

Finite Element Simulation and Experiment of Chip Formation Process during High Speed Machining of AISI 1045 Hardened Steel

C.Z.Duan^{1,2}, T.Dou¹, Y.J.Cai², Y.Y.Li¹

¹Dalian University of Technology/School of Mechanical Engineering/Institute of Die and Mould, Dalian, China
Email: dcx71@163.com

²Tianjin University of Technology and Education/Tianjin Key Laboratory of High Speed Cutting & Precision Machining, Tianjin, China

Abstract—As an advanced manufacturing technology which has been developed rapidly in recent years, high speed machining is widely applied in many industries. The chip formation during high speed machining is a complicated material deformation and removing process. In research area of high speed machining, the prediction of chip morphology is a hot and difficult topic. A finite element method based on the software ABAQUS which involves Johnson-Cook material model and fracture criterion was used to simulate the serrated chip morphology and cutting force during high speed machining of AISI 1045 hardened steel. The serrated chip morphology and cutting force were observed and measured by high speed machining experiment of AISI 1045 hardened steel. The effects of rake angle on cutting force, sawtooth degree and space between sawteeth were discussed. The investigation indicates that the simulation results are consistent with the experiments and this finite element simulation method presented can be used to predict the chip morphology and cutting force accurately during high speed machining of hardened steel.

Index Terms—finite element simulation, high speed machining, serrated chip, chip formation, hardened steel

I. INTRODUCTION

As an advanced manufacturing technology which has been developed rapidly in more than last ten years, high speed machining can provide high efficiency of production and low cost, as well as improve the quality of machined surface. In addition, it can remove the difficult-to-cut materials with high hardness. High speed machining technology is widely applied in many industrial fields such as aeronautics and astronautics, automobile, mould, light industry, etc. One of the most important differences on cutting mechanics between high speed machining and conventional machining is that in high speed machining, a serrated chip is most often generated which affects nearly every aspect of high speed machining process, such as cutting force[1], cutting temperature[2], cutting tool wear[3] and life and machined surface quality[4]. Therefore, it is necessary to investigate and to predict the formation of serrated chip and the effect of chip morphology on vibration of cutting force, and their relationship with workpiece material and machining condition. At present, the published researches on prediction of serrated chip formation have focused on the theoretical modeling and the finite element simulation[5-6]. High speed machining is a strongly non-linear and complex contact

process. But these characteristics, especially the material constitutive relationship in high deformation condition are not fully considered by the existing methods. In addition, the simulation results of commonly used Deform-2D FE software are usually not consistent with the experiments because of their weak capability for non-linear problems. In this paper, a finite element method involving Johnson-Cook material model and fracture criterion was used to simulate the serrated chip formation during high speed machining using commercial FE software ABAQUS which can in principle handle such strongly non-linear problems and allow the definition of complex contact conditions. By using above method for FE simulation, the chip morphology during high speed machining of AISI 1045 hardened steel was accurately predicted and the effects of rake angle on the chip morphology and cutting force were discussed.

II. CHIP MORPHOLOGY SIMULATION

A. Material Model

For the simulation of chip morphology and cutting force, a Johnson-Cook model was used. This model is a strain rate and temperature dependent[7-8] visco-plastic material model which describes the relationship of stress, strain, strain rate and temperature. It is suitable for problems where the strain rate varies over a large range (10^0s^{-1} to 10^6s^{-1}), and the temperature changes due to plastic deformation caused by thermal softening. This model uses the following equivalent flow stress:

$$\sigma = [A + B(\bar{\epsilon})^n] \left[1 + C \ln \left(\frac{\dot{\bar{\epsilon}}}{\dot{\bar{\epsilon}}_0} \right) \right] \left[1 - \left(\frac{T - T_0}{T_{\text{melt}} - T_0} \right)^m \right] \quad (1)$$

Where $\bar{\sigma}$ is the equivalent stress, $\bar{\epsilon}$ is the equivalent plastic strain, $\dot{\bar{\epsilon}}$ is the plastic strain rate, $\dot{\bar{\epsilon}}_0$ is the reference strain rate (1.0s^{-1}), T_0 is the room temperature, T_{melt} is the melting temperature, A is the initial yield stress (MPa), B is the hardening modulus, n is the work-hardening exponent, C is a coefficient dependent on the strain rate (MPa), and m is the thermal softening coefficient. The Johnson-Cook parameter values used to simulate the behaviour of AISI 1045 workpiece are specified in Table I.

