1. Dynamic response analysis of helical gear systems considering periodic surface waviness deviation

Wang, Yu (1); Li, Guolong (1); Li, Yan (1); Liu, Ziqian (2); Cao, Bing (2, 3); Li, Pengcheng (1)
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Abstract: Tooth surface waviness (TSW) is a periodic manufacturing deviation, which has a critical influence on the vibration and noise of transmission systems. To accurately evaluate waviness effects on dynamic responses, this study proposes a coupled analytical model of the elastohydrodynamic lubrication (EHL) state and system vibration considering TSW. Firstly, a two-dimensional waviness deviation characterization method based on 2D-FFT and a reverse reconstruction interface for rough tooth surfaces are proposed. An efficient semi-analytical method is developed to address the normal contact issue for rough surfaces. Subsequently, the EHL analysis model is established to calculate internal dynamic excitations, including comprehensive time-varying meshing stiffness (TVMS) and quasi-static transmission error (QSTE) induced by TSW. Finally, a helical gear dynamic model that incorporates the effects of elastic and inertial forces caused by the instantaneous contact state changes of rough tooth surfaces is presented. The effectiveness of the proposed model is validated through quasi-static and dynamic experiments. Through a series of dynamic simulations, the waviness effects on dynamic responses under different operating conditions are investigated. Results show that TSW has significant effects on dynamic characteristics of helical gears. This study provides a theoretical foundation and technical support for gear quality control and fault diagnosis in gear transmission. © 2025 Elsevier Ltd. (47 refs)
Main heading: Elastohydrodynamic lubrication
Controlled terms: Analytical models - Dynamic response - Elastohydrodynamics - Electric power transmission - Excited states - Gear teeth - Helical gears - Power transmission - Transmissions - Vibration analysis
Uncontrolled terms: Contact state - Dynamic response analysis - Dynamics characteristic - Helical gear systems - Lubrication / - ON dynamics - Surface waviness - Teeth surface - Tooth surface waviness - Waviness excitation
Classification Code: 301.1.1 Liquid Dynamics - 601.2 Machine Components - 602.2 Mechanical Transmissions - 606.2 Lubrication - 706.1.1 Electric Power Transmission - 941.5 Mechanical Variables Measurements - 1201.12 Modeling and Simulation - 1301.1.3 Atomic and Molecular Physics - 1301.1.4 Quantum Theory; Quantum Mechanics
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Database: Compendex
Data Provider: Engineering Village

2. Loaded tooth contact analysis for helical gears with surface waviness error

Wang, Yu (1); Li, Guolong (1); Tao, Yijie (1); Zhao, Xiaoliang (1); He, Xiaohu (1)
Source: *Mechanical Systems and Signal Processing*, v 224, January 1, 2025; **ISSN:** 08883270, **E-ISSN:** 10961216; **DOI:** 10.1016/j.ymssp.2024.112045; **Article number:** 112045; **Publisher:** Academic Press
Author affiliation: (1) The State Key Laboratory of Mechanical Transmissions, Chongqing University, Chongqing; 400044, China
Abstract: Meshing characteristics are crucial for the transmission performance of vibration noise and strength of gear systems. Gear transmission error has been acknowledged as a prominent excitation in vibration systems, but the surface waviness deviations that directly affect it in contact analysis are generally ignored. This study proposes a comprehensive model for quasi-static analysis of tooth surfaces with waviness error. The model reconstructs the actual tooth surface in reverse based on the gear Fourier measurement principle. Instead of solving the meshing equations to pre-assume contact position, the problem of normal contact between surfaces with deviations is solved by an innovative multiscale grid and a local iterative numerical algorithm. Combining the finite element numerical method and surface integral of the Boussinesq solution determines gear deformation and develops a loaded contact model. The validity of the model is verified through numerical examples. Furthermore, the proposed model is applied to discuss the tooth surfaces with different waviness amplitudes, frequencies, and distribution angles for the first time. It explains the interaction between local microscale and

global scale introduced by waviness error on tooth surfaces and reveals the mechanism of the waviness error on meshing performance. © 2024 (51 refs)
Main heading: Gear transmissions
Controlled terms: Convergence of numerical methods - Gear teeth - Helical gears - Iterative methods - Vibration analysis
Uncontrolled terms: Loaded tooth contact analysis - Loaded tooth contact analyze - Meshing characteristics - Rough surfaces - Surface waviness - Teeth surface - Transmission error - Transmission performance - Vibration noise - Waviness
Classification Code: 601.2 Machine Components - 602.2 Mechanical Transmissions - 662.3 Automobile Components and Materials - 941.5 Mechanical Variables Measurements - 1201.9 Numerical Methods
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Database: Compendex
Data Provider: Engineering Village

3. Real-time direct measurement and calculation of tooth flank contact temperature for point contact spur-face gear drive

Xu, Bo (1); Zhu, Lingyun (1, 2); Gou, Xiangfeng (1, 2, 4); Chai, Changyin (3); Liu, Guoliang (4, 5); Zhao, Xinhao (4, 5); Chen, Min (4, 5); Liu, Zhanglong (4, 5); Liu, Chang (1); Liang, Dong (1); Jin, Guoguang (1); He, Shujun (1); Niu, Shilin (1); Guo, Qingfu (1); Wei, Dazhong (1)
Source: *International Journal of Heat and Fluid Flow*, v 120, June 2026; **ISSN:** 0142727X; **DOI:** 10.1016/j.ijheatfluidflow.2026.110405; **Article number:** 110405; **Publisher:** Elsevier B.V.
Author affiliation: (1) School of Mechanical Engineering, Tiangong University, Tianjin; 300387, China (2) Shaoxing keqiao Institute of Tiangong University, Shaoxing; 312030, China (3) Xiamen Truly Pack Machine Co., Ltd., Xiamen; 361100, China (4) AECC Aviation Gear Manufacturing Technology Innovation Center, Changsha; 410299, China (5) AECC Zhongchuan Transmission Machinery Co., Ltd., Changsha; 410299, China
Abstract: Excessive thermal elevation is a critical factor contributing to gear scuffing. The phenomenon is particularly pronounced in point contact drive under highly concentrated loads. The friction heat generation mechanism and temperature distribution law in point contact spur-face gear drive (SFGD) are systematically analyzed. Time-varying parameter models can be constructed to enable the quantitative analysis of the tooth flank temperature (TFT). A contact temperature prediction model for SFGD is proposed by combining point contact characteristics and heat transfer theory. The face gear and pinion are respectively processed using steel and constantan. A J-type thermocouple temperature measurement circuit is constructed. The real-time measurement of the TFT in the contact area is achieved by the Seebeck effect. The correctness of the theoretical model is verified by comparing various working conditions under dry friction drive. The actual meshing trajectory is consistent with the trend of the theoretical calculation trajectory. The relative error between the theoretical and measured values of contact temperature is less than 5.49%. The ability to accurately predict TFT in point contact drive is enabled by the established calculation model. The relevant characteristics of point contact transmission are fundamentally revealed. © 2026 Elsevier Inc. (52 refs)
Main heading: Seebeck effect
Controlled terms: End effectors - Friction - Gear teeth - Heat transfer - Point contacts - Spur gears - Temperature distribution - Thermocouples - Time varying control systems
Uncontrolled terms: Contact temperature - Direct calculation - Face gear drive - Face gears - Flank temperatures - Real- time - Seebeck - Spur-face gear - Thermal network models - Tooth flank
Classification Code: 302.2 Heat Transfer - 601.2 Machine Components - 704.1 Electric Components - 714.2 Semiconductor Devices and Integrated Circuits - 731.1 Control Systems - 731.5 Robotics - 941.8 Temperature Measurements - 942.1.11 Temperature Measuring Instruments - 1004 Thermoelectric Energy and Power Generation - 1301.1.1 Mechanics
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Database: Compendex
Data Provider: Engineering Village

4. Research on Measurement Uncertainty Analysis and Verification of a High-Precision Gear Measuring Center

Liu, Yangpeng (1); Hu, Congzheng (1); Ding, Jianjun (2); Zhang, Ruhan (1); Zhang, Keyuan (1); Wang, Mingxin (1)
Source: *2025 5th International Conference on Measurement Control and Instrumentation, MCAI 2025*, p 96-105, 2025, *2025 5th International Conference on Measurement Control and Instrumentation, MCAI 2025*; **ISBN-13:** 9798331539375; **DOI:** 10.1109/MCAI66356.2025.11381953; **Conference:** 5th International Conference on Measurement Control and Instrumentation, MCAI 2025, November 21, 2025 - November 23, 2025; **Sponsor:** IEEE; Measurement Control Technology and Equipment Application Promotion Association of Guangdong Province; **Publisher:** Institute of Electrical and Electronics Engineers Inc.
Author affiliation: (1) Xi'an Jiao Tong University, State Key Laboratory for Manufacturing Systems Engineering, Xi'an; 710049, China (2) Shaanxi Aladdin Precision Instrument Technology Co., Ltd, R&D Department, Xi'an; 710116, China
Abstract: This study presents a comprehensive measurement uncertainty analysis for a self-developed high-precision four-axis Gear Measuring Center (GMC). The primary objective is to establish mathematical models, quantify the influence of key error sources, and verify the equipment's capability for inspecting high-grade gears according to international standards. Methods: Systematic uncertainty models were developed for three critical measurement items: tooth profile, helix (lead), and pitch. The combined standard uncertainty for each item was calculated based on the Guide to the Expression of Uncertainty in Measurement (GUM), incorporating experimentally characterized geometric errors of the machine's linear and rotary axes (e.g., positioning, straightness, and rotational errors) and other influencing factors. The expanded uncertainty was then determined. A comparative verification against the ISO 1328-1 standard demonstrated that these uncertainty values are approximately one-fifth of the tolerance band specified for Grade 4 gears. This result conclusively validates that the developed Gear Measuring Center is capable of performing reliable measurements for gears of ISO Grade 4 and higher precision levels. The analysis also identifies the dominant error sources, providing clear direction for future accuracy enhancements. © 2025 IEEE. (8 refs)
Main heading: Uncertainty analysis
Controlled terms: Errors - Gears - ISO Standards
Uncontrolled terms: Accuracy verification - Analysis and verifications - Comprehensive measurement - Error sources - Gear measuring center - Gear metrology - High-precision - Measurement uncertainty - Measurement uncertainty analysis - Uncertainty
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 731.1.1 Error Handling - 902.2 Codes and Standards - 1202.1 Probability Theory
Funding text: This research was funded by Shaanxi Provincial Key R&D Plan, grant number 2022QCY-LL-09.
Database: Compendex
Data Provider: Engineering Village

5. Research on Compensation of Tooth Surface Twist Error in Form Grinding of Internal Helical Gears with Lead Modification (*Open Access*)

Deng, Jing (1); Li, Shaoyang (1); Su, Jianxin (1); Jiang, Chuang (1); Yang, Hao (1)
Source: *Applied Sciences (Switzerland)*, v 16, n 7, April 2026; **E-ISSN:** 20763417; **DOI:** 10.3390/app16073574; **Article number:** 3574; **Publisher:** Multidisciplinary Digital Publishing Institute (MDPI)
Author affiliation: (1) School of Mechatronics Engineering, Henan University of Science and Technology, Luoyang; 471003, China
Abstract: To address the issue of tooth surface twist, induced by lead modification during the form grinding of internal helical gears, this paper proposes a twist error compensation method based on tooth surface accuracy measurement and machine tool motion correction. First, the generation mechanism of the twist error is analyzed. Through the calculation of the involute helicoid and the trajectory planning for lead modification, a mathematical model of the lead-modified internal helical gear surface is established. Subsequently, a kinematic model of the grinding process is developed, grounded in the spatial structure and feed motion relationships of the CNC form gear grinding machine. Based on this, the influence of machine feed motion errors on the tooth surface topological deviation is investigated, and a corresponding compensation strategy for the twist error is formulated. Finally, experimental grinding trials on internal helical gears were conducted. The measurement results of the tooth surface deviations demonstrate the validity and effectiveness of the proposed twist error compensation method. © 2026 by the authors. (28 refs)
Main heading: Error compensation
Controlled terms: Gear teeth - Grinding (machining) - Grinding machines - Helical gears - Kinematics
Uncontrolled terms: Accuracy measurements - CNC form gear grinding machine - Error compensation methods - Form grinding - Gear grinding machines - Internal helical gear - Lead modification - Surface accuracy - Teeth surface - Tooth surface twist

Classification Code: 601.2 Machine Components - 604.2 Machining Operations - 731.1.1 Error Handling - 942.2.3 Abrasive Devices and Processes - 1301.1.1 Mechanics
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Funding text: This research was funded by National Natural Science Foundation of China (52175049) and Henan Provincial Key Research and Development Program (251111241400, 241111221200) and the Major Science and Technology Program of Henan Province (241100220300).

Database: Compendex
Data Provider: Engineering Village

6. Research on 3D tooth flank topography of face-hobbed spiral bevel gears incorporating dynamic characteristics of machine tool

Huang, Kaifeng (1, 2); Fu, Chunming (1); Yu, Jianwu (2); Qian, Jun (3); Shang, Zhentao (2); Zhou, Jie (4)
Source: *Mechanical Systems and Signal Processing*, v 241, December 1, 2025; **ISSN:** 08883270, **E-ISSN:** 10961216; **DOI:** 10.1016/j.ymssp.2025.113476; **Article number:** 113476; **Publisher:** Academic Press
Author affiliation: (1) College of Mechanical Engineering, University of South China, Hengyang; 421001, China (2) College of Mechanical and Vehicle Engineering, Hunan University, Changsha; 410082, China (3) Department of Mechanical Engineering, KULeuven & Member Lfanders Make, Leuven; 3001, Belgium (4) Hunan Provincial Key Laboratory of Health Maintenance for Mechanical Equipment, Hunan University of Science and Technology, Xiangtan; 411201, China
Abstract: Cutting vibrations greatly influence the topography of the tooth flank and, in turn, the performance of spiral bevel gears. However, few studies have explored the tooth flank topography of face-hobbed spiral bevel gears, considering cutting vibrations, due to their complex geometrical features. This research fills this gap by thoroughly examining the principles of tooth formation for face-hobbed spiral bevel gears affected by cutting vibrations, using an efficient vectorization method based on gearing theory. The study highlights how cutting vibrations and the overall structural dynamic characteristics of the machine tool impact the tooth flank topography. It calculates the normal deviation between the machined tooth flank affected by cutting vibrations and the ideal tooth flank to predict the topography. Additionally, a data visualization technique is used to simulate the surface texture, followed by an image recognition method to verify the effectiveness and feasibility of the proposed tooth flank simulation. Ultimately, it was found that the relationship between the tooth passing frequency of cutting velocity and the natural frequency of the machine tool significantly influences the surface texture, mean value, maximum value, and variance of the machined tooth flank deviation. Notably, A lower tooth passing frequency of cutting velocity leads to a wider bandwidth of ghost order frequencies caused by tooth flank waviness. © 2025 Elsevier Ltd (47 refs)
Main heading: Bevel gears
Controlled terms: Cutting - Cutting tools - Gear teeth - Image recognition - Machine tools - Structural dynamics - Surface topography - Textures - Topography - Vibrations (mechanical)
Uncontrolled terms: Cutting velocity - Cutting vibration - Dynamics characteristic - Face hobbing - Flank topographies - Machining deviation - Performance - Spiral bevel gears - Surface textures - Tooth flank
Classification Code: 208 Coatings, Surfaces, Finishes, Films and Deposition - 214 Materials Science - 408 Structural Design - 601.2 Machine Components - 603 Machine Tools - 603.1 Machine Tool Accessories - 604.1 Metal Cutting - 1106.5 Computer Applications - 1301.1.1 Mechanics
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Database: Compendex
Data Provider: Engineering Village

7. Planet needle roller bearing with waviness effect in the planetary gear system: Nonlinear dynamic modeling and simulation

Shi, Zhifeng (1, 2, 3); Liu, Jing (4, 5); Xiao, Guijian (3)
Source: *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, v 239, n 8, p 2809-2822, April 2025; **ISSN:** 09544062, **E-ISSN:** 20412983; **DOI:** 10.1177/09544062241306661; **Publisher:** SAGE Publications Ltd
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of Technology, Lanzhou, China (3) College of Mechanical and Vehicle Engineering, Chongqing University, Chongqing, China (4) School of Marine Science and Technology, Northwestern Polytechnical University, Xi'an, China (5) Key Laboratory for Unmanned Underwater Vehicle, Northwestern Polytechnical University, Xi'an, China
Abstract: Planet needle roller bearings (PNRBs) are important components of the planetary gear system (PGS). Waviness exists in PNRB races and can alter the contact and vibration properties of PNRBs. To address this issue, a dynamic model of a PNRB in a PGS is provided using a lumped parameter technique, which includes the roller-cage interaction and waviness effect. The dynamic model takes into account the interactions between the rollers and cage pockets in each PNRB. Furthermore, the waviness model is constructed and included in the roller-race contact deformation. A case of PGS and its PNRBs is adopted to investigate the roller-race contact forces, roller-cage impact forces, and cage dynamic relationships. In particular, the waviness effects on the roller-cage forces and vibrations are discussed. The results demonstrate that waviness has a significant influence on impact force characteristics and affects PNRB vibrations. © IMechE 2024. (46 refs)
Main heading: Needles
Controlled terms: Digital elevation model - Epicyclic gears - Needle roller bearings - Rollers (machine components)
Uncontrolled terms: Dynamic model and simulation - Dynamics models - Impact force - Needle-roller bearing - Nonlinear dynamic models - Nonlinear dynamic simulation - Planet needle roller bearing - Planetary gear systems - Vibration - Waviness
Classification Code: 101.2 Biomedical Equipment - 213.6 Textile Mills, Machinery and Equipment - 601.2 Machine Components - 1106.2 Data Handling and Data Processing - 1106.3.1 Image Processing
Funding Details: Number: 51975068, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: 3102020HHZY030001, Acronym: -, Sponsor: Fundamental Research Funds for the Central Universities; Number: -, Acronym: -, Sponsor: Fundamental Research Funds for the Central Universities; Number: 24JRRA197, Acronym: -, Sponsor: -; Number: 2024G0262, Acronym: -, Sponsor: -;
Funding text: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was funded by the National Natural Science Foundation of China (No. 51975068), the Fundamental Research Funds for the Central Universities (No. 3102020HHZY030001), the Gansu Youth Science and Technology Fund Program (NO. 24JRRA197), the Wenzhou Basic Scientific Research Public Welfare Project (Grant No.2024G0262), and the Hongliu Excellent Young Talents Support Program of Lanzhou University of Technology.
Database: Compendex
Data Provider: Engineering Village

