1. Positioning of a material sensor in a splined shaft (*Open Access*)

Quanz, Markus (1); Gansel, René (2); Krahl, Sören (1); Schäfer, Günter (1); Barton, Sebastian (2); Maier, Hans Jürgen (2); Lohrengel, Armin (1)
Source: *Forschung im Ingenieurwesen/Engineering Research*, v 89, n 1, December 2025; **ISSN:** 00157899, **E-ISSN:** 14340860; **DOI:** 10.1007/s10010-025-00847-6; **Article number:** 89; **Publisher:** Springer Vieweg
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Abstract: To evaluate the load condition and remaining service life of a splined shaft, a material sensor can be utilized to determine the experienced torsional loads. There are several options for its placement. The stresses occurring in the material sensor and in the splined shaft depend on the position of the material sensor and on other geometric characteristics of the shaft-hub connection, including the number of teeth, the root radius, and, for hollow shafts, the bore diameter. To estimate the maximum stresses in the material sensor and the splined shaft, a calculation model is presented. This model can also be used to convert the stresses in the material sensor to the maximum stress in the splined shaft. The model is validated by comparisons with numerical simulations, which show a high level of agreement. © The Author(s) 2025. (29 refs)
Uncontrolled terms: Geometric characteristics - Hollow shafts - Integrating machines - Load condition - Machine element - Material sensor - Maximum stress - Sensor integrating machine element - Splined shaft - Torsional loads
Funding Details: Number: 466760574, Acronym: DFG, Sponsor: Deutsche Forschungsgemeinschaft; Number: -, Acronym: DFG, Sponsor: Deutsche Forschungsgemeinschaft;
Funding text: This study was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)\u2014Project number 466760574. The project is part of the SPP 2305 with the project number 441853410. The authors thank the DFG for the financial support.
Open Access type(s): All Open Access, Hybrid Gold
Database: Compendex
Data Provider: Engineering Village

2. Axial load of vibratory thru-feed rolling process for involute splined shaft

Liu, Dazhou (1, 3); Cao, Yangfeng (1, 3); Ren, Hengwang (1, 3); Wang, Yongfei (1, 2, 3); Zhao, Shengdun (1, 2, 3)
Source: *International Journal of Advanced Manufacturing Technology*, v 136, n 5, p 2493-2506, January 2025; **ISSN:** 02683768, **E-ISSN:** 14333015; **DOI:** 10.1007/s00170-025-15011-1; **Publisher:** Springer Science and Business Media Deutschland GmbH
Author affiliation: (1) School of Mechanical Engineering, Xi'an Jiaotong University, Xi'an; 710049, China (2) National Key Laboratory of Metal Forming Technology and Heavy Equipment, Xi'an; 710049, China (3) Xi'an Key Laboratory of Intelligent Equipment and Control, Xi'an; 710049, China
Abstract: A novel vibratory thru-feed rolling process for involute splined shaft was proposed and validated on a prototype equipped with a resonant module. The effects of lubricating medium, vibration frequency, and vibration amplitude on axial load were investigated. Through experimental analysis with the nonlinear surface fitting method, the optimum process parameters were determined to be a vibration frequency of 41 Hz, amplitude of 0.5 mm, and oil lubrication. An additional experimental validation was performed under these optimal conditions, resulting in a 39.06% reduction in axial load compared to the condition with neither vibration nor lubrication. Furthermore, the dimensional accuracy and mechanical properties were still within the requirements. Specifically, the grain size was refined by 56.54%, residual compressive stress increased by 143%, and hardness improved by 31%. © The Author(s), under exclusive licence to Springer-Verlag London Ltd., part of Springer Nature 2025. (40 refs)
Main heading: Splines
Controlled terms: Compressive stress - Rolling - Shafts (machine components)
Uncontrolled terms: Experimental analysis - Forming loads - Nonlinear surface - Rolling process - Splined shaft - Tool wear - Vibration amplitude - Vibration frequency - Vibration vibrations - Vibratory forming
Classification Code: 201.5.1 Metal Rolling - 214.1.1 Stress and Strain - 601.2 Machine Components - 602 Mechanical Drives and Transmissions
Funding Details: Number: S2308100.W08, Acronym: -, Sponsor: -; Number: 390D9EDA, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China;
Funding text: This work was supported by the National Key Laboratory of Metal Forming Technology and Heavy Equipment [No. S2308100.W08] and the National Natural Science Foundation of China [No. 390D9EDA].
Database: Compendex
Data Provider: Engineering Village