A Finite Element Study Of Chip Formation Process In

Jun Peng Shao,Xian Li Liu



A Finite Element Study Of Chip Formation Process In:

An Analytical Study and Finite Element Modeling of Chip Formation in Metal Machining Process Qufei Xie,1993 Statistical and Computational Techniques in Manufacturing J. Paulo Davim,2012-03-06 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 *Dynamic Methods and Process Advancements in Mechanical, Manufacturing, and Materials Engineering* Davim, J. Paulo,2012-07-31 Engineering and design are often a necessary steps for an industry to become effective Industry modeling can help to bridge the communication gap among engineers and system designers *Dynamic Methods and Process Advancements in Mechanical Manufacturing and Materials Engineering* examines the principles of physics and materials science for analysis design manufacturing and maintenance of mechanical equipments and systems Targeting researchers practitioners and academicians this volume promotes innovative findings in mechanical manufacturing and materials engineering **Light Metals—Advances in Research and Application: 2012 Edition** ,2012-12-26 *Light Metals Advances in Research and Application 2012 Edition* is a ScholarlyEditions eBook that delivers timely authoritative and comprehensive information about Light Metals The editors have built *Light Metals Advances in Research and Application 2012 Edition* on the vast information databases of ScholarlyNews You can expect the information about Light Metals in this eBook to be deeper than what you can access anywhere else as well as consistently reliable authoritative informed and relevant The content of *Light Metals Advances in Research and Application 2012 Edition* has been produced by the world s leading scientists engineers analysts research institutions and companies All of the content is from peer reviewed sources and all of it is written assembled and edited by the editors at ScholarlyEditions and available exclusively from us You now have a source you can cite with authority confidence and credibility More information is available at <http://www.ScholarlyEditions.com> Applied Mechanics Reviews ,1974 **Manufacturing Engineering and Process** Xiaoxiao Zhou,2012-04-25 Selected peer reviewed papers from the 2012 International Conference on Manufacturing Engineering and Process ICMEP 2012 April 21 22 2012 Kunming China **Manufacturing Automation Technology** Guang Lin Wang,Huifeng Wang,Jun Liu,2008-10-21 Selected peer reviewed papers from the 13th Conference of China

University Society on Manufacturing Automation July 22 24 2008 Harbin China CIRP Annals International Institution for Production Engineering Research,1993 *Finite Element Method in Machining Processes* Angelos P. Markopoulos,2012-08-04 Finite Element Method in Machining Processes provides a concise study on the way the Finite Element Method FEM is used in the case of manufacturing processes primarily in machining The basics of this kind of modeling are detailed to create a reference that will provide guidelines for those who start to study this method now but also for scientists already involved in FEM and want to expand their research A discussion on FEM formulations and techniques currently in use is followed up by machining case studies Orthogonal cutting oblique cutting 3D simulations for turning and milling grinding and state of the art topics such as high speed machining and micromachining are explained with relevant examples This is all supported by a literature review and a reference list for further study As FEM is a key method for researchers in the manufacturing and especially in the machining sector Finite Element Method in Machining Processes is a key reference for students studying manufacturing processes but also for industry professionals **Computational Methods in Materials Processing** American Society of Mechanical Engineers. Winter Annual Meeting,1992 **Advanced Materials and Manufacturing Technology II** Hun Guo,Tai Yong Wang,Dun Wen Zuo,Zi Jing Wang,Jun Li,Ji Xu,2016-05-20 Special topic volume with invited peer reviewed papers only **Metals Abstracts Index** ,1996 Advances in Materials Manufacturing Science and Technology XIII: Advanced manufacturing technology and equipment, and manufacturing systems and automation ,2009 Fundamental Issues in Machining American Society of Mechanical Engineers. Winter Annual Meeting,1990 *Mechanical Engineering, Materials Science and Civil Engineering* Jun Peng Shao,Xian Li Liu,2013-01-11 Selected peer reviewed papers from the 2012 International Conference on Mechanical Engineering Materials Science and Civil Engineering ICMEMSCE 2012 August 18 20 2012 Harbin China **Journal of Engineering for Industry** ,1996 Finite Element Analysis of Two-dimensional Chip Formation Process for Machining with Grooved Tool Inserts Ramesh Ramalingam,1996 **Manufacturing Science and Engineering** ,1995 *Manufacturing Science and Engineering 1995* ,1995 **Current Advances in Mechanical Design and Production III** Salah E. A. Bayoumi, Maher Y. A. Younan,1986

