

Research in Mechanical Engineering and Material Science

Edited by
Zhongjun Hu



TRANS TECH PUBLICATIONS

Research in Mechanical Engineering and Material Science

Selected, peer reviewed papers from the
2013 International Conference on
Mechanical, Material Engineering
(MME 2013),
November 23-24, 2013, Shiyan, Hubei, China

Edited by

Zhongjun Hu



Copyright © 2014 Trans Tech Publications Ltd, Switzerland

All rights reserved. No part of the contents of this publication may be reproduced or transmitted in any form or by any means without the written permission of the publisher.

Trans Tech Publications Ltd
Kreuzstrasse 10
CH-8635 Durnten-Zurich
Switzerland
<http://www.ttp.net>

Volume 456 of
Applied Mechanics and Materials
ISSN print 1660-9336
ISSN cd 1660-9336
ISSN web 1662-7482

Full text available online at <http://www.scientific.net>

Distributed worldwide by
Trans Tech Publications Ltd
Kreuzstrasse 10
CH-8635 Durnten-Zurich
Switzerland

Fax: +41 (44) 922 10 33
e-mail: sales@ttp.net

and in the Americas by
Trans Tech Publications Inc.
PO Box 699, May Street
Enfield, NH 03748
USA

Phone: +1 (603) 632-7377
Fax: +1 (603) 632-5611
e-mail: sales-usa@ttp.net

printed in Germany

Preface

2013 International Conference on Mechanical, Material Engineering (MME2013) will be held on November 23-24, 2013, at Hubei University of Automotive Technology, Shiyan, Hubei, China. And it will last for two days.

This conference will provide a platform to discuss Mechanical, Material Engineering, Industrial Engineering and their application, with participants from all over the world, both from academia and from industry. Its success is reflected in the papers received, with participants coming from several countries, allowing a real multinational multicultural exchange of experiences and ideas.

The conference has so far been an important event and has attracted many scientists, engineers and researchers from academia, government laboratories, and industry internationally.

A total of 236 contributions were presented at the meeting, orally or as a poster. After a rigorous and time consuming refereeing procedure, 139 contributions could be published in the conference proceedings now in front of you. Herewith we would like to thank all reviewers for their time spent on the manuscripts!

The conference proceedings will be published by APPLIED MECHANICS AND MATERIALS, issn: 1662-7482. Which will be indexed by Elsevier: SCOPUS www.scopus.com and Ei Compendex (CPX) www.ei.org/. Cambridge Scientific Abstracts (CSA) www.csa.com, Chemical Abstracts (CA) www.cas.org, Google and Google Scholar google.com, ISI (ISTP, CPCI, Web of Science) www.isinet.com, Institution of Electrical Engineers (IEE) www.icee.org, etc.

We are looking forward to welcoming you all in Shiyan, November 23-24 2013, and hope your stay will both be rewarding and enjoyable!

The Editors
2013.11.23

Conference Committees

Conference Chairman

Prof.Zhongjun Hu ,The president of Hubei University of Automotive Technology

Organizing Committee Chair

Prof.Wei Jian ,The vice president of Hubei University of Automotive Technology

Program Chairman

Prof.Guoqiang Xu, Teesside University ,Britain

Prof.YuRong Chen, Hubei University of Automotive Technology

Prof.Wancheng Chen, Hubei Mechanical Engineering Society

Program Committee Members

Prof. Yiming Rong, WPI ,The United States

Dr. Weidong Li, Coventry University, UK

Prof. Hong Lu, Wuhan University of Technology

Prof. Xiaojing Wang, Wuhan University

Prof. Xiao Pan, Wuhan University

Prof. Hanbao Li, Wuhan University

Prof. Huamin Zhou, Huazhong University of Science and Technology

Prof. Deqing Zou, Huazhong University of Science and Technology

Prof. Tingrong Zou, Huazhong Agricultural University

Prof. Qianjie Gao, Wuhan University of Science and Technology

Prof. Daxing Zhao, Hubei University of Technology

Prof. Xinqiao Qiu, Hubei University of Automotive Technology

Prof. Aihong Gong, Hubei University of Automotive Technology

Prof. Shenghuai Wang, Hubei University of Automotive Technology

Prof. Daxin Zeng, Hubei University of Automotive Technology

Prof. George Q. Huang, University of Hong Kong

Prof. Renzhong Tang, Zhejiang University

Prof. Shuping Yi, Chongqing University

Prof. Chuanjun Zhu, Hubei University of Technology

Sponsored by

Hubei University of Automotive Technology

Co-Sponsored by

Hubei University of Mechanical Engineering

University of Teesside

Wuhan University

Wuhan University of Technology

Hubei University of Technology

Table of Contents

Preface	v
Committees and Sponsors	vi

Chapter 1: Mechanical Engineering and Manufacturing Technology

Research of Line Contact Rotate-Milling about Space Ruled Surface D.X. Zheng and B. Wang.....	3
A Decoupling Algorithm for Full Vehicle Active Suspension Rolling Control J.G. Chen.....	10
A Vibration Attenuation Control Algorithm of Half Vehicle Using Active Suspension J.G. Chen, X. Feng and X.L. Zhang.....	14
The Design of Electric Car Battery Box Test Equipment Q.D. Cui, L. Yao and Y.X. Zhu	18
An Optimizing Process Design for Sinking with the Thin-Wall Cylindrical Cup H.C. Teng and B.Y. Teng	22
Simulation Research of Five-Bar Pneumatic Clamping Mechanism Y. Wu and X. Zhou.....	28
Design and Experimental Investigation on High Efficient Horizontal Micro Electrical Discharge Machine X.Y. Shu and H.H. Zhang.....	32
The Analysis and Improvement for Side Impact of Car Body Structure A.H. Gong and M.M. Hu	38
Path Planning of the Intersecting Line of Cylindrical Pipes Welded by the Welding Robot Y.Q. Wang	43
Study on Leaky Fault Mechanism and Influential Factors of Hydraulic System of Artillery R.B. Zhou, X.B. Liao, A.Q. Ming and Z. Zhang	50
Simulation Study on Armor-Piercing Effect of Armor-Piercing Bomb R.B. Zhou, X.B. Liao, A.Q. Ming and Y.F. Zhang.....	55
The Effects of the Wear Elongation on the Load of a Long-Distance Transmission Chain J.T. Zhao, S.Z. Wang and Z.X. Wang.....	60
Research on Influencing Factors of Magnesium Alloy Wheels Forging Forming Force J. Li, H.X. Sun, S.M. Sun and X.X. Liu.....	65
A Simplified Representation of the Intersecting Lines of the Common Rotary Bodies Intersected in Symmetric Vertical Intersection Position in Mechanical Drawings Y.Q. Wang and Y.M. Cheng.....	69
Dynamics Analysis and Optimization of Gear Transmission System H.D. Zhang and T. Sun	76
Design of the Fault Diagnosis and Maintenance Support System of New Self-Propelled Artillery Electromechanical Equipment X.B. Liao, R.B. Zhou, L.H. Huang and L.J. Huang.....	80
Numerical Simulation and Experiment of Hot Roll Forming Large Module Gear X.X. Zhu, B.Y. Wang and Z.H. Hu.....	86