3. Design and development of a load-sensitive autonomous splined shaft with material sensors, integrated evaluation unit, wireless data transmission and energy harvesting (*Open Access*)

Gansel, René (1); Quanz, Markus (2); Heinrich, Christian (2); Zwoch, Stefan (1); Schäfer, Günter (2); Barton, Sebastian (1); Maier, Hans Jürgen (1); Lohrengel, Armin (2)
Source: *Forschung im Ingenieurwesen/Engineering Research*, v 89, n 1, December 2025; **ISSN:** 00157899, **E-ISSN:** 14340860; **DOI:** 10.1007/s10010-025-00909-9; **Article number:** 145; **Publisher:** Springer Vieweg
Author affiliation: (1) Institut für Werkstoffkunde (Materials Science), Leibniz Universität Hannover, An der Universität 2, Garbsen; 30823, Germany (2) Institut für Maschinenwesen (Mechanical Engineering), Technische Universität Clausthal, Robert-Koch-Str. 32, Clausthal-Zellerfeld; 38678, Germany
Abstract: This article summarises the main research findings of the first funding period of the project "Load sensitive spline shaft with sensory material", which is part of the DFG Priority Programme 2305 "Sensor-Integrated Machine Elements Pave the Way for Widespread Digitalization". In the present project, the combination of a load-sensitive material sensor and eddy current testing is used for load monitoring. The splined shaft was designed as a hollow shaft and has an integrated evaluation unit that enables eddy current testing, data evaluation and wireless data transmission via LoRaWAN. The required energy is provided by an integrated generator. Functional verification of the load monitoring was performed by testing the splined shaft under alternating torsional loads. © The Author(s) 2025. (47 refs)
Main heading: Energy harvesting
Controlled terms: Eddy currents - Electric load management - Load testing - Splines
Uncontrolled terms: Austenitic stainless - Eddy-current testing - Energy - Integrated evaluation - Load monitoring - Load-sensitive - Material sensor - Overload monitoring - Splined shaft - Wireless data transmission
Classification Code: 215.1.2 Mechanical Properties Testing Methods - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 701.1 Electricity: Basic Concepts and Phenomena - 706.1.2 Electric Power Distribution - 1009 Energy Management
Funding Details: Number: -, Acronym: DFG, Sponsor: Deutsche Forschungsgemeinschaft;
Funding text: This work is intended to provide an overview of the subproject of the first funding period within the DFG Priority Programme 2305 and is structured according to the procedure described.This study was funded by the German Research Foundation (Ger. Deutsche Forschungsgemeinschaft, DFG)\u2014Project number 466760574 with the title \u201CLoad sensitive spline shaft with sensory material\u201D. The project is part of the SPP 2305 with the project number 441853410. The authors thank the DFG for financial support.
Open Access type(s): All Open Access, Hybrid Gold
Database: Compendex
Data Provider: Engineering Village