Reviewing **A Finite Element Study Of Chip Formation Process In**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is truly astonishing. Within the pages of "**A Finite Element Study Of Chip Formation Process In**," an enthralling opus penned by a very acclaimed wordsmith, readers attempt an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve in to the book is central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

<https://matrix.jamesarcher.co/public/scholarship/default.aspx/dark%20romance%20thriller%20primer.pdf>

Table of Contents A Finite Element Study Of Chip Formation Process In

1. Understanding the eBook A Finite Element Study Of Chip Formation Process In
 - The Rise of Digital Reading A Finite Element Study Of Chip Formation Process In
 - Advantages of eBooks Over Traditional Books
2. Identifying A Finite Element Study Of Chip Formation Process In
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an A Finite Element Study Of Chip Formation Process In
 - User-Friendly Interface
4. Exploring eBook Recommendations from A Finite Element Study Of Chip Formation Process In
 - Personalized Recommendations
 - A Finite Element Study Of Chip Formation Process In User Reviews and Ratings
 - A Finite Element Study Of Chip Formation Process In and Bestseller Lists

5. Accessing A Finite Element Study Of Chip Formation Process In Free and Paid eBooks
 - A Finite Element Study Of Chip Formation Process In Public Domain eBooks
 - A Finite Element Study Of Chip Formation Process In eBook Subscription Services
 - A Finite Element Study Of Chip Formation Process In Budget-Friendly Options
6. Navigating A Finite Element Study Of Chip Formation Process In eBook Formats
 - ePub, PDF, MOBI, and More
 - A Finite Element Study Of Chip Formation Process In Compatibility with Devices
 - A Finite Element Study Of Chip Formation Process In Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of A Finite Element Study Of Chip Formation Process In
 - Highlighting and Note-Taking A Finite Element Study Of Chip Formation Process In
 - Interactive Elements A Finite Element Study Of Chip Formation Process In
8. Staying Engaged with A Finite Element Study Of Chip Formation Process In
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers A Finite Element Study Of Chip Formation Process In
9. Balancing eBooks and Physical Books A Finite Element Study Of Chip Formation Process In
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection A Finite Element Study Of Chip Formation Process In
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine A Finite Element Study Of Chip Formation Process In
 - Setting Reading Goals A Finite Element Study Of Chip Formation Process In
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of A Finite Element Study Of Chip Formation Process In
 - Fact-Checking eBook Content of A Finite Element Study Of Chip Formation Process In
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

A Finite Element Study Of Chip Formation Process In Introduction

In today's digital age, the availability of A Finite Element Study Of Chip Formation Process In books and manuals for download has revolutionized the way we access information. Gone are the days of physically flipping through pages and carrying heavy textbooks or manuals. With just a few clicks, we can now access a wealth of knowledge from the comfort of our own homes or on the go. This article will explore the advantages of A Finite Element Study Of Chip Formation Process In books and manuals for download, along with some popular platforms that offer these resources. One of the significant advantages of A Finite Element Study Of Chip Formation Process In books and manuals for download is the cost-saving aspect. Traditional books and manuals can be costly, especially if you need to purchase several of them for educational or professional purposes. By accessing A Finite Element Study Of Chip Formation Process In versions, you eliminate the need to spend money on physical copies. This not only saves you money but also reduces the environmental impact associated with book production and transportation. Furthermore, A Finite Element Study Of Chip Formation Process In books and manuals for download are incredibly convenient. With just a computer or smartphone and an internet connection, you can access a vast library of resources on any subject imaginable. Whether you're a student looking for textbooks, a professional seeking industry-specific manuals, or someone interested in self-improvement, these digital resources provide an efficient and accessible means of acquiring knowledge. Moreover, PDF books and manuals offer a range of benefits compared to other digital formats. PDF files are designed to retain their formatting regardless of the device used to open them. This ensures that the content appears exactly as intended by the author, with no loss of formatting or missing graphics. Additionally, PDF files can be easily annotated, bookmarked, and searched for specific terms, making them highly practical for studying or referencing. When it comes to accessing A Finite Element Study Of Chip Formation Process In books and manuals, several platforms offer an extensive collection of resources. One such platform is Project Gutenberg, a nonprofit organization that provides over 60,000 free eBooks. These books are primarily in the public domain, meaning they can be freely distributed and downloaded. Project Gutenberg offers a wide range of classic literature, making it an excellent resource for literature enthusiasts. Another popular platform for A Finite Element Study Of Chip Formation Process In books and manuals is Open Library. Open Library is an initiative of the Internet Archive, a non-profit organization dedicated to digitizing cultural

artifacts and making them accessible to the public. Open Library hosts millions of books, including both public domain works and contemporary titles. It also allows users to borrow digital copies of certain books for a limited period, similar to a library lending system. Additionally, many universities and educational institutions have their own digital libraries that provide free access to PDF books and manuals. These libraries often offer academic texts, research papers, and technical manuals, making them invaluable resources for students and researchers. Some notable examples include MIT OpenCourseWare, which offers free access to course materials from the Massachusetts Institute of Technology, and the Digital Public Library of America, which provides a vast collection of digitized books and historical documents. In conclusion, A Finite Element Study Of Chip Formation Process In books and manuals for download have transformed the way we access information. They provide a cost-effective and convenient means of acquiring knowledge, offering the ability to access a vast library of resources at our fingertips. With platforms like Project Gutenberg, Open Library, and various digital libraries offered by educational institutions, we have access to an ever-expanding collection of books and manuals. Whether for educational, professional, or personal purposes, these digital resources serve as valuable tools for continuous learning and self-improvement. So why not take advantage of the vast world of A Finite Element Study Of Chip Formation Process In books and manuals for download and embark on your journey of knowledge?

FAQs About A Finite Element Study Of Chip Formation Process In Books

How do I know which eBook platform is the best for me? Finding the best eBook platform depends on your reading preferences and device compatibility. Research different platforms, read user reviews, and explore their features before making a choice. Are free eBooks of good quality? Yes, many reputable platforms offer high-quality free eBooks, including classics and public domain works. However, make sure to verify the source to ensure the eBook credibility. Can I read eBooks without an eReader? Absolutely! Most eBook platforms offer web-based readers or mobile apps that allow you to read eBooks on your computer, tablet, or smartphone. How do I avoid digital eye strain while reading eBooks? To prevent digital eye strain, take regular breaks, adjust the font size and background color, and ensure proper lighting while reading eBooks. What the advantage of interactive eBooks? Interactive eBooks incorporate multimedia elements, quizzes, and activities, enhancing the reader engagement and providing a more immersive learning experience. A Finite Element Study Of Chip Formation Process In is one of the best book in our library for free trial. We provide copy of A Finite Element Study Of Chip Formation Process In in digital format, so the resources that you find are reliable. There are also many Ebooks of related with A Finite Element Study Of Chip Formation Process In. Where to download A Finite Element Study Of Chip Formation Process In online for free? Are you looking for A Finite Element Study Of Chip Formation Process In PDF? This is definitely

going to save you time and cash in something you should think about.

Find A Finite Element Study Of Chip Formation Process In :

dark romance thriller primer

primer alphabet learning workbook

fan favorite psychological suspense

personal finance literacy how to

2026 guide home DIY manual

coloring activity book step by step

collection urban fantasy academy

AI in everyday life ebook

~~trauma healing workbook 2025 edition~~

trauma healing workbook international bestseller

positive psychology guide 2025 edition

guitar learning manual collection

hardcover phonics practice guide

~~reference home DIY manual~~

guitar learning manual fan favorite

A Finite Element Study Of Chip Formation Process In :

Building Manuals | The Australian Building Manual Guideline Building Manual Guideline. Free Download · Building Manual Solutions ... DOWNLOAD THE CURRENT AUSTRALIAN building manual guideline. DOWNLOAD FREE. Owners. The Australian house building manual / [Allan Staines] The Australian house building manual / [Allan Staines] ; Format: Book; Author: ; Edition: 1st ed. Description: ; ISBN: 1875217185; Notes: ; Subject: House ... Building manuals Dec 10, 2021 — This guidance is a national model for building manuals in the context of minimum building manual information requirements and the legislative ... The Australian house building manual / [Allan Staines] A step-by-step guide to house building, for builders, apprentice training, owner builders, designers, and teaching institutions. Contents cover brick veneer, ... Australian House Building Manual Step by Step 9th ... This entirely Australian manual is thoroughly researched in co-operation with the Australian Timber, Brick, Concrete and other relevant associations. It is ... The Australian House Building Manual [used

book] The House Building Manual is an entirely Australian manual and is thoroughly researched in co-operation with the Australian timber, brick and concrete ... Your home technical manual (4th Edition).pdf It was the first Australian publication to provide a comprehensive guide to sustainable building aimed at ordinary householders and occupiers as well as ... Building Code of Australia The Australian Building Codes Board (ABCB) is established by agreement between the Commonwealth Government and each State and Territory Government. It is a co- ... The Australian House Building Manual - 9th Edition Aug 13, 2021 — The House Building Manual is an entirely Australian manual and is thoroughly researched in co-operation with the Australian timber, brick, ... Driver Air Bag Module Service Manual 09 Ford Fusion Driver Air Bag Module Service Manual 09 Ford Fusion pdf download online full. Read it. Save. Read it. Save. More like this. the fuel oil purifier manual. 2009 Air Bag SRS Fuses Nov 26, 2014 — I am attempting to repair the Airbag system on my 2009 Fusion following an accident. The driver airbag and the driver seat belt tensioner ... 2009 Ford: SE...I need to replace the Air Bag control Module May 15, 2011 — I have a 2009 Ford Fusion SE. Car has been in a major accident. I need to replace the Air Bag control Module. Where is it located? User manual Ford Fusion (2009) (English - 312 pages) Manual. View the manual for the Ford Fusion (2009) here, for free. This manual comes under the category cars and has been rated by 6 people with an average ... Table of Contents - IIS Windows Server (25 cm) between an occupant's chest and the driver airbag module. WARNING: Never place your arm over the airbag module as a deploying airbag can result in ... Ford Fusion SRS RCM Airbag Module Reset (Restraint ... This service is for an airbag module reset after your vehicle was in accident. This is a repair and return service for Ford Fusion SRS RCM Airbag Module ... Programming new Ford blank airbag srs control modules or ... Ford Fusion 2012 - 2019 RCM Airbag Module Location & ... Aug 22, 2021 — How to remove Ford Fusion RCM airbag restraint control module & seat belt pretensioners. Vehicle in the video is Ford Fusion 2012 - 2019. Airbag light question Jan 28, 2010 — The car is an 09 S manual that has less than eight k on it. I have only been in one bad wreck that caused the whole front and rear bumper covers ... Toro S200 Snowthrower □ READ OPERATORS MANUAL FOR COMPLETE SAFETY AND. OPERATING INSTRUCTIONS FREE OPERATORS MANUALS ARE. AVAILABLE FROM THE TORO COMPANY. MINNEAPOLIS MINN 55420. OPERATOR'S MANUAL Read operator's manual before operating snowthrower. LO. 5. Page 6. SETTING UP INSTRUCTIONS ... S-200 snowthrower and may be obtained from your local TORO dealer. Parts - S-200 Snowthrower Manuals. Service Manual. Print. English (492-0700). Operator's Manual. Print. English (3320-263EN). Product Details. Model # 38235; Serial # 3000001 - 3999999 ... SINGLE STAGE SNOWTHROWER SERVICE MANUAL Adults should operate the snowthrower only after reading the owner's manual and receiving proper instructions. • Keep everyone, especially children and pets, ... Parts - S-200 Snowthrower Manuals. Service Manual. Print. English (492-0700). Operator's Manual. Print. English (3311-577). Product Details. Model # 38120; Serial # 1000351 - 1999999 ... Toro s200 snowblower owners manual Toro s200 snowblower owners manual. Why won't my toro snow blower start. This page currently provides links to Service

Manuals for CURRENT PRODUCTION MODELS ... Parts - S-200 Snowthrower Manuals. Service Manual. Print. English (492-0700). Operator's Manual. Print. English (3311-202). Product Details. Model # 38130; Serial # 0000001 - 0015000 ... Toro S-200 Snowblower Starting Instructions Prime it two or three pushes. Pull out the choke all the way. Turn on/off key to on and crank it. In the shop I immediatly push the choke all the way off but in ... Toro 38120, S-200 Snowthrower, 1984 (SN 4000001- ... Toro 38120, S-200 Snowthrower, 1984 (SN 4000001-4999999) Exploded View parts lookup by model. Complete exploded views of all the major manufacturers. My Neglected Toro S-200 Snowblower Oct 23, 2012 — Specifications and Features · 20" wide blow path · TECUMSEH AH520 engine · 2.5 HP @4100 RPM · Champion RJ18YC Spark Plug with .035 gap · A/C powered ...