Research on Quality Information Management Based on Quality BOM in Multi-Specification & Small-Batch Production	
D. Zhou, M. He and Z.B. Yang.....	90
Introduction of Modular Design in the Conceptual Design of Refrigerators	
J.M. Zhang, J. Xu and B. Tang	96
Numerical Simulation and Orthogonal Design Method Research Effect of Splitter Blade's Main Geometry Factors on the Performance of Pump as Turbine	
J.H. Yang and S.C. Miao.....	100
Analysis of Die Lock for Stamping Parts	
L. Jing, M. Liao and M.J. Yin.....	106
Experimental Investigation on Damping Characteristic of Metal Rubber Material at Simulated Marine Environment	
Z. Lin, G.Z. Li, H.B. Bai and C.H. Lu	110
Angle Measurement Based on Computer Vision	
J. Wang and X.H. Ni	115
Design of a Novel Down-Hole Pump with Hydro-Automatic Reversing Valve	
W. Zhao and C.W. Guo.....	120
Laser Shock Processing of Titanium Alloy Blade and FEM Simulation	
B. Yan and R. Wang	125
Study on Profile Design and Analysis of Screw Expander	
G.B. Liu, Q.C. Yang and L. Wang.....	129
Research on Dynamic Characteristics of Globoidal Cam Employed in Automatic Tool Changer (ATC) of Machine Center	
Q.S. Gong, M. Luo, A.H. Ren and Z.B. Chang	133
The Analysis of Motion Characteristics of Variable Forward-Swept Wing Mechanism with a Double Slideways	
X.B. Su, Z. Zhou, X. Wang, J.C. Shi and P. Chen.....	137
Theory Design Research and the Application Prospect of the Future for the Ever Moving Car	
G.Q. Cao, Y.J. Li and J.N. Liu	142
Kinematics and Workspace Analysis of 3-RPP Parallel Mechanism	
Z.J. Xie, J. Zhang and X.B. Liu	146
Design and Simulation Analysis of Compost Pallet Transfer Device of <i>Agaricus bisporus</i> Factory Cultivation	
W.Y. Zhao, J. Yang, X.P. Tang and F. Dai.....	151
Dynamics Simulation and Fatigue Life Study of the Drive System of Rack and Pinion Climbing Vertical Shiplift	
X.Q. Sun, Y. Zhang and D.W. Shi	155
The Design of the Self-Propelled All-Filming Double-Furrow Vertical Dropping Accurate Hill-Drop Planter for Corn	
W.Y. Zhao, X.P. Tang, Q. Fei and F. Dai.....	159
Finite Element Analysis of Spur Gears on Modal and Stress	
J.Y. Wang, Y.Y. Huang and Z.H. Chen.....	164
Rotor/Stator Interactions Study under Different Operating Condition in Axial Flow Pump	
W.D. Shi, S.Q. Wu and J. Yao	168
Application of Modified PANS Model for Computation of Cloud Cavitation around a Clark-Y Hydrofoil	
W.D. Shi and G.J. Zhang	173
Cloud Service Platform for Big Data of Manufacturing	
H.P. Zhu, Y. Xu, Q. Liu and Y.Q. Rao	178

A Research on the Positioning and Tracking Technology of the Mobile Device for Testing the Thermal Performance of Solar Collector	
T. He, J. Wu, X.H. Wu, M. Zhong and J. You.....	184
Characteristics Analysis of the Automobile with Negative Stiffness Suspension	
X.Z. Qu, G.Q. Hou, H. Liu and H. He	189
Study on the Maximum Contact Stress of Involute Gear Pair with a Small Number of Teeth	
Y.F. Liu, Y.H. Sun, Q. Sun and J. Xiao.....	193
The Design of Nanoscale 3D Precision Displacement System	
X.W. Deng, Y.R. Chen, B.B. Dan and S.H. Wang	199
Research on 3D Reconstruction of Flatness Error Measurement System	
C.L. Zou, S.H. Wang, H. Hao and Y.R. Chen	203
Based on CFX Numerical Simulation of Francis Turbine Runner	
F. He.....	207
Study on the Engine Speed Sensor Position Measuring Tool Based on Minitab	
W. Cen and L.X. Xia.....	211
Numerical Simulation of Influence of Different Heat Source Models on Temperature Field of Aluminum-Alloy Ring Weld Seam	
W.F. Zhu, J. Wang, P.J. Lin and B.Y. Zhang	216
Ontology-Based Knowledge Modeling for Power Source Subsystem of Satellite Fault Diagnosis	
X.Q. Li, S.K. Jing, H.C. Yang and J.T. Zhou	220
Calculation and Analysis of Submersible Well Pump Clearance Leakage Loss	
X.F. Gao, W.D. Shi, Q.H. Zhang and D.S. Zhang.....	225
Design and Dynamic Simulation for Hydraulic Support	
D.M. Li, Y.H. Tan, R.Y. Xu, J.J. Yuan, B.Y. Li, D.J. Huang and T.L. Jia.....	230
Sensitivity Analysis of Surface Accuracy of Mesh Antennas to Cable Length	
Y.S. Fan, X.F. Ma, Z.J. Li and T.J. Li	234
Research on Adaptive Learning Control Strategy of Daul-Cylinder Synchronous Hydraulic System	
G.H. Zhao.....	240
Research on Fuzzy Adaptive Control of Multi-Cylinder Synchronous Hydraulic System	
G.H. Zhao.....	244
The Calculation for Digging-Resistance of Small-Scale Excavator Based on Torque Method	
J.L. He, H.H. Zheng and D. Li.....	248
Kinematics Analysis and Simulation on Hydraulic Efficiency Manipulator	
Y.X. Liu, Z.F. He and R. Zhao	252
Research on the Dynamics of the Double Helical Gear Transmission	
F. Ren, D.T. Qin and X.L. Wu.....	256
Application of LABVIEW in the Experiments of Temperature Acquisition	
J. Long and C.L. Zhang.....	260
Fan Cooling Scheme Analysis of the Injection Molding Machine Controller	
J. Long and C.L. Zhang.....	264
Green Design and Manufacturing of Premium Efficiency Motor	
L.Z. Wang and Z.Q. Liu.....	268
Combining Ontology and Retrieval in Case-Based Reasoning for Heavy Industry Machinery Design	
H.L. Zhang, Y.H. Ge, J.S. Xia and X.F. Huang.....	274
Thermal Design of Power IC Chip Based on Icepak	
L.F. Pang.....	278