4. Rolling torque of vibratory thru-feed rolling process for involute splined shaft

Liu, Dazhou (1, 3); Ren, Hengwang (1, 3); Cao, Yangfeng (1, 3); Wang, Yongfei (1, 2, 3); Zhao, Shengdun (1, 2, 3)
Source: *International Journal of Advanced Manufacturing Technology*, v 136, n 7, p 3491-3504, February 2025; **ISSN:** 02683768, **E-ISSN:** 14333015; **DOI:** 10.1007/s00170-025-15052-6; **Publisher:** Springer Science and Business Media Deutschland GmbH
Author affiliation: (1) School of Mechanical Engineering, Xi'an Jiaotong University, Xi'an; 710049, China (2) National Key Laboratory of Metal Forming Technology and Heavy Equipment, Xi'an; 710049, China (3) Xi'an Key Laboratory of Intelligent Equipment and Control, Xi'an; 710049, China
Abstract: A novel vibratory thru-feed rolling process for involute splined shafts was introduced and experimentally validated. The effects of lubricating medium, vibration frequency, and vibration amplitude on rolling torque were investigated and analyzed. Through experimental analysis and the use of a non-linear surface fit method, optimum process parameters were determined as 40 Hz for frequency and 0.5 mm for amplitude under oil lubrication. An additional experimental validation under these optimum conditions showed that rolling torque was reduced by 26.14%, providing a further decrease of 12.45% compared to the best results obtained without vibration. Moreover, the dimensional precision and mechanical performance remained within the specified requirements. In particular, the grain size underwent a refinement of 50.75%, residual compressive stress was improved by 145.44%, and hardness increased by 30.22%. © The Author(s), under exclusive licence to Springer-Verlag London Ltd., part of Springer Nature 2025. (44 refs)
Main heading: Vibration analysis
Controlled terms: Compressive stress - Lubrication - Rolling - Shafts (machine components) - Splines
Uncontrolled terms: Experimental analysis - Forming loads - Rolling process - Rolling torque - Splined shaft - Tool wear - Vibration amplitude - Vibration frequency - Vibration vibrations - Vibratory forming
Classification Code: 201.5.1 Metal Rolling - 214.1.1 Stress and Strain - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 606.2 Lubrication - 941.5 Mechanical Variables Measurements
Funding Details: Number: S2308100.W08, Acronym: -, Sponsor: -; Number: 390D9EDA, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China;

Funding text: This work was supported by the National Key Laboratory of Metal Forming Technology and Heavy Equipment [No. S2308100.W08] and the National Natural Science Foundation of China [No. 390D9EDA].
Database: Compendex
Data Provider: Engineering Village

5. Dynamic modeling and analysis of a shaft system with the floating spline and angular misalignment

Li, Xinbin (1, 2); Xu, Yajun (1, 2); Liu, Jing (1, 2); Liu, Jianyu (1, 2); Pan, Guang (1, 2); Shi, Zhifeng (3)
Source: *Mechanical Systems and Signal Processing*, v 249, April 2026; **ISSN:** 08883270, **E-ISSN:** 10961216; **DOI:** 10.1016/j.ymssp.2026.114058; **Article number:** 114058; **Publisher:** Academic Press
Author affiliation: (1) School of Marine Science and Technology, Northwestern Polytechnical University, Xi'an; 710072, China (2) Laboratory for Unmanned Underwater Vehicle, Northwestern Polytechnical University, Xi'an; 710072, China (3) School of Mechanical and Electrical Engineering, Lanzhou University of Technology, Lanzhou; 730050, China
Abstract: Floating splines are widely used in aerospace and marine power transmission systems. The angular misalignment is one primary form of misalignment in the floating splined shaft systems. Most previous works ignored the spline tooth meshing stiffness (TMS) variations caused by the meshing point differences along the tooth width direction, which did not comprehensively consider the combined influences of additional radial forces, axial force, and torque induced by the angular misalignment. These issues may reduce the accuracy of the calculated dynamics for floating splined shaft systems. Therefore, a spline force model including six-directional excitations induced by the angular misalignment is presented. Moreover, a meshing force calculation model considering the meshing point changes along the tooth width direction is proposed. The accuracy of the proposed spline force model and the floating splined shaft dynamic model is validated by the experiments. Then, the influence of angular misalignment on the dynamics of the floating splined shaft system is analyzed. The underlying mechanisms are also investigated. © 2026 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies. (44 refs)
Main heading: Dynamic analysis
Controlled terms: Alignment - Data mining - Dynamic models - Dynamics - Electric power transmission - Interpolation - Splines - Stiffness
Uncontrolled terms: Angular misalignment - Dynamics analysis - Dynamics models - Excitation force - Floating splined shaft system - Force modeling - Meshing stiffness - Modelling and analysis - Shaft system - Spline excitation force
Classification Code: 214 Materials Science - 215.1.2 Mechanical Properties Testing Methods - 601.1 Mechanical Devices - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 706.1.1 Electric Power Transmission - 1106.2.1 Data Mining - 1201.9 Numerical Methods - 1301.1.1 Mechanics - 1301.7 Statistical and Nonlinear Physics
Funding Details: Number: -, Acronym: NPU, Sponsor: Northwestern Polytechnical University; Number: 524B2151,52525111, Acronym: NNSF, Sponsor: National Natural Science Foundation of China;
Funding text: Support provided by the National Natural Science Foundation of China under Contract No. 524B2151 and 52525111; and Innovation Foundation for Doctor Dissertation of Northwestern Polytechnical University.
Database: Compendex
Data Provider: Engineering Village

6. Dimensional Accuracy Analysis of Splined Shafts and Hubs Obtained by Fused-Deposition Modeling 3D Printing Using a Genetic Algorithm and Artificial Neural Network (*Open Access*)

Rizea, Alin-Daniel (1); Banică, Cristina-Florena (2); Georgescu, Tatiana (2); Sover, Alexandru (3); Anghel, Daniel-Constantin (1)
Source: *Applied Sciences (Switzerland)*, v 15, n 7, April 2025; **E-ISSN:** 20763417; **DOI:** 10.3390/app15073958; **Article number:** 3958; **Publisher:** Multidisciplinary Digital Publishing Institute (MDPI)
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Abstract: Splined assemblies ensure precise torque transmission and alignment in mechanical systems. Three-dimensional printing, especially FDM, enables fast production of customized components with complex geometries, reducing material waste and costs. Optimized printing parameters improve dimensional accuracy and performance. Dimensional accuracy is a critical aspect in the additive manufacturing of mechanical components, especially for splined shafts and hubs, where deviations can impact assembly precision and functionality. This study investigates the influence of key FDM 3D printing parameters—layer thickness, infill density, and nominal diameter—on the dimensional deviations of splined components. A full factorial experimental design was implemented, and measurements were conducted using a high-precision coordinate measuring machine (CMM). To optimize dimensional accuracy, artificial neural networks (ANNs) were trained using

experimental data, and a genetic algorithm (GA) was employed for multi-objective optimization. Three ANN models were developed to predict dimensional deviations for different parameters, achieving high correlation coefficients (R2 values of 0.961, 0.947, and 0.910). The optimization process resulted in an optimal set of printing conditions that minimize dimensional errors. The findings provide valuable insights into improving precision in FDM-printed splined components, contributing to enhanced design tolerances and manufacturing quality. © 2025 by the authors. (32 refs)
Main heading: Fused Deposition Modeling
Controlled terms: Interpolation - Layered manufacturing - Multilayer neural networks - Shafts (machine components) - Splines
Uncontrolled terms: 3-D printing - 3D-printing - Accuracy analysis - Deposition modeling - Dimensional accuracy - Dimensional deviation - FDM 3d printing - Neural-networks - Splined shaft and hub - Torque transmission
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 745.2 Reproduction, Copying - 913.4 Manufacturing - 1101 Artificial Intelligence - 1201.9 Numerical Methods
Open Access type(s): All Open Access, Gold, Green
Database: Compendex
Data Provider: Engineering Village

7. Modeling hysteresis behavior of spline coupling and its application in rotodynamic prediction

Yu, Pingchao (1, 2); Jiang, Ke (1); Jin, Yize (1); Zhang, Jiae (1); Xiang, Zhenyang (1)
Source: *Mechanical Systems and Signal Processing*, v 230, May 1, 2025; **ISSN:** 08883270, **E-ISSN:** 10961216; **DOI:** 10.1016/j.ymssp.2025.112598; **Article number:** 112598; **Publisher:** Academic Press
Author affiliation: (1) College of Civil Aviation, Nanjing University of Aeronautics and Astronautics, Nanjing; 211106, China (2) Key Laboratory of Civil Aircraft Health Monitoring and Intelligent Maintenance, Nanjing; 211106, China
Abstract: In aeronautical applications, spline couplings are widely used and often exhibit hysteretic behavior under non-synchronous whirl conditions. This behavior significantly influences the vibration characteristics of rotor systems. However, existing research has paid insufficient attention to the hysteretic mechanisms of spline couplings and lacks a deep understanding of the dynamic characteristics of spline rotor systems with complex structural features. In this paper, we propose a novel analytical model that accounts for the contact-slip behavior of engaging teeth to predict the nonlinear hysteretic characteristics of spline couplings. Model's high accuracy and computational efficiency are validated through comparison with the finite element (FE) results. Based on this analytical model, the nonlinear stiffness, damping, and contact characteristics of spline couplings are further revealed. Subsequently, a dynamic model and analysis process for spline rotor systems are developed by incorporating the nonlinear stiffness and damping of spline couplings. Finally, the nonlinear vibrations of spline rotor systems are discussed. Results indicate that as lateral load increases, the stiffness of spline coupling decreases while its loss factor increases. This behavior is closely related to the normal contact and tangential slip of engaging teeth. Due to the nonlinearity of spline coupling, splined rotor systems exhibit phenomena such as leftward shifts in critical speeds, complex frequency contents, and self-excited vibrations. © 2025 Elsevier Ltd (46 refs)
Main heading: Vibration analysis
Controlled terms: Damping
Uncontrolled terms: Aeronautical applications - Condition - Hysteresis behavior - Hysteretic behaviour - ITS applications - Non-linear stiffness - Nonlinear damping - Rotor systems - Self-excited vibrations - Spline couplings
Classification Code: 941.5 Mechanical Variables Measurements - 1301.1.1 Mechanics
Funding Details: Number: 2022#M711615 , Acronym: -, Sponsor: -; Number: 52372387, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: BK20211187, Acronym: -, Sponsor: Natural Science Foundation of Jiangsu Province; Number: -, Acronym: -, Sponsor: Natural Science Foundation of Jiangsu Province; Number: NJ2024022, Acronym: -, Sponsor: -; Number: xcxjh20240721, Acronym: NUAA, Sponsor: Nanjing University of Aeronautics and Astronautics; Number: -, Acronym: NUAA, Sponsor: Nanjing University of Aeronautics and Astronautics;
Funding text: The authors would like to acknowledge the financial support from the National Natural Science Foundation of China (Grant Nos. 52372387), the Open Funds for Key Laboratory of Civil Aircraft Health Monitoring and Intelligent Maintenance (NJ2024022), and the Postdoctoral Science Foundation Project (Grant No. 2022\u202F M711615), Jiangsu Province Natural Science Foundation (Grant No. BK20211187), and Postgraduate Research & Practice Innovation Program of NUAA (xcxjh20240721).
Database: Compendex
Data Provider: Engineering Village

8. Effective simplified analytical and FEM models for load-bearing capacity of unconventional metal-composite shaft joint (*Open Access*)

Kazda, Lukas (1); Novotny, Ctirad (2)
Source: *Journal of Composite Materials*, v 60, n 4, p 369-384, February 2026; **ISSN:** 00219983, **E-ISSN:** 1530793X; **DOI:** 10.1177/00219983251362312; **Publisher:** SAGE Publications Ltd
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Abstract: Composite-metal joints are usually implemented in the form of adhesive joints as there are well established best practices and theories of how to model them. In some cases, using the conventional method such as adhesive joint isn't desirable, be it due to external environment or other factors. For the purpose of connecting two parts of a joint shaft (steel constant-velocity joint and fiber-reinforced polymer tube), a splined coupling was considered. The connection consists of a steel shaft with small splines on the contact surface with its FRP counterpart. The FRP tube has a smooth cylindrical surface and the steel splines cut into this material during a press-fitting process. This connection is referred to as the press-fitted spline joint (PFSJ). This paper presents a simplified yet surprisingly well-functioning analytical model of such a joint that calculates the damage of the joint and its torque capacity based on dimensions and materials. This model utilizes the theory of thick-walled cylinders, the classical lamination theory, and the Hashin damage criteria. Furthermore, a FEM model was proposed to verify the analytical model and to study the joint in more detail. Lastly, the models were compared to the data from the static torsion test. The most time-efficient and yet trustworthy way to model the behavior of the PFSJ is to use the slip-dependent friction model. The more precise way is to employ the exponential traction-separation law coupled with friction, which on the other hand converges slowly than the sole friction model. © The Author(s) 2025. This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (https://creativecommons.org/licenses/by-nc/4.0/) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access page (https://us.sagepub.com/en-us/nam/open-access-at-sage). (44 refs)
Main heading: Fiber reinforced plastics
Controlled terms: Adhesive joints - Adhesives - Analytical models - Bridge decks - Friction - Presses (machine tools) - Splines - Steel fibers - Torsion testing
Uncontrolled terms: Composite shafts - FEM models - Friction modeling - FRP - Load-bearing capacity - Metal composites - Metal joints - Press fitting - Spline joints - Splined joint
Classification Code: 205.1 Polymeric Materials - 210 Adhesive Materials - 213.4 Fiber Products - 215.1.2 Mechanical Properties Testing Methods - 401.1 Bridges - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 603 Machine Tools - 1201.12 Modeling and Simulation - 1301.1.1 Mechanics
Funding Details: Number: TN02000054, Acronym: -, Sponsor: Technology Agency of the Czech Republic;
Funding text: The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research has been realized using the support of Technological Agency, Czech Republic, program National Competence Centres, project # TN02000054 Božek Vehicle Engineering National Center of Competence (BOVENAC).
Open Access type(s): All Open Access, Hybrid Gold
Database: Compendex
Data Provider: Engineering Village

9. Dynamic modelling of a floating spline-coupling shaft system with parallel misalignment and tooth backlash

Li, Xinbin (1, 2); Xu, Yajun (1, 2); Liu, Jing (1, 2); Liu, Jianyu (1, 2); Pan, Guang (1, 2); Shi, Zhifeng (3)
Source: *Mechanical Systems and Signal Processing*, v 226, March 1, 2025; **ISSN:** 08883270, **E-ISSN:** 10961216; **DOI:** 10.1016/j.ymssp.2025.112363; **Article number:** 112363; **Publisher:** Academic Press
Author affiliation: (1) School of Marine Science and Technology, Northwestern Polytechnical University, Xi'an; 710072, China (2) Laboratory for Unmanned Underwater Vehicle, Northwestern Polytechnical University, Xi'an; 710072, China (3) School of Mechanical and Electrical Engineering, Lanzhou University of Technology, Lanzhou; 730050, China
Abstract: Floating splines are widely used in various shaft systems with high installation difficulty. The spline couplings' stiffness characteristics significantly affect the shaft system dynamics. Most previous works have focused on ordinary spline-coupling shaft system dynamic modeling and ignored the effect of internal spline fillet-foundation deflection on the spline coupling stiffness. Thus, an improved stiffness calculation method of spline coupling considering internal spline fillet-foundation deflection is proposed in this work. The meshing force considering parallel misalignment and tooth backlash, and the parallel misalignment force are given. Then, the floating spline-coupling shaft system dynamic model with parallel misalignment and tooth backlash is established. An experiment is conducted to validate the accuracy of the proposed floating spline-coupling shaft system dynamic model. The results obtained from the proposed method and finite element (FE) models are compared. Moreover, the results obtained using the proposed method and other works are compared. Finally, the effects of parallel misalignment on the spline meshing force and spline coupling-shaft system dynamics are

investigated. This work helps in accurate floating spline-coupling shaft system dynamic modeling and can provide guidance for diagnosing parallel misalignment error. © 2025 (43 refs)
Main heading: Deflection (structures)
Controlled terms: Digital elevation model - Splines
Uncontrolled terms: Coupling shafts - Dynamics models - Floating spline-coupling shaft system - Internal spline fillet-foundation deflection - Internal splines - Parallel misalignment - Shaft system - Spline couplings - System dynamics modelling - Teeth stiffness
Classification Code: 408.1 Structural Members and Shapes - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 1106.2 Data Handling and Data Processing - 1106.3.1 Image Processing
Funding Details: Number: 524B2151,52175120, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China;
Funding text: Support provided by the National Natural Science Foundation of China under Contract No. 524B2151 and 52175120, and Innovation Foundation for Doctor Dissertation of Northwestern Polytechnical University.
Database: Compendex
Data Provider: Engineering Village

10. Tooth damage analysis with coupled wear and fatigue for spline coupling under combined high-low cycle fatigue

Xiao, Li (1); Chen, Zhigang (2); Luo, Tenglang (1); Zhang, Ning (1); Yu, Wei (1); Wang, Zhongrong (3); Xue, Xiangzhen (1)
Source: *Engineering Failure Analysis*, v 185, March 1, 2026; **ISSN:** 13506307; **DOI:** 10.1016/j.engfailanal.2025.110405; **Article number:** 110405; **Publisher:** Elsevier Ltd
Author affiliation: (1) College of Mechanical and Electrical Engineering, Shaanxi University of Science and Technology, Shaanxi, Xi'an; 710021, China (2) AECC Hunan Aviation Powerplant Research Institute, Hunan, Zhuzhou; 412002, China (3) AECC Sichuan Gas Turbine Turbine Establishment, Sichuan, Chengdu; 610500, China
Abstract: Spline coupling widely used in aerospace drive devices suffers early tooth damage failure, resulting in power instability and shortened life cycle, etc. This problem is particularly significant in heavy-duty and high-power aero-engine and helicopter transmission with combined high and low cycle fatigue (CCF) conditions. To investigate the tooth damage behavior, this work presents a numerical method of tooth damage coupled wear and fatigue considering elastic-plasticity mechanics for spline coupling. Specifically, the modified tooth wear model based on energy model and the CCF damage criterion by combining HCF and LCF damage are established within the unified continuous damage mechanics (CDM) framework. The results show that the LCF damage considering plastic behavior is severely weakened by tooth wear, while the HCF damage considering elastic behavior is further developed by tooth wear. Tooth wear is regarded as the main failure mode of spline coupling under CCF load condition, instead of fatigue damage failure. The evolution of tooth wear is regulated by contact pressure, shear stress and tooth sliding parameters, and the tooth wear depth increases variously and unsteadily in different load cycles. These findings provide theoretical guidance for life prediction of spline coupling. © 2025 (62 refs)
Main heading: Numerical methods
Controlled terms: Elasticity - Elastoplasticity - Electric power transmission - Fatigue damage - Life cycle - Low-cycle fatigue - Outages - Plasticity - Shear flow
Uncontrolled terms: Continuous damage mechanics - Cycle fatigue - Damage analysis - Damage failures - Drive devices - High-low - Low cycle fatigues - Spline couplings - Teeth damage - Wear and fatigue
Classification Code: 214 Materials Science - 214.1.1 Stress and Strain - 214.1.3 Elasticity, Plasticity, Creep and Deformation - 301.1.5 Flow of Fluid-Like Materials - 706.1.1 Electric Power Transmission - 706.1.2 Electric Power Distribution - 913.1 Production Engineering - 1201.9 Numerical Methods
Funding Details: Number: 52405068, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: Y2022-IV-0001, Acronym: -, Sponsor: National Science and Technology Major Project; Number: -, Acronym: -, Sponsor: National Science and Technology Major Project; Number: 2025JC-YBMS-503, Acronym: -, Sponsor: Natural Science Foundation of Shaanxi Province; Number: -, Acronym: -, Sponsor: Natural Science Foundation of Shaanxi Province; Number: 2024, Acronym: -, Sponsor: -;
Funding text: The work is financially supported by National Natural Science Foundation of China (NSFC) through Grant No. 52405068 , National Science and Technology Major Project through Grant Y2022-IV-0001 , National Natural Science Foundation of Shaanxi (2025JC-YBMS-503), and and Youth Innovation Team of Shaanxi Universities (2024). The authors would like to acknowledge the editors and the anonymous reviewers for their valuable comments and suggestions.
Database: Compendex
Data Provider: Engineering Village

11. Numerical Modeling and Nonlinear Mechanism Analysis of Spline Coupling Stiffness Considering Contact Surface Friction

Jiang, Ke (1); Yu, Pingchao (1, 2); Yan, Xunjin (3); Zheng, Huaqiang (4); Jiang, Zihan (1); Tao, Xuanjun (1)
Source: *Zhongguo Jixie Gongcheng/China Mechanical Engineering*, v 37, n 2, p 332-341, February 25, 2026; **ISSN:** 1004132X; **DOI:** 10.3969/j.issn.1004-132X.2026.02.008; **Publisher:** Chinese Mechanical Engineering Society
Author affiliation: (1) College of Civil Aviation, Nanjing University of Aeronautics and Astronautics, Nanjing; 210016, China (2) Key Laboratory of Civil Aviation Aircraft Health Monitoring and Intelligent Maintenance, Nanjing University of Aeronautics and Astronautics, Nanjing; 210016, China (3) Nantong Airport Group Co. Ltd, Jiangsu, Nantong; 226371, China (4) AECC Hunan Aviation Powerplant Research Institute, Hunan, Zhuzhou; 412002, China
Abstract: Taking the flexible spline coupling structure of an engine as the research object, a contact-friction model was introduced at the meshing points of all shaft segment in the spline coupling. Combined with the geometric relationships of the structure, force equilibrium conditions, and numerical iteration methods, a modeling and calculation approach for the nonlinear stiffness of the spline couplings was proposed. The high solving efficiency and accuracy of the proposed calculation method were validated through comparisons with ANSYS finite element model results and experimental results. Using the proposed method, detailed analyses were conducted on the nonlinear stiffness characteristics of the spline couplings and the influence patterns of key parameters. The intrinsic mechanism of the nonlinear stiffness variation was revealed by combining the changing patterns of contact states in the meshing tooth pairs. Results indicate that the stiffness of the spline coupling structures gradually decreases with the increasing linear displacement, while the decreasing rate progressively diminishes. The reduction in contact area of meshing teeth during this process was identified as the fundamental cause of the stiffness degradation. The stiffness of the spline couplings shows improvement with the increase of the friction coefficient, the meshing stiffness, the spline width, and the applied torque. Among these parameters, the torque exhibits the most significant influence. © 2026, Chinese Mechanical Engineering Society. All rights reserved. (9 refs)
Main heading: Numerical models
Controlled terms: End effectors - Flexible couplings - Friction - Interpolation - Iterative methods - Numerical methods - Splines - Stiffness - Tribology
Uncontrolled terms: Contact friction - Contact-friction model - Coupling structures - Friction modeling - Model mechanisms - Non-linear stiffness - Nonlinear mechanisms - Spline connection - Spline couplings - Stiffness characteristics
Classification Code: 214 Materials Science - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 602.2 Mechanical Transmissions - 606 Lubrication and Tribology - 731.5 Robotics - 1201.4 Applied Mathematics - 1201.9 Numerical Methods - 1301.1.1 Mechanics
Database: Compendex
Data Provider: Engineering Village

12. Replacement of the Pinion Shaft by a Split Shaft-Hub Connection with Justification for the Choice of Connection Type

Plugovoy, V.V. (1); Kireev, S.O. (1); Korchagina, M.V. (1); Lebedev, A.R. (1)
Source: *Springer Proceedings in Materials*, v 3, p 665-678, 2025; **ISSN:** 26623161, **E-ISSN:** 2662317X; **DOI:** 10.1007/978-3-031-87677-6_56; **Publisher:** Springer
Author affiliation: (1) Don State Technical University, Rostov-On-Don, Russia
Abstract: One of the most important elements of hydraulic fracturingHydraulic fracturing equipment are pumping unitsPumping unit. Mechanical transmissionsMechanical transmission of various types and gearing are often used to transmit force from the power unit to the operating unit. One of the fundamental parts in mechanical transmissions is often the pinion shaftPinion shaft. The pinion shaft offers several advantages over the bevel gear, but it is not without its disadvantages. The alternatives for replacing the bevel gear with a pinion shaftPinion shaft are the following types of connection: keyed, splined and profile. The aim of the study is to replace the pinion shaft with a split shaft-to-sleeve type connection with justification of the choice of the type of connection. In the present work, profile joints of shaft-stub type have been analyzed. A calculation methodology for this type of profile connectionProfile connection has been created. A verification calculation for bucklingBuckling of keyed and splined joints has been performed. According to the resultsResult of the conducted research of the profile joint with an oval hole for shaft fit, the conclusions are made that the greater the range of distances within which it is possible to change the larger diameter of the oval at a given value of the maximum torque, the less the arising contact stresses and displacements in the joint. In the result of the study of replacing the pinion shaftPinion shaft with a split joint of the shaft-hub type, the diagrams of contact stresses and displacements in the keyed, splined and profile joints at a given value of maximum torque were constructed and analyzed at a given value of maximum torque. © The Author(s), under exclusive license to Springer Nature Switzerland AG 2025. (23 refs)
Main heading: Hydraulic fracturing
Controlled terms: Bevel gears - Hydraulic machinery - Pumping plants - Shaft displacement
Uncontrolled terms: Contact Stress - Keyed connection - Maximum torque - Mechanical transmission - Pinion shaft - