5 and 6 2023 The articles present latest scientific concepts and technological advances in innovative and sustainable textile materials and processes worldwide The conference promotes exchange of ideas and emerging technologies to foster collaboration between academia and industry   Bio-polymerized Sulfur for Sustainable Practice in Applied Sciences and Engineering Abdel-Mohsen O. Mohamed,Maisa El Gamal,2025-04-10 Bio polymerized Sulfur for Sustainable Practice in Applied Sciences and Engineering explores innovative approaches in sustainable chemistry by leveraging renewable resources and sulfur as foundational elements for creating sustainable functional materials The book highlights the potential of bio polymeric materials derived from sulfur and renewable sources offering new avenues for environmentally friendly manufacturing Additionally the text delves into lifecycle assessment studies and the principles of a circular economy emphasizing the importance of sustainability in modern engineering The work emphasizes the criticality of sustainable practices highlighting the intersection of bio polymeric materials and circular economy principles ultimately guiding the reader towards a more sustainable future The book also presents an in depth analysis of bio polymerized sulfur s role in promoting sustainable development It discusses how polymerized sulfur can be used to develop engineered products that align with sustainability goals Introduces the basic principles of bio and sulfur polymerization Outlines the methods for conducting lifecycle assessment in the manufacturing of bio polymerized sulfur for use in waste management agriculture ground treatment construction road infrastructures and in the production of high functional materials Contributes to the achievement of the UN Sustainable Development Goals

Multiple-Criteria Decision-Making (MCDM) Techniques for Business Processes Information Management Edmundas Kazimieras Zavadskas,Jurgita Antuchevičienė,Prasenjit Chatterjee,2019-03-08 Information management is a common paradigm in modern decision making A wide range of decision making techniques have been proposed in the literature to model complex business and engineering processes In this Special Issue 16 selected and peer reviewed original research articles contribute to business information management in various current real world problems by proposing crisp or uncertain multiple criteria decision making MCDM models and techniques mostly including multi attribute decision making MADM approaches in addition to a single paper proposing an interactive multi objective decision making MODM approach Particular attention is devoted to information aggregation operators 65% of papers dealt with this item The topics of this Special Issue gained attention in Europe and Asia A total of 48 authors from seven countries contributed to this Issue The

papers are mainly concentrated in three application areas supplier selection and rational order allocation the evaluation and selection of goods or facilities and personnel selection partner selection A number of new approaches are proposed that are expected to attract great interest from the research community **Springer Handbook of Engineering Statistics** Hoang Pham,2006 In today s global and highly competitive environment continuous improvement in the processes and products of any field of engineering is essential for survival This book gathers together the full range of statistical techniques required by engineers from all fields It will assist them to gain sensible statistical feedback on how their processes or products are functioning and to give them realistic predictions of how these could be improved The handbook will be essential reading for all engineers and engineering connected managers who are serious about keeping their methods and products at the cutting edge of quality and competitiveness Statistics II for Dummies Deborah J. Rumsey,2009-08-19 The ideal supplement and study guide for students preparing for advanced statistics Packed with fresh and practical examples appropriate for a range of degree seeking students Statistics II For Dummies helps any reader succeed in an upper level statistics course It picks up with data analysis where Statistics For Dummies left off featuring new and updated examples real world applications and test taking strategies for success This easy to understand guide covers such key topics as sorting and testing models using regression to make predictions performing variance analysis ANOVA drawing test conclusions with chi squares and making comparisons with the Rank Sum Test

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