Large-Size Wheel Rotary Forging Process Research	
J. Li, H.X. Sun, L.M. Wang and M.H. Tao	282
Spindle System Dynamic Characteristics Analysis of Vertical Gantry Machining Center	
H.B. Huang, Y.M. Wang and S. Xia	286
Application Research on High-Tech Tax Preference Policy of Manufacturing	
S.F. Cui, M. Du and Z.X. Li	291
The Study on Linear Guide Precision Straightening Stroke Prediction Quick Algorithm	
L. He and L. Hong	294
Multi-Function Fusion Measurement Method for Surface Texture	
S.H. Wang, F.H. Xu, Y.R. Chen and T.B. Xie	299
Research on Modeling and Simulation of the Trafficability of Vertical Screw Conveyors	
Intermediate Support Based on EDEM	
L. Mei, J.Q. Hu, Y.Z. Li and T.P. Chen	303
The Design of Torsional Fatigue Life Test of Vehicle Steering Driveshaft	
W. Bao	310
Numerical Simulation for Solid-Liquid Two-Phase Flow in Stirred Vanadium Leaching Tank	
J.Y. Kong, Z.W. Wu, Y. Hou and X.D. Wang	314
A Novel Friction Model Basing on Journal Bearing Theory for Reciprocating Compressor	
L. Wang, B. Tang and Y.Y. Zhao	320
Safety Assessment and Remaining Service Life Prediction of Sandwich Marine Air Bottles	
G.J. He and A.M. Diao	324
Dynamics of Flexible Slider-Crank Mechanism Based on the Floating Frame Reference Formulation	
W.F. Sun, X.Z. Zheng and J.R. Liang	330
Optimal Design of Pendulum in High Impact Shock Testing Machine for Middleweight	
T. Wang, X.Z. Zheng and S.B. Wang	334
Effect of Nitrogen on Crystal Grain Forming of Metastable Austenitic Manganese Steel	
S.C. Chen, X.J. Chen, Y.M. Lu, Y.B. Wu, X.Y. Lin and Y. Lin	338
Impact Test Method for Automobile Plastic Tank Research and Equipment Development	
L.L. Wang, T.Q. Du and W. Liu	345
Comparative Study on the Wear Behavior of FPM and NBR in the Natural Crude Oil Medium	
Z. Wang and S.J. Wang	349
Casting Process Design and Simulation for Shaft Locking Pin	
G.H. Zhang, R.D. Li, C. Tian and K.Q. Qiu	354
A Study on the Method for Punching Small Holes with Cold Stamping Dies	
J.H. Ning and Z.P. Hai	358
Current Control Type Power Distribution Algorithm of Indirect Fuel Cell Hybrid Vehicle	
P. Xiao and S.H. Quan	363

Chapter 2: Materials Science and Chemical Engineering

Study on the Test of Pulse Laser Processing of Brittle Materials	
P.P. Liu and L. Wei	369
Characterization of Microstructure, Texture and Properties of a Continuously-Annealed Cold-Rolled High Strength Structural Steel	
G.T. Zhang, S.H. Deng, Z.W. Zheng and Q.C. Liu	373

Assessment of Aging Properties of Anti-Scratch Coatings by Nanoindentation X. Zhang, Y.L. Zhong, X.W. Zhang, L. Li and Y. Yan.....	378
Numerical Simulation of Temperature Field and Stress Field to Multiple Laser Cladding Co Coatings L. Ding, M.X. Li, D.Y. Huang and H.Y. Jang.....	382
Influence of Pearlite Interlamellar Spacing on the Deformation Behavior and Fracture Characteristics in Spring Steel 60Si2MnA C.L. Zhang, Y.Z. Liu and L.Y. Zhou.....	388
Influence of MoSi₂ Addition in Co Based Alloy Cladding Coating on Microstructure Evolution and Pitting Corrosion Behaviour Z.F. Liang and M. Zheng.....	392
Electrochemical Analysis of the Phase Structures in Galvannealed Coatings X.H. Yuan, D.W. Guo, S.M. Jiang and Q.F. Zhang.....	399
Research Progress of Surface Nanocrystallization on Metallic Materials by Surface Mechanical Attrition Treatment H. Wang, Y.X. Wu, C.S. Ma and Z.L. Zhan.....	406
Photoluminescence Properties of ZnO Thin Film Prepared by Sol-Gel Route Y.J. Hu, W.Y. Pei, L.G. Ying and L.S. Jun.....	411
Research on the Performance and Process of Fe/Cr-V – WC Surfacing Welding Layer on Weapons Parts Department X.B. Liao, R.B. Zhou, A.Q. Ming and Z.Z. Quan.....	416
Study on the Method of Typical Defects in Butt Welding of 20 Steel P.L. Zhang, Z.Q. Zhao, Y. Sang and Y.X. Xu.....	421
Forming Load Calculation of Hot Precision Forging of Cylindrical Gears B. Zuo, B.Y. Wang and L.Y. Yang.....	425
Recent Development of Vacancy Formation Energy X.H. Yu, Z.L. Zhan, J. Rong and Y. Wang.....	429
Study on the Erosion and Abrasion Mechanism of the Modern Artillery Barrel X.B. Liao, R.B. Zhou, Y.F. Yang and C.H. Gong.....	433
Fabrication and Corrosion Properties of Electroplated Ni-Co-Cr Alloy Coatings T. Yang, C.Z. Peng, L. Xiang and H. Cao.....	438
Thermodynamic Properties of Nb₄AlC₃ A.L. Ding, W.B. Yu, C.M. Li and Z.Q. Chen.....	442
The Reach on the Salt Spray Corrosion of 6000 Series Aluminum Alloys for the High-Speed Trains B. Li, J. Yang, X.M. Wang, P.X. Qiu, S.F. Zhang and Q. Jia.....	447
Influence of Stress Concentration on Fatigue Property of Welded Joints of 5083 Aluminum Alloy J. Yang, B. Li, Q. Jia, Y.X. Li, M.Y. Zhang and H. Chen.....	451
Research Progress of Phase Change Materials on Heat Transfer F. Ma and Y. Qin.....	456
The Advances in Research of Complexes of Chitosan and its Derivatives F. Ma and F.Y. Lu.....	461
The Study on the Basic Theory of Gold Seamless Pipe Welding Numerical Simulation W.C. Qin, J.R. Qi, L.X. Wang and W.H. Ye.....	467
Synthesis, Morphology and Hydrophobicity of Core-Shell Fluorinated Copolymer Latexes P. Guo, X. Zhao and Z.G. Xiao.....	471

Surface Hardening of a Vermicular Cast Iron Used for Integral Molding Valve Seat by High Power Laser	
M. Pang, W. He, C.Z. Liu, X.L. Wang and X.B. Kang	474
Numerical Simulation of Aluminum Alloy Welding for Butt-Joint of AA2024 Considering Surface Effect Element	
W.F. Zhu, J. Wang, P.J. Lin and B.Y. Zhang	478
Microstructural Characteristics of Mg-Zn-Y Alloy Containing Quasicrystal Phase under Pulsed Magnetic Field	
L. Zhang, Q. Zhou, K. Luo and L. Yang.....	482
Research Progress of Plasma Nitriding in Low-Temperature for Austenitic Stainless Steel	
Y.X. Wu, H. Wang, X.H. Yu and Z.L. Zhan	486
Thermoelectric Properties of <i>n</i>-Type AgPbSbTe Composites Containing Nanoscaled Phases	
J. Liu and L.M. Peng.....	490
Microstructure and Tensile Properties of Al_{0.5}CoCrCuFeNi High-Entropy Alloy	
H.F. Sheng and L.M. Peng.....	494
Recognition and Control of the Influence Factors on the Surface Defects of Cold Rolled Strip with Emulsion Lubrication	
Y. Li and J.L. Sun	498
Theoretical and Experimental Research on Preparing Silicon Microspheres by Pulsed Electrical Discharge Method	
J. Hong and W. Zhang.....	503
Effect of Grain Refinement and Composition on the Wear of Cemented Carbide Cutting Tools	
J.B. Cheng, S.Q. Pang, X.B. Wang and Q.X. Yu.....	507
Effect of Activating Hot Dipping Aluminum Process on High Strength Steel and Aluminum Alloy Welding Properties	
Y. Xu, Y.H. Zhang and C.B. Yu	512
Microstructure Changes of Beta Alumina Sintering at Lower Temperature	
H. Li, J.C. Lu, G.Y. Cheng, Y.N. Zhu and X.B. Jiang.....	517
The Effect of RE on the Microstructure and Properties of Weld of 7075 Aluminum Alloy	
L.J. Li, X.R. Huang and H.K. Wei.....	521
Effect Dehydrants to Increasing Molecular Weight of Condensed Polylactic Acid	
M.Y. Yin, R.J. Yang and D.H. Li	525
Numerical Study on Compressive Properties of Mineral Composite Material	
P. Li, Z. Ji and R. Liu.....	529
Orientation Relationship between Fe₂M and Martensite in M50NiL Steel	
Y.Z. Lou	533
Experimental Study of Solid Dispersion in a Seeded Precipitation Tank with Slight Agitation for Gibbsite Crystallization	
Y.F. Ding, X.D. Su, D.Q. Hu, J.K. Liu, L. He and D.N. Li.....	537
HREM Study on Heterogeneous Formation of Titanium Carbonitride in Ti Microalloyed Steel	
Y.Z. Lou	541
Investigation of the Mechanical Properties of Nanocrystalline Cemented Carbides by Nano-Indentation Technique	
X.M. Liu, X.Y. Song, H.B. Wang, Y. Wang, Y. Gao and X.L. Wang	545
A Novel Method to Determine EHL Film Thickness with Optical Interference	
Q.Q. Yang, Y.J. Chen and P. Huang.....	549
Design and Realization of Automatic Control System in Process of Plasma Extraction	
W. Ren and Y. Wang	555

Experimental Research on Mercury-Containing Wastewater by Fly Ash Y. Li and P. Sun	559
--	-----

Chapter 3: Industrial Engineering and Other Related Topics

Design of Clamping Fixture for Active Fixing-Board Used in Vibration Experiment M. Wang and Z.L. Wang	567
Design of 5HZL-1200 Type Maize Ear Vertical Drying System W.Y. Zhao, Q. Fei, J. Yang and F. Dai	571
Finite Element Model of Human Cochlea Considering of the Helicotrema Size L.F. Xu, N. Ta, Z.S. Rao and J.B. Tian	576
A Review of Dynamic Fluid Level Detection for Oil Well W. Jia, W. Zhou and T.F. Li	582
Application of Intelligent Expert System on Growth Model of Plant W.Q. Zhang, Y. Li, X.G. Liu and X.N. Liu	587
Research on Technology of Building Three-Dimensional Geological Simulation Model by Octree Algorithm Method S.M. Wu, Y.K. Wang, J.W. Song and X.N. Liu	591
Structural Analysis and Design of Pre Heating Automotive Control System Based on AVR J.B. Zhu and J.Y. Wang	595
Condition Assessment of MRTB Based on Fuzzy Theory J. Dai and G.R. Chen	599
Anti-Control of Discrete Chaos Based on the Oblique Wave Feedback Control Z.H. Yang	603
Research on Unmanned Helicopter Communication System Based on μC/OS-II Operating System M.L. He, N. Luo and A.C. Amenuvor	607
Local and Global Contrast for Saliency Estimate in DCT Domain N.P. Ling and H.L. Zhang	611
The Simulation of the Novel SCRLH Transmission Line Structure Bandpass Filter X.K. Tang, Y.L. Guan and L.B. Wan	616
Research on Process Planning for the Job Shop Scheduling Integration X.D. Liu, Y. Zhang and Y. Li	620
A Bandpass Filter Based on Novel SCRLH Transmission Line Structure L.B. Wan, Y.L. Guan and X.K. Tang	624
Impact of the Variable Sampling Intervals Scheme on the CQC Chart Y. Zhang and X.J. Wang	627
Thoughts on How Construction Enterprises Improve Performance Management J.L. Zuo	631
Research on Appointing Diversified Subjects for Evaluating Performances of Energy-Saving and Emission-Reducing of Local Party and Government Leaders J.K. Zhou and Q. Hao	636
The Power Measurement of DBD Ozone Reactor Based on the Quasi-Synchronous Algorithm H.C. Zhang, Z.J. Liu and Y. Li	640
Measurement and Characterization the Flocculation Processes by PIV J.F. Gao	644

Study on Forming Process of the Oil Pipe with Upset Ends	
L. Kong and Y.K. Liu	648
Photoacoustic Measurement and Experiment of Glucose Concentrations in an Aqueous Matrix	
G.D. Liu, J. Dong, Z. Ren, L.M. Zeng and H. Xu	652
Research of PDM System Based on Solid Edge Insight	
J.J. Mao and G.Q. Shen.....	656
Keyword Index	661
Author Index	667

CHAPTER 1:

Mechanical Engineering and Manufacturing Technology

Research of Line Contact Rotate-milling about Space Ruled Surface

Zheng De-xing^{1,a}, Wang Bin^{1,b}

¹School of UG, Yancheng Institute of Technology, Yancheng 224051, P.R. China

^azdxeducn@163.com, ^bwangbin@ycit.cn

Keywords: ruled surface; line contact rotate-milling; motion analysis and realization; precision analysis;

Abstract. For there are small contact area between tool and workpiece, low machining precision, and poor quality of face in point-milling, point-milling and line contact milling used in processing are analyzed on this paper. Line contact rotate-milling using which the workpiece is processed as the profile laws is shown, the realization method of line contact rotate-milling is discussed in milling various surfaces, the movement to processing the various surfaces is studied, and the movement function is analyzed. Next, the factors affecting the machining accuracy are analyzed, and the main factors - the geometric errors are analyzed and integrated. Then the error model is created in differential analysis, the output accuracy is analyzed in "Matlab". To point-milling, the line contact rotate-milling is the method of processing based on face. In this processing, the way of no profile theory-error is taken, the tool contact length with the workpiece is increased, axis as few as possible and even single-axis is taken, and the accuracy of processing is improved.

Introduction

The ruled surface is a straight line set, which is generated by the movement of the straight line in space. For its special geometric properties, it is widely used in the engineering of the wing, turbine impeller, blade class parts of the fluid machine, etc. [1]. Currently, the finishing of the complex workpieces having ruled surface characteristics is done by 5-axis CNC machine tools using the general ball tool, arc-shaped tool, and drum-shaped tool, etc. In the traditional five-axis machining, the tool is contacted with the workpiece on the point and its small neighborhood in the processing area, the tool path is planned in point-line, and tool-position computing is simple, so this method is versatility and can be used for the processing of the arbitrary curved surfaces. However, this processing method has the following disadvantages: firstly, because the contact area between the tool and the workpiece is theoretically a point, the contact area is very small, so the processing efficiency is low; secondly, there is the theoretical approximation error, and machining accuracy is limited by the machine precision and interpolation accuracy; thirdly, for the curvature of the contact point in each of the contact area between the tool and the workpiece is inconsistent, cutting speed on each point of the cutting edge is inconsistent, and eventually a deterioration in the quality of the machined surface is caused.

So, in order to improve processing accuracy and efficiency, there have been studies about the processing methods for example: belt polishing, WEDM surface machining, line contact milling (side milling, face milling) processing methods etc. [2-7]: Sorby, Tonnessen, Torjusen, et al. [4] proposed the high-speed line contact machining tool and cutting method based on the tool life and cutting force; Larue, Anselmetti [5] proposed the error calculation method of line contact machining; Menzel, Cornelia [6] proposed the cutter path planning method based on three-point cut-touch side milling by the error analysis; Li Chenggang [7] proposed the design method of quadratic NURBS surfaces by using the least squares method.

Compared to the traditional point-contact machining, the contact length between tool and workpiece is increased in line contact machining, then this is a surface-based processing. While, in the line contact machining based on WEDM, the processing efficiency is low, and there is the metamorphic layer on the surface of the work piece after processing. In the current line contact

machining based on 5_axis CNC, the rotary axis is fixed or the radius of gyration is fixed about rotary feed, therefore the processing route is mainly planned by point-line. So, even a simple space plane also requires a large number of tool position data. When there is spiral surface or space tapered surface on the surface of the workpiece, the surface approximation and multi-axis are more needed, so the approximation error and nonlinearity error is inevitable.

In the line contact rotate-milling, the research about directly finishing theoretical profile of developable ruled surface is first carried out, and the method with no profile theory-error is applied in processing. The tool axis is always moving in the offset surface which is "r" away from the processing surfaces, the stimulation of turning and milling is done directly through arc feed instead of circular interpolation, a composite machining of turning and milling is formed by using the rotary cutting movement of tool flank and rotary feed motion. and the machining having the high efficiency and precision is realized.

Movement Realization of Line Contact Rotate-milling

The principle of line contact rotate-milling is illustrated in Fig. 1. In processing, the machined surface is made up of the enveloping motion of the tool side-edge. We define: machined surface is the surface which will be milled; the guide moving lines is the curve by which the tool movement is guided; the check surface is the end position for each cutting. Because the machined surface after line contact rotate-milling can only be ruled surface, in machining non-ruled surface, the non-ruled surface is approximated in use of ruled surface. So, according to the specific circumstances, a sideline " $P_Q(u)$ " of Ruled Surface is selected as a guide line, the tool side edge is very contacted with machined surface. When the contact point at the bottom of tool is moved to the check surface, the processing of ruled surface is completed.

Achievement on ruled surface machining. If each one of a family of straight lines which is in existence is all in the curved surface "S", the "S" is called a ruled surface.

If the " $P_Q(u)$ " and " $P_P(u)$ " are used to respectively express as two baselines of a ruled surface the equation of ruled surface can be defined as:

$$r(u, v) = (1 - v)P_Q(u) + vP_P(u) \quad (1)$$

A ruled surface includes a developable ruled surface and a non-developable ruled surface, the developable ruled surface includes a cylinder, a tapered surface, and a tangent surface. Because the processing of tangent surfaces requiring five-axis is similar to non-developable ruled surfaces, now the discuss of line contact rotate-milling is focused on the cylinders, cones, and the developable ruled surfaces which can be decomposed into the cylinder and cone.

(1) In formula (1), when $P_Q(u)$ is a certain point " r_0 ", the formula (1) is converted to the taper equation: $r(u, v) = P_Q(u) + v(r_0 - P_Q(u))$ (2)

When the surfaces are milled, the tool axis vector is consistent with the straight generatrix vector of taper surface through the control of B, C axis; by controlling the feed of X-axis and Y-axis feed of workbench and the W-axis feed of tool, the bottom edge of tool is always contacted with the baseline (the guide lines). The tool axis is always running in the equidistant surface of the machined surface:

$$r^*(u, v) = P_Q(u) + v(r_0 - P_Q(u)) + Rn(u) \quad (3)$$

Especially, when an angle which is formed between the connection line between $P_Q(u)$ and r_0 and a line over r_0 is remained unchanged, the ruled surface is cone, the angle is the half-cone angle. The milling of cone is illustrated in Fig. 2. First, the rotary feed axis of tool or table is adjusted to have a

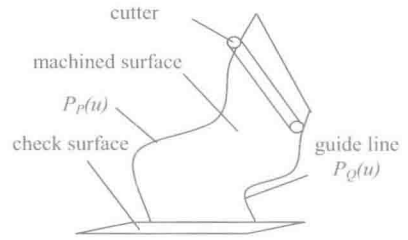


Fig.1 Diagram on line contact rotate-milling

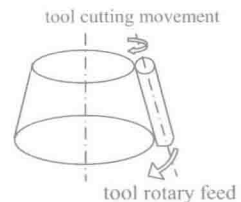


Fig.2 Diagram on milling cone