8. Analytical study on meshing performance of helical cylindrical gears with the coupling of tooth flank morphology and installation error (*Open Access*)

Liang, Chengcheng (1); Zhang, Yihao (1); Liu, Longhua (1); Liu, Ruijun (2)
Source: *Journal of Advanced Mechanical Design, Systems and Manufacturing*, v 19, n 4, 2025; **E-ISSN:** 18813054; **DOI:** 10.1299/jamdsm.2025jamdsm0037; **Article number:** jamdsm0037; **Publisher:** Japan Society of Mechanical Engineers
Author affiliation: (1) School of Mechatronics and Vehicle Engineering, East China Jiaotong University, Nanchang, Jiangxi Province, 808 Shuanggang East Street, Nanchang; 330013, China (2) Jiangxi Dongrui Intelligent Equipment Technology Co., LTD, 1299 Yingxiong Avenue, Nanchang; 330013, China
Abstract: This paper investigates the coupling mechanism between installation errors of helical cylindrical gears and tooth flank modification methods on meshing performance. Firstly, based on gear meshing principles, the tooth flank morphology adopts a tooth direction and tooth profile bidirectional composite modification method. Then, a finite element analysis model is established considering installation errors based on the modified tooth flank. Finally, the tolerance range for helical cylindrical gear modification under installation error is proposed according to meshing performance. The results show that the modification coefficients of lead crowning are selected from 0.2 μm to 4 μm and the peak-to-peak values of transmission error of 4 μrad and 6.7 μrad are the tolerance boundaries under the standard installation to ensure that the contact pattern area is within the range of 69% to 73%. The tolerance area selection is similar to standard installation with the axial displacement error. Under the axial angle error, the tooth profile direction cannot avoid the edge contact, and the modification tolerance area only selects the tooth direction and the modification curve corresponding to the proportion of root modification length ratio 10%. © 2025 The Japan Society of Mechanical Engineers. (17 refs)
Main heading: Errors
Controlled terms: Fits and tolerances - Gear teeth - Helical gears - Installation - Morphology
Uncontrolled terms: Analytical studies - Composite tooth flank modification - Helical cylindrical gear - Installation error - Meshing performance - Modification methods - Tolerance area - Tooth flank - Tooth flank modifications - Tooth profile
Classification Code: 214 Materials Science - 601 Mechanical Design - 601.2 Machine Components - 731.1.1 Error Handling - 912.1 Industrial Engineering
Funding Details: Number: 52405060, Acronym: NNSFC, Sponsor: National Natural Science Foundation of China; Number: 20242BAB20199, Acronym: -, Sponsor: Natural Science Foundation of Jiangxi Province; Number: 20244BCE52123, Acronym: -, Sponsor: -;

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Open Access type(s): All Open Access, Gold, Green
Database: Compendex
Data Provider: Engineering Village

9. Flexible Machining and Precision Control Method of Tooth Flank Topological Modification for Worm Wheel Gear Grinding (*Open Access*)

Han, Jiang (1, 2); Jiang, Hong (3); Lu, Yiguo (1, 2); Tian, Xiaoqing (1, 2); Xia, Lian (1, 2)
Source: *Jixie Gongcheng Xuebao/Journal of Mechanical Engineering*, v 61, n 17, p 360-370, September 5, 2025; **ISSN:** 05776686; **DOI:** 10.3901/JME.2025.17.360; **Publisher:** Chinese Mechanical Engineering Society
Author affiliation: (1) School of Mechanical Engineering, Hefei University of Technology, Hefei; 230009, China (2) Anhui Engineering Laboratory of Intelligent CNC Technology and Equipment, Hefei University of Technology, Hefei; 230009, China (3) School of Artificial Intelligence, Anhui University of Science and Technology, Huainan; 232000, China
Abstract: In order to solve the problem of tooth flank accuracy error that exists when grinding helical gears with worm wheel for topological modification, a topological modification method based on flexible electronic gearbox is proposed. First of all, according to the forming principle of involute tooth flank and topological modification curve, the mathematical models of standard involute tooth flank and double drum modification tooth flank are established. Secondly, the kinematic inverse solution method is applied to derive the additional motions of each axis corresponding to the topological modification tooth flank. Since the multi-axis linkage synchronization control of machine tool in the process of generating gear grinding is realized by the control of electronic gearbox, the additional motion amount is proposed to be added in the control model of electronic gearbox. Finally, numerical simulation of tooth flank modification is carried out to compare the tooth flank deviation obtained by traditional modification method and the tooth flank modification method based on flexible electronic gearbox through two numerical simulation examples. The results show that this method can effectively improve the tooth flank modification accuracy of gear grinding with worm wheel. © 2025, Assoc. of Mechanical Eng. and Technicians of Slovenia. All rights reserved. (21 refs)
Main heading: Numerical methods
Controlled terms: Gear teeth - Helical gears - Inverse kinematics - Inverse problems - Machine tools - Numerical models - Topology - Wheels - Worm gears
Uncontrolled terms: Electronic gearbox - Gear grinding - Modification methods - Precision control - Tooth flank - Tooth flank modifications - Topographical modifications - Topological modification - Worm wheel gear grinding - Worm wheels
Classification Code: 601.2 Machine Components - 603 Machine Tools - 1201 Mathematics - 1201.2 Calculus and Analysis - 1201.4 Applied Mathematics - 1201.9 Numerical Methods - 1201.14 Geometry and Topology - 1301.1.1 Mechanics
Open Access type(s): All Open Access, Gold
Database: Compendex
Data Provider: Engineering Village

10. Surface Topography and Tolerance Quality Evaluation of Polymer Gears Using Non-Contact 3D Scanning Method (*Open Access*)

Muratović, Enis (1); Muminović, Adis J. (1); Gierz, Lukasz (2); Smailov, Ilyas (3); Sydor, Maciej (4, 5); Dizdarević, Edin (6); Pervan, Nedim (1); Delić, Muamer (1)
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Abstract: The shift toward lightweight powertrain architectures necessitates a detailed characterization of polymer gears to verify their efficiency and durability. This study investigated the effectiveness of non-contact structured-light 3D scanning for evaluating the surface topography and dimensional tolerance quality of polymer gears produced via distinct manufacturing technologies. A structured-light 3D scanner was used to capture dense point clouds (exceeding 6 million points) of gears produced by three methods: conventional hobbing (POM-C), Material Extrusion (MEX) with carbon fiber reinforcement, and

Selective Laser Sintering (SLS). The manufactured parts were compared against the nominal Computer Aided Design (CAD) models to evaluate their geometrical deviations in accordance with DIN 3961 and surface roughness parameters per ISO 25178. The experimental results revealed a consistent ranking of manufacturing quality. The conventionally hobbed POM-C gear exhibited superior precision, achieving DIN quality grades of Q9–Q10 and the smoothest surface finish (Sa = 5.0 μm). Among additive manufacturing techniques, SLS-printed PA 12 showed intermediate quality (Q11, Sa = 12 μm), whereas MEX-printed PPS-CF exhibited significant deviations (exceeding Q12) and the highest surface irregularity (Sa = 25 μm) due to stair-stepping effects. These findings indicate that while additive manufacturing offers geometric flexibility, conventional hobbing retains a decisive advantage in dimensional precision. The optical scanning methodology demonstrated here constitutes an efficient metrological framework for gear quality control, with potential applications extending to the quality assurance of additively manufactured adaptive fixtures and assembly tooling, including automotive assembly operations. © 2026 by the authors. (71 refs)
Main heading: Quality control
Controlled terms: Additives - Assembly - Computer aided design - Fits and tolerances - Gear manufacture - Gears - Powertrains - Quality assurance - Surface analysis - Surface roughness - Topography
Uncontrolled terms: 3D-scanning - Adaptive tooling - Automotive assemblies - Hobbing - Involute gear - Non-contact - Polymer gear - Structured Light - Structured-light metrology - Tolerance grade
Classification Code: 208 Coatings, Surfaces, Finishes, Films and Deposition - 214 Materials Science - 601 Mechanical Design - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 662.3 Automobile Components and Materials - 663.2 Heavy Duty Motor Vehicle Components - 803 Chemical Agents and Basic Industrial Chemicals - 904 Design - 913.1 Production Engineering - 913.3 Quality Assurance and Control
Open Access type(s): All Open Access, Gold, Green
Database: Compendex
Data Provider: Engineering Village

11. Gear flank modification and precision control based on electronic gearbox

Tian, Xiao-Qing (1); Lu, Yi-Guo (1); You, Tong-Fei (1); Tang, Jian-Ping (1); Rui, Xiao-Yu (1); Li, Guang-Hui (1); Xia, Lian (1); Han, Jiang (1)
Source: *Journal of Central South University*, v 32, n 2, p 509-522, February 2025; **ISSN:** 20952899, **E-ISSN:** 22275223; **DOI:** 10.1007/s11771-025-5881-y; **Publisher:** Central South University
Author affiliation: (1) School of Mechanical Engineering, Hefei University of Technology, Hefei; 230009, China
Abstract: Gear flank modification is essential to reduce the noise generated in the gear meshing process, improve the gear transmission performance, and reduce the meshing impact. Aiming at the problem of solving the additional motions of each axis in the higher-order topology modification technique and how to accurately add the different movements expressed in the form of higher-order polynomials to the corresponding motion axes of the machine tool, a flexible higher-order gear topology modification technique based on an electronic gearbox is proposed. Firstly, a two-parameter topology gear surface equation and a grinding model of wheel grinding gears are established, and the axial feed and tangential feed are expressed in a fifth-order polynomial formula. Secondly, the polynomial coefficients are solved according to the characteristics of the point contact when grinding gears. Finally, an improved electronic gearbox model is constructed by combining the polynomial interpolation function to achieve gear topology modification. The validity and feasibility of the modification method based on the electronic gearbox are verified by experimental examples, which is of great significance for the machining of modification gears based on the continuous generative grinding method of the worm grinding wheel. © Central South University 2025. (24 refs)
Main heading: Grinding (machining)
Controlled terms: Grinding wheels - Interpolation - Mesh generation - Polynomials - Topology - Worm gears
Uncontrolled terms: Electronic gearbox - Flank modifications - Gear flank - Gear grinding - Grinding model - High-order - Higher-order - Polynomial interpolation - Topological modification - Topology modifications
Classification Code: 601.2 Machine Components - 604.2 Machining Operations - 942.2.3 Abrasive Devices and Processes - 1201.1 Algebra and Number Theory - 1201.2 Calculus and Analysis - 1201.8 Discrete Mathematics and Combinatorics, Includes Graph Theory, Set Theory - 1201.9 Numerical Methods - 1201.14 Geometry and Topology
Funding Details: Number: -, Acronym: -, Sponsor: Fundamental Research Funds for the Central Universities; Number: JZ2023HGPA0292, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China;
Funding text: Foundation item: Projects(52275483, 52075142, U22B2084) supported by the National Natural Science Foundation of China; Project (JZ2023HGPA0292) supported by the Fundamental Research Funds for the Central Universities of China
Database: Compendex
Data Provider: Engineering Village

12. Design and Calibration of a Single-Lens Telecentric Four-Camera Array Based on Planar Mirrors and Its Application in Strain Measurement (*Open Access*)

Zhang, Xu (1); Chen, Guo (2)
Source: *Sensors*, v 26, n 5, March 2026; **E-ISSN:** 14248220; **DOI:** 10.3390/s26051427; **Article number:** 1427; **Publisher:** Multidisciplinary Digital Publishing Institute (MDPI)
Author affiliation: (1) College of Civil Aviation, Nanjing University of Aeronautics and Astronautics, Nanjing; 210016, China (2) College of General Aviation and Flight, Nanjing University of Aeronautics and Astronautics, Liyang; 213300, China
Abstract: As the primary power transmission conduits, aircraft hydraulic pipelines are critical for actuating flight control surfaces and landing gear systems. Accurate in situ strain evaluation of these pipelines is essential, as installation-induced pre-loads directly compromise fatigue life and sealing performance, threatening overall system reliability. However, such evaluation is frequently hindered by the perspective distortions and limited depth of field inherent in conventional imaging systems. To overcome these metrological limitations, this study presents a novel virtual telecentric camera array system designed for high-precision, non-contact strain measurement. Unlike traditional pinhole models, the proposed system leverages a catadioptric setup with planar mirrors to create a virtual four-eye telecentric array from a single physical lens, ensuring constant magnification within the depth of field. A comprehensive simulation framework was established to rigorously compare the reprojection errors and scale accuracies between telecentric and pinhole projection models, quantitatively demonstrating the superior stability of the telecentric approach. Furthermore, a dedicated calibration strategy for non-overlapping telecentric fields of view was developed and validated. Experimental results from pipeline installation tests indicate a high concordance with strain gauge data, confirming that the proposed telecentric system effectively mitigates parallax errors and provides a robust solution for static and quasi-static micro-scale deformation monitoring in complex assembly environments. © 2026 by the authors. (19 refs)
Main heading: Strain measurement
Controlled terms: Calibration - Cameras - Electric power transmission - Errors - Fatigue of materials - Flight control systems - Gears - Geometrical optics - Imaging systems - Landing gear (aircraft) - Mirrors - Optical testing - Pipelines - Strain gages
Uncontrolled terms: Camera arrays - Error elimination - Perspective error elimination - Perspective errors - Pipeline assembly - Planar mirrors - Precision metrology - Telecentric imaging - Virtual camera - Virtual camera array
Classification Code: 214 Materials Science - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 610.1 Pipe, Piping, and Pipelines - 652.3 Aircraft Instruments and Equipment - 706.1.1 Electric Power Transmission - 731.1 Control Systems - 731.1.1 Error Handling - 741.1 Light/Optics - 741.3 Optical Devices and Systems - 742.2 Photographic and Video Equipment - 746 Imaging Techniques - 941.5 Mechanical Variables Measurements - 942.1.6 Mechanical and Miscellaneous Measuring Instruments - 1106.3.1 Image Processing
Funding Details: Number: -, Acronym: NUAA, Sponsor: Nanjing University of Aeronautics and Astronautics; Number: 52272436, Acronym: NNSFC, Sponsor: National Natural Science Foundation of China; Number: 2024Z071052005, Acronym: -, Sponsor: -;
Funding text: The authors acknowledge the support of the Foundation and the Intelligent Diagnosis and Expert System Laboratory of Nanjing University of Aeronautics and Astronautics.This work was supported by \u201Cthe National Natural Science Foundation of China\u201D [grant number 52272436] and \u201Cthe Aviation Foundation of China\u201D [grant number 2024Z071052005].
Open Access type(s): All Open Access, Gold, Green
Database: Compendex
Data Provider: Engineering Village

13. Binder Jetting of Gears: Evaluation of the Tooth Flank Load Capacity of Binder Jetting Gears Made of 17-4PH (*Open Access*)

Breuer, Emil-Elias (1); Klee, Lukas (1); Bergs, Thomas (1, 3); Davidovic, Mareike (1); Westphal, Christian (1, 2)
Source: *Forschung im Ingenieurwesen/Engineering Research*, v 89, n 1, December 2025; **ISSN:** 00157899, **E-ISSN:** 14340860; **DOI:** 10.1007/s10010-025-00908-w; **Article number:** 147; **Publisher:** Springer Vieweg
Author affiliation: (1) Manufacturing Technology Institute (MTI), Gear Department, RWTH Aachen University, Aachen, Germany (2) Laboratory for Machine Tools and Production Engineering, Gear Department, Chair of Machine Tools, RWTH Aachen University, Campus-Boulevard 30, Aachen; 52074, Germany (3) Fraunhofer Institute for Production Technology IPT, Steinbachstraße 17, Aachen; 52074, Germany
Abstract: Powder metallurgical gears are susceptible to failure due to tooth root fracture, mainly as a result of excessive bending stress. Consequently, Klee conducted research to determine the tooth bending strength of gears manufactured via Binder Jetting (Binder Jetting gears) made of 17-4PH stainless steel. Klee's research demonstrated that the tooth bending strength of Binder Jetting gears made of 17-4PH is approximately 30% inferior to that of conventionally manufactured gears made from the same wrought steel grade. However, to establish the Binder Jetting process in gear manufacturing, it is necessary to demonstrate the performance of Binder Jetting gears in terms of both their tooth bending strength and their tooth flank load capacity. The present work investigated the tooth flank load capacity of Binder Jetting gears made of 17-4PH. Furthermore, a classification of the performance achieved by the Binder Jetting gears in comparison to gears of

the same geometry conventionally manufactured from wrought 17-4PH was conducted. The evaluation of the tooth flank load capacity of Binder Jetting gears is based on the number of load cycles N achieved in back-to-back tests and the local tooth flank pressure pH. To calculate the local tooth flank pressure pH, the program tooth contact analysis (ZaKo3D) from the geartoolbox of the wzl gear research circle is used. The simulations are based on topography measurements of the tested gears to consider the load-induced deformation of the tooth flank topography. As detailed in the investigations, the number of load cycles N achieved by the Binder Jetting gears until failure due to pitting were comparable to those achieved by the reference gears. Furthermore, the calculated load cycles N50% for a failure probability of Pa#= 50% were N50%,BJT#= 8,028,772 LC for the BJT gears and N50%,Ref#= 9,505,924 LC for the reference gears and were therefore comparable. Finally, a further analysis of the experimental results was conducted to determine the local tooth flank stress (local tooth flank pressure pH) that led to the failure. It was found that the local tooth flank pressure pH of the BJT gears before pitting was lower than that of the reference gears. Thus, despite a similar number of load cycles N until failure, the BJT pinions have a lower flank load capacity. © The Author(s) 2025. (28 refs)
Main heading: Bending strength
Controlled terms: Binders - Fracture - Gear manufacture - Gear teeth - Outages - Spur gears - Steel research - Topography
Uncontrolled terms: Bending stress - Load capacity - Load cycle - Performance - Pittings - Powder metallurgical - Tooth bending strength - Tooth flank - Tooth root - Wrought steel
Classification Code: 202.5.3 Steel - 214 Materials Science - 214.1.2 Fatigue, Cracks and Fracture - 601.2 Machine Components - 706.1.2 Electric Power Distribution - 803 Chemical Agents and Basic Industrial Chemicals - 901.3 Engineering Research
Funding Details: Number: 49673496734156,BE2542/134-1, Acronym: DFG, Sponsor: Deutsche Forschungsgemeinschaft; Number: -, Acronym: DFG, Sponsor: Deutsche Forschungsgemeinschaft;
Funding text: The project is funded by the German Research Foundation (DFG) under the project number: 49673496734156, Ref.-Nr. BE2542/134\u20111. The project is funded by the Federal Ministry for Economic Affairs and Climate Protection on the basis of a\uooAodecision by the German Bundestag (funding code: AiF/FKM-FVA Nr. 989 I).The project is funded by the German Research Foundation (DFG) under the project number: 49673496734156, Ref.-Nr. BE2542/134\u20111. The project is funded by the Federal Ministry for Economic Affairs and Climate Protection on the basis of a decision by the German Bundestag (funding code: AiF/FKM-FVA Nr. 989 I).
Open Access type(s): All Open Access, Hybrid Gold, Green
Database: Compendex
Data Provider: Engineering Village

14. Failure Analysis and Improvement of the Worm Gear Pair Tooth Flank in Robotic Slewing Reducers*

Chen, Yan (1); Chen, Yonghong (2); Wang, Fang (1)
Source: *SAFEPROCESS 2025 - 14th CAA Symposium on Fault Detection, Supervision, and Safety for Technical Processes*, 2025, *SAFEPROCESS 2025 - 14th CAA Symposium on Fault Detection, Supervision, and Safety for Technical Processes*; **ISBN-13:** 9781665457507; **DOI:** 10.1109/SAFEPROCESS67117.2025.11268014; **Conference:** 14th CAA Symposium on Fault Detection, Supervision, and Safety for Technical Processes, SAFEPROCESS 2025, August 22, 2025 - August 24, 2025; **Publisher:** Institute of Electrical and Electronics Engineers Inc.
Author affiliation: (1) Chongqing Business Vocational College, Artificial Intelligence Academy, Chongqing, China (2) Chongqing University, State Key Laboratory of Mechanical, Transmissions for Advanced Equipment, Chongqing, China
Abstract: In response to the technical challenges of low transmission efficiency, failure to meet required output torque, severe adhesion and pulling marks on worm tooth surfaces in robotic slewing reducers for automated drilling equipment, this study investigated the causes of tooth surface failure in worm gears. A redesigned transmission pair was selected and corresponding mathematical models along with three-dimensional solid models were established. The tooth surface load-bearing characteristics of the hourglass worm gear pair under varying loads were analyzed using finite element method. A prototype robotic slewing reducer was developed and validated through contact pattern analysis and real-world operational testing. Analytical results demonstrate that the redesigned transmission pair achieves simultaneous engagement of up to 8 tooth pairs, with contact patterns exhibiting linear distribution from tooth crest to root evenly. The maximum equivalent stress on tooth surfaces remained significantly below the material yield strength under extreme loading conditions of 50,000 N•m. During one-month field testing, the prototype exhibited no tooth surface damage while maintaining required transmission efficiency and output torque specifications, thereby achieving successful industrial implementation. © 2025 IEEE. (10 refs)
Main heading: Drilling equipment
Controlled terms: Efficiency - Failure (mechanical) - Failure analysis - Finite element method - Gear teeth - Infill drilling - Robots - Stress analysis - Worm gears - Yield stress
Uncontrolled terms: Contact pattern - Output torque - Reducer - Surface damages - Technical challenges - Teeth surface - Tooth flank - Tooth surface damage - Transmission efficiency - Worm gear pair

Classification Code: 214 Materials Science - 214.1 Mechanical Properties of Materials - 214.1.1 Stress and Strain - 512.1.2 Petroleum Development Operations - 601.2 Machine Components - 603 Machine Tools - 731.5 Robotics - 913.1 Production Engineering - 1201.9 Numerical Methods
Funding text: This research was funded by the Science and TechnologyResearch Program of Chongqing Municipal Education Commission KJZDK202204401, KJON202404402), and Application Technology Promotion Center for Membrane Separation Environmental Control System (2023YJZX06)
Database: Compendex
Data Provider: Engineering Village

15. Effects of Load and Measurement Speed on Dynamic Measurement Process of Surface Morphology of Fe-Based Micro-Gears: A Molecular Dynamics Simulation

Chen, Song (1); Chen, Ming (1); Chen, Wei (1); Zhang, Xiaohong (1); Shi, Zhaoyao (2); Wei, Lei (1); Liu, Jiaming (1)
Source: *Journal of Materials Engineering and Performance*, v 35, n 14, p 13738-13745, April 2026; **ISSN:** 10599495, **E-ISSN:** 15441024; **DOI:** 10.1007/s11665-025-12616-1; **Publisher:** Springer
Author affiliation: (1) College of Mechanical Engineering, Hunan Institute of Science and Technology, Hunan, Yueyang; 414006, China (2) Beijing Engineering Research Center of Precision Measurement Technology and Instruments, College of Mechanical & Energy Engineering, Beijing University of Technology, Beijing; 100124, China
Abstract: Contact measurement plays a pivotal role in manufacturing and application of micro-gears. Nevertheless, conventional contact measurement techniques may result in data gaps at the tooth roots and induce measurement errors stemming from microscopic interactions. In this paper, the mechanism of the effects of the WC probe on the dynamic measurement of Fe-based micro-gears was investigated. The three-dimensional (3D) morphological changes were analyzed by using LAMMPS simulation software. Wear count and displacement, friction change rule, and mechanism of the Fe-based micro-gear surface during dynamic measurement under different loads and measurement speeds were studied. The local dislocation during the dynamic measurement was predicted. The results show that the height of the worn atom accumulation and the count of worn atoms on both edges of the wear scar decrease with the increase in the measurement speed under the same load. However, the height of the atom accumulation ahead of the probe increases, resulting in increased friction and the decrease in the count of worn atoms ahead of the probe. At a fixed measurement speed, both the overall stacking height of worn atoms and their total count increase with increasing load, thereby increasing the coefficient of friction. © ASM International 2026. (20 refs)
Main heading: Loading
Controlled terms: Atoms - Computer software - Friction - Gears - Load testing - Morphology - Probes - Speed regulators - Tribology - Wear of materials
Uncontrolled terms: Contact measurements - Dynamic measurement - Fe-based - Fe-based micro-gear - Load - Load speed - Measurement process - Measurement speed - Microgears - ON dynamics
Classification Code: 208 Coatings, Surfaces, Finishes, Films and Deposition - 214 Materials Science - 215.1.2 Mechanical Properties Testing Methods - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 606 Lubrication and Tribology - 691.2 Materials Handling Methods - 704.2 Electric Equipment - 732.1 Control Equipment - 801.3 Physical Chemistry - 1106.9 Computer Software - 1301.1.1 Mechanics - 1301.1.3 Atomic and Molecular Physics
Funding Details: Number: 52227809,52575059,52105055, Acronym: NNSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NNSFC, Sponsor: National Natural Science Foundation of China;
Funding text: This project was supported by the National Major Scientific Instruments and Equipments Development Project of National Natural Science Foundation of China (Grant No. 52227809) and National Natural Science Foundation of China (Grant No. 52575059 & No. 52105055).
Database: Compendex
Data Provider: Engineering Village

16. An uncertainty-guided contrastive learning method for OOD detection in trustworthy fault diagnosis

Lin, Fanwei (1, 2); Ren, Jiaxin (1, 2); Zhao, Zhibin (1, 2); Zhang, Xingwu (1, 2); Chen, Xuefeng (1, 2)
Source: *Reliability Engineering and System Safety*, v 267, March 2026; **ISSN:** 09518320; **DOI:** 10.1016/j.ress.2025.111967; **Article number:** 111967; **Publisher:** Elsevier Ltd
Author affiliation: (1) National Key Lab Aerospace Power System and Plasma Technology, Xi'an Jiaotong University, Shannxi, Xi'an; 710049, China (2) School of Mechanical Engineering, Xi'an Jiaotong University, Xi'an; 710049, China
Abstract: In the field of Prognostics Health Management (PHM), the "black-box" nature of deep learning-based intelligent fault diagnosis raises concerns about reliability in safety-critical applications. Traditional deterministic networks provide point estimates only, making them inadequate for quantifying prediction uncertainty and detecting out-of-distribution (OOD) samples. To address these limitations, this paper explicitly models feature representations as Gaussian distributions,

thereby preserving both predictive information and data-inherent uncertainty. Building on this foundation, we introduce a distribution-level contrastive learning strategy that enhances the separability between in-distribution and OOD samples while avoiding the challenge of negative pair selection in conventional contrastive learning. This joint design establishes a more reliable decision boundary and improves model trustworthiness. Experiments on two representative testbeds — the planetary gearbox and the main gearbox (MGB) — demonstrate that the proposed method not only achieves superior OOD detection but also maintains high in-distribution diagnostic accuracy under noisy conditions. These results highlight the method's potential for trustworthy deployment in real-world industrial fault diagnosis. Copyright © 2025. Published by Elsevier Ltd. (47 refs)
Main heading: Failure analysis
Controlled terms: Deep learning - Gears - Learning systems - Safety engineering - Uncertainty analysis
Uncontrolled terms: Black boxes - Deterministics - Faults diagnosis - Intelligent fault diagnosis - Learning methods - Out-of-distribution detection - Prognostic health managements - Safety critical applications - Uncertainty - Uncertainty quantifications
Classification Code: 214.1 Mechanical Properties of Materials - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 914 Safety Engineering - 942.2.2 Detectors and Sensing - 1101.2 Machine Learning - 1101.2.1 Deep Learning - 1202.1 Probability Theory
Database: Compendex
Data Provider: Engineering Village

17. Remaining Useful Life Prediction and Uncertainty Assessment of Wind Turbines

Chen, Xuanyu (1); Wu, Guoxin (2); Liu, Xiuli (1); Cui, Shuo (1); Jiang, Zhanglei (1)
Source: *IEEE Sensors Journal*, v 26, n 1, p 452-465, January 2026; **ISSN:** 1530437X, **E-ISSN:** 15581748; **DOI:** 10.1109/JSEN.2025.3628352; **Publisher:** Institute of Electrical and Electronics Engineers Inc.
Author affiliation: (1) Beijing Information Science and Technology University, Key Laboratory of Modern Measurement and Control Technology, Ministry of Education, Beijing; 100192, China (2) Beijing Information Science and Technology University, School of Mechanical and Electrical Engineering, Key Laboratory of Modern Measurement and Control Technology, Ministry of Education, Beijing; 100192, China
Abstract: Wind turbines (WTs) are vital to modern energy systems, with their stable operation influencing power generation efficiency and grid security. The gearbox, a critical component, requires accurate life prediction of its key rotating parts to ensure long-term reliability and minimize maintenance costs. This study addresses the challenges posed by complex degradation patterns under varying loads and the inherent uncertainties in life prediction. We propose a method for remaining useful life (RUL) prediction that enhances accuracy and quantifies uncertainty. A bidirectional long short-term memory (BiLSTM) network captures dynamic changes in monitoring signals, extracting degradation trends over time. A mixed local channel attention (MLCA) mechanism strengthens spatial feature learning, improving data representation. Additionally, a deep Gaussian process (DGP) model assesses prediction uncertainty, delivering precise RUL estimates. The approach was refined through ablation experiments using Xi'an Jiaotong University bearing dataset and validated via a life acceleration experiment on a WT gearbox. Results demonstrate that, compared to other methods, our method achieves a lower root-mean-square error (RMSE), offering a robust solution for high-precision gearbox life prediction. This work advances WT reliability by integrating deep learning and uncertainty quantification, providing a comprehensive tool for operational efficiency. © 2001-2012 IEEE. (35 refs)
Main heading: Wind turbines
Controlled terms: Deep learning - Forecasting - Gaussian distribution - Gears - Mean square error - Signal processing - Uncertainty analysis
Uncontrolled terms: Deep gaussian process - Energy systems - Gaussian Processes - Life predictions - Remaining useful life predictions - Stable operation - Uncertainty - Uncertainty assessment - Uncertainty quantifications - Wind turbine gearboxes
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 716.1 Information Theory and Signal Processing - 1008.5 Wind Power and Wind Power Generation - 1101.2.1 Deep Learning - 1202 Statistical Methods - 1202.1 Probability Theory - 1202.2 Mathematical Statistics
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Funding text: Received 29 September 2025; accepted 30 October 2025. Date of publication 12 November 2025; date of current version 30 December 2025. This work was supported in part by the National Natural Science Foundation of China under Grant 62303065 and in part by the \u201CQinxin Talents\u201D Program of Beijing University of Information Science and Technology under Grant QXTCPC202120. The associate editor coordinating the review of this article and approving it for publication was Prof. Rui Yuan. (Corresponding author: Xiuli Liu.) Xuanyu Chen, Xiuli Liu, Shuo Cui, and Zhanglei Jiang are with the Key Laboratory of Modern Measurement and Control Technology, Ministry of Education, Beijing Information Science and Technology University, Beijing 100192, China (e-mail: xuanyuc2023@163.com; liuxiulilw@163. com; 1317754704@qq.com; Jiang_Zhanglei@126.com).

Database: Compendex
Data Provider: Engineering Village

18. Deep learning-based dynamic error correction and uncertainty estimation for digital twin-assisted fringe projection profilometry of rotating gears

Li, Zhang Sheng (1); Qiu, Jian Cheng (1); Wu, Gao Xu (1)
Source: *arXiv*, November 30, 2025; **E-ISSN:** 23318422; **DOI:** 10.48550/arXiv.2512.00859; **Repository:** arXiv
Author affiliation: (1) Jiangxi University of Science and Technology, China
Abstract: This paper presents a deep learning-based method for dynamic gear measurement and uncertainty estimation. A digital twin system based on Unity is used to flexibly generate diverse simulated datasets, making it easy to obtain large amounts of simulation data for convenient verification of network performance, especially when real data is difficult to acquire. The proposed CD-DCU-Net integrates Concrete Dropout for pixel-wise uncertainty estimation and employs dual 3×3 convolutions in the output layer to enhance the spatial continuity of the predictions. During network training, a transfer learning strategy is adopted: the network is first pretrained with only a small amount of simulated data, and then further trained on the target dataset. In addition, a weighted loss function is introduced to better balance phase prediction accuracy and uncertainty estimation. Experimental results show that, compared with the traditional three-step phase-shifting (3-step PS) method, the proposed approach achieves significant improvements in phase prediction, 3D reconstruction accuracy, dynamic error correction, and uncertainty estimation, providing a practical and efficient solution for fringe projection measurement of gears. Copyright © 2025, The Authors. All rights reserved. (53 refs)
Main heading: Deep learning
Controlled terms: 3D reconstruction - Digital twin - Electromagnetic wave attenuation - Error correction - Forecasting - Gears - Learning systems - Profilometry - Projection systems - Transfer learning - Uncertainty analysis
Uncontrolled terms: Deep learning - Dynamic error - Dynamic measurement - Errors correction - Fringe projection - Gear measurements - Phase prediction - Phase-shifting - Three-step phase-shifting - Uncertainty estimation
Classification Code: 208 Coatings, Surfaces, Finishes, Films and Deposition - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 711.1 Electromagnetic Waves in Different Media - 731.1.1 Error Handling - 742.2 Photographic and Video Equipment - 1101.2 Machine Learning - 1101.2.1 Deep Learning - 1106.5 Computer Applications - 1106.8 Computer Vision - 1202 Statistical Methods - 1202.1 Probability Theory
Database: Compendex
Data Provider: Engineering Village

19. Automatic Calibration Strategy Based on Artificial Neural Networks for Shift Control of Automatic Transmission

Li, Songlin (1); Zhao, Yanle (2); Guo, Wei (2)
Source: *Applied Sciences (Switzerland)*, v 16, n 9, May 2026; **E-ISSN:** 20763417; **DOI:** 10.3390/app16094432; **Article number:** 4432; **Publisher:** Multidisciplinary Digital Publishing Institute (MDPI)
Author affiliation: (1) School of Transportation Science and Engineering, Beihang University, Beijing; 100191, China (2) Ningbo Institute of Technology, Beihang University, Ningbo; 315800, China
Abstract: As the number of gears in automatic transmissions (AT) increases, the calibration parameters in the gear shift control process of the transmission control unit (TCU) increase exponentially, significantly increasing the calibration workload during engineering development. To address the challenges of high cost and long cycle times associated with traditional manual calibration, this paper proposes an automatic calibration strategy for shift control based on artificial neural networks (ANNs). The core of this method lies in utilizing an ANN to establish a non-linear mapping relationship between shift characteristics and calibration parameters, thereby simulating and replacing the analysis and adjustment process of engineers. In this research, a vehicle simulation model based on a 9-speed automatic transmission (9AT) was first constructed. A large-scale dataset of shift characteristics was obtained by traversing various parameter combinations, and key features were extracted for model training. Simulation results demonstrate that the trained ANN model performs excellently in the automatic calibration process, requiring only 4 to 5 iterations to adjust shift quality to a level comparable to manual calibration. Its convergence speed and efficiency are significantly superior to traditional rule-based calibration methods. Furthermore, the model exhibits a certain degree of generalization ability and robustness across different throttle openings and gear-shifting conditions. The proposed automatic calibration method does not rely on high-precision physical models, effectively shortening the development cycle and improving calibration efficiency, which holds significant application value in the field of automatic transmission engineering development. © 2026 by the authors. (49 refs)
Main heading: Neural networks
Controlled terms: Calibration - Efficiency - Gear transmissions - Gears - Large datasets - Personnel training - Precision engineering - Vehicle transmissions

Uncontrolled terms: Automatic calibration - Automatic transmission - Calibration parameters - Gear shift control - Gear-shifts - Neural-networks - Rule based - Rule-based calibration - Shift characteristic - Shift controls
Classification Code: 101.1 Biomedical Engineering - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 602.2 Mechanical Transmissions - 662.3 Automobile Components and Materials - 901 Engineering Profession - 912.3 Personnel - 913.1 Production Engineering - 1101 Artificial Intelligence - 1106.2 Data Handling and Data Processing
Funding Details: Number: 52572429, Acronym: NSFC, NNSF, NNSFC, Sponsor: National Natural Science Foundation of China;
Funding text: This research was funded by the National Natural Science Foundation of China, grant number 52572429; Ningbo Yinzhou Technology Innovation Challenge Project, grant number 2025YZQ090011.
Database: Compendex
Data Provider: Engineering Village

20. Three-dimensional reconstruction of gearbox from multi-view point clouds with surface feature parfameter measurement method

Chen, Jian (1); Zhang, Zhijia (2); Liu, Guanghui (2); Li, Dejian (1); Li, Qiushuang (2)
Source: *Engineering Research Express*, v 7, n 4, December 31, 2025; **E-ISSN:** 26318695; **DOI:** 10.1088/2631-8695/ae1547; **Article number:** 045253; **Publisher:** Institute of Physics
Author affiliation: (1) School of Information Science and Engineering, Shenyang University of Technology, Shenyang, China (2) School of Artificial Intelligence, Shenyang University of Technology, Shenyang, China
Abstract: Accurate reconstruction of the three-dimensional (3D) information of a gearbox and precise acquisition of its surface features are crucial for ensuring coating quality. This paper proposes a method for 3D reconstruction of gearbox surface and measurement of characteristic parameters based on multi-view point clouds. A multi-view, multi-rotation visual acquisition system based on the kinect sensor was built to obtain comprehensive point cloud data of the workpiece model from six views. Then, the acquired point cloud data was preprocessed. Normal vector filtering(NF), Fruit fly optimization algorithm(FOA) modified point cloud erosion method and fast point feature histogram(FPFH) algorithm were applied for point cloud coarse registration, and generalized iterative closest point(GICP) method for accurate registration, thus completing point cloud 3D reconstruction. Subsequently, the contour, part height and curvature feature parameters of the reconstructed model were measured. Compared with ground-truth values, the method yields mean absolute errors of 6.47 mm for workpiece contour, 1.056 mm for part height, and 0.107 m–1 for surface curvature, with corresponding relative accuracies of 98.7%, 93.125%, and 97.426%, respectively, where accuracy denotes the percentage of the computed mean relative to the actual mean. This study demonstrates the feasibility of the proposed approach for gearbox surface characterization and supports further 3D reconstruction and quantitative analysis. However, the current validation is limited to six gearboxes under controlled laboratory conditions; future work will address more challenging industrial scenarios involving oil contamination, occlusion, and variable reflections. © 2025 IOP Publishing Ltd. All rights, including for text and data mining, AI training, and similar technologies, are reserved. (42 refs)
Main heading: Gears
Controlled terms: 3D reconstruction - Data mining - Image reconstruction - Iterative methods - Surface reconstruction - Three dimensional computer graphics
Uncontrolled terms: Feature parameters - Fly optimization algorithms - Measurement methods - Multi-views - Point cloud data - Point-clouds - Surface feature - Three-dimensional information - Three-dimensional reconstruction - Workpiece
Classification Code: 208 Coatings, Surfaces, Finishes, Films and Deposition - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 902.1 Engineering Graphics - 1106.2 Data Handling and Data Processing - 1106.2.1 Data Mining - 1106.3.1 Image Processing - 1106.8 Computer Vision - 1201.9 Numerical Methods
Funding Details: Number: 2024-BSLH-185, Acronym: -, Sponsor: -; Number: LJ212410142054, Acronym: -, Sponsor: Department of Education of Liaoning Province;
Funding text: This research was funded by the Joint Project of the Liaoning Provincial Science and Technology Plan (Natural Science Foundation Doctoral Research Initiation Project) (2024-BSLH-185) and the Basic Science Research Project of the Liaoning Provincial Department of Education (LJ212410142054).
Database: Compendex
Data Provider: Engineering Village

21. Bidimensional fuzzy-based propagation of interdependent uncertainty in pseudo-rigid multibody models of spur gears (*Open Access*)

D'Angelo, Luca (1); Cirelli, Marco (1); Valentini, Pier Paolo (1); Giannini, Oliviero (2)
Source: *Mechanism and Machine Theory*, v 216, November 15, 2025; **ISSN:** 0094114X; **DOI:** 10.1016/j.mechmachtheory.2025.106229; **Article number:** 106229; **Publisher:** Elsevier Ltd

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Abstract: In gear analysis, pseudo-rigid multibody models offer a strategic compromise between accuracy and computational efficiency. However, these models are characterized by parameters affected by epistemic uncertainty, which is often neglected. This work proposes a bidimensional fuzzy representation to quantify such uncertainty while explicitly accounting for physical correlations between key parameters, such as joint positions and elastic element values. The approach is applied to both quasi-static and dynamic analyses. In the static case, fuzzy membership levels of static transmission error consistently enclose finite element results across three torque levels, whereas assuming independent uncertainties leads to a misleading overestimation of the output uncertainty. In the dynamic case, the model reveals a progressive widening of the uncertainty band around resonance, linked to nonlinear jump phenomena and dynamic hysteresis. However, experimental results from the literature fall within the fuzzy zero-level envelopes, verifying the model's predictive capabilities. This bidimensional fuzzy framework provides a physically consistent and computationally efficient tool for uncertainty quantification in geartrain simulations. Its generality makes it applicable to other multibody systems with physically linked uncertainties, enhancing simulation interpretability and guiding the need for higher-fidelity modeling. © 2025 (40 refs)
Main heading: Computational efficiency
Controlled terms: Fuzzy models - Gear teeth - Spur gears - Uncertainty analysis
Uncontrolled terms: Epistemic uncertainties - Fuzzy uncertainties - Gear dynamics - Gear tooth contacts - Multi-body - Multi-body modelling - Pseudo rigid bodies - Pseudo-rigid-body - Transmission error - Uncertainty
Classification Code: 601.2 Machine Components - 1101 Artificial Intelligence - 1102.1 Computer Theory, Includes Computational Logic, Automata Theory, Switching Theory, Programming Theory - 1202.1 Probability Theory
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Open Access type(s): All Open Access, Hybrid Gold
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22. Multi-objective Optimization of Profile and Flank Line Crowning Modification Parameters for a Spur Planetary Gear Drive Using Uniform Design, Entropy-weighted TOPSIS, and Thin-plate Spline Interpolation (*Open Access*)

Lee, C.K. (1)
Source: *Journal of Physics: Conference Series*, v 3044, n 1, 2025; **ISSN:** 17426588, **E-ISSN:** 17426596; **DOI:** 10.1088/1742-6596/3044/1/012008; **Article number:** 012008; **Conference:** 9th International Conference on Mechanical, Aeronautical and Automotive Engineering, ICMAA 2025, April 2, 2025 - April 4, 2025; **Publisher:** Institute of Physics
Author affiliation: (1) Department of Industrial Engineering and Management, Cheng Shiu University, 840 Chengcing Rd., Kaohsiung, Taiwan
Abstract: Gear tooth modification is a pivotal process for improving performance, enhancing durability, and reducing noise in gear systems. This research focuses on optimizing the profile and flank line crowning modification parameters in an NGW involute spur planetary gear drive. A multi-objective optimization framework, integrating uniform design, entropy-weighted TOPSIS, thin-plate spline interpolation, and the Nelder-Mead simplex method, achieves significant advancements in performance metrics. Key outcomes include substantial reductions in peak-to-peak transmission error and system power loss, as well as notable improvements in safety factors and transmission efficiency. The proposed methodology offers a robust and systematic approach for optimizing gear modification parameters, providing broad applicability to complex mechanical systems. Future studies could explore extensions to other gear configurations and evaluate long-term performance under varying operating conditions. © Published under licence by IOP Publishing Ltd. (10 refs)
Main heading: Interpolation
Controlled terms: Electric power transmission - Entropy - Epicyclic gears - Gear teeth - Gear trains - Gear transmissions - Multiobjective optimization - Safety factor - Splines - Spur gears - Transmissions
Uncontrolled terms: Gear system - Gear tooth modification - Improving performance - Multi-objectives optimization - Performance enhancing - Planetary gear drive - Reducing noise - Spline interpolation - Thin plate spline - Uniform design
Classification Code: 302.1 Thermodynamics - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 602.2 Mechanical Transmissions - 661 Automotive Engines and Related Equipment - 662.3 Automobile Components and Materials - 706.1.1 Electric Power Transmission - 914 Safety Engineering - 914.1 Accidents and Accident Prevention - 1201.7 Optimization Techniques - 1201.9 Numerical Methods

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23. A vision-based measurement method for small-module gears using asymmetric Gaussian fitting and phase-angle analysis

Jing, Yuan (1, 2); Hu, Lin (2); Xian, Wang (1)
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Abstract: Pitch and profile deviations in small-module gears are key factors affecting transmission performance. To overcome the instability of traditional vision-based measurements caused by blurred edges and abnormal points, this paper proposes a unified vision-based measurement method combining asymmetric Gaussian integral fitting with phase-angle analysis. The proposed approach achieves robust sub-pixel localization using an asymmetric Gaussian integral model and establishes a unified phase-angle parameter space for both pitch and profile deviations, enabling their simultaneous extraction and stable computation. Simulation experiments under varying noise levels demonstrate that the proposed sub-pixel method achieves higher localization accuracy than conventional Gaussian integral and symmetric double-Gaussian approaches. Tests on virtual standard gear images verify that measurement errors for both pitch and profile deviations remain within 1 μm. In practical tests on Small-module gears, the method shows good consistency with coordinate measuring machine (CMM) results, with maximum differences of 2.6 μm in total profile deviation, 2.6 μm in form deviation, 3.5 μm in slope deviation, and within 1 μm for both the single-pitch deviation and the cumulative pitch deviation. The uncertainty analysis reveals an expanded uncertainty of approximately 4.5 μm, which is mainly attributed to the intrinsic geometric characteristics of the gear flanks. These results demonstrate that the proposed method enables integrated, high-precision measurement of both pitch and profile deviations within a single measurement system, providing a feasible and efficient solution for micro-gear inspection. © 2026 (46 refs)
Main heading: Pixels
Controlled terms: Computer vision - Coordinate measuring machines - Edge detection - Gaussian distribution - Gears - Geometry - Power transmission
Uncontrolled terms: Gear measurements - Machine-vision - Micro-gear measurement - Microgears - Phase angles - Pitch deviation - Profile deviations - Subpixel edge detection - Uncertainty - Vision-based measurements
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 602.2 Mechanical Transmissions - 942.1.7 Special Purpose Instruments - 1106.3.1 Image Processing - 1106.8 Computer Vision - 1201.14 Geometry and Topology - 1202.1 Probability Theory - 1202.2 Mathematical Statistics
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24. Multi-tooth contact analysis of rough-flank hypoid gears based on non-uniform rational B-splines

Yang, Ji-Xuan (1); Yang, Hong-Bo (2); Chen, Zhi-Yong (1); Shi, Wen-Ku (1); Song, Hai-Sheng (3)
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Abstract: In this study, a tooth flank modelling and contact analysis method for hypoid bevel gears is introduced using the non-uniform rational B-splines (NURBS) surface-fitting technique. Based on the effect of weighting factor variations on NURBS geometry, the local tooth-fitting accuracy is optimised while maintaining acceptable computational complexity. The simulations of meshing characteristic and flank micro-modification is conducted. The computational model for the loaded tooth contact analysis (LTCA) of a gear pair incorporates tangential friction at the contact point, and the influence

of the friction one simulation results is thoroughly examined. Additionally, an iterative method is employed to extend the single-tooth LTCA to multi-tooth scenarios, which enables the calculation of tooth load distribution at a lower computational cost. The transmission error, meshing stiffness, and contact area obtained using the proposed rough-flank LTCA (R-LTCA) model agree better with experimental measurements than the results of finite-element simulation. The findings indicate that proposed R-LTCA method outperforms the finite-element method in terms of simulation accuracy and computation cost. © 2025 (46 refs)
Main heading: Bevel gears
Controlled terms: Computational geometry - End effectors - Finite element method - Friction - Gear teeth - Iterative methods - Splines - Tribology
Uncontrolled terms: Bench tests - Elastic frictional contact - Frictional contact - Hypoid bevel gear - Loaded tooth contact analysis - Multi-tooth meshing - Non uniform rational B-spline surface - Tooth meshing - Transmission error - Transmission error bench test
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 606 Lubrication and Tribology - 731.5 Robotics - 1201.5 Computational Mathematics - 1201.8 Discrete Mathematics and Combinatorics, Includes Graph Theory, Set Theory - 1201.9 Numerical Methods - 1201.14 Geometry and Topology - 1301.1.1 Mechanics
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25. Design and analysis of cycloid planetary gears with transmission error-based flank modification for smaller gear ratios

Tsai, Shyi-Jeng (1); Cho, Pei-Chen (1); Chen, Yi-Hwa (1); Chang, Ling-Chiao (2); Zhuang, Qi-You (1)
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Abstract: Cycloid planetary gear reducers are widely used due to their high reduction ratio, large contact ratio, high load capacity, and compact size. However, at speed ratios of 10 to 15, their transmission performance declines, particularly when using a tooth number difference (TND) of one. To address this, an optimized tooth profile modification method is proposed to enhance the transmission performance of cycloid planetary gear reducers with a TND of one. Unlike conventional approaches, this study introduces a novel modification approach based on a predetermined transmission error of the mechanism. This method employs a parameterized logarithmic function and incorporates additional tip/root relief. A loaded contact analysis model, considering bearing clearance, is used to evaluate the effects of modification parameters on contact characteristics. Two case studies are conducted: a comparative study assessing conventional and new modification methods, and a demonstration study analyzing the effects of bearing clearance and tip/root relief in an 11-tooth cycloid gear. The results highlight improvements in contact ratio, load distribution, and transmission errors under real working conditions. The analysis results demonstrate that using the proposed approach enhances cycloid gear reducers with 11 teeth by increasing the contact ratio and reducing contact stresses, bearing loads, and transmission errors. The impact of bearing clearance remains minimal. It enables the development of cycloid gear reducers with fewer teeth, expanding their applicable speed ratios while maintaining improved transmission performance. © Der/die Autor(en), exklusiv lizenziert an Springer-Verlag GmbH Deutschland, ein Teil von Springer Nature 2025. (26 refs)
Main heading: Errors
Controlled terms: Epicyclic gears - Gear teeth - Gear transmissions
Uncontrolled terms: Bearing clearance - Contact ratio - Cycloid gears - Gear reducers - Modification methods - Planetary Gears - Speed ratio - Tooth number - Transmission error - Transmission performance
Classification Code: 601.2 Machine Components - 602.2 Mechanical Transmissions - 662.3 Automobile Components and Materials - 731.1.1 Error Handling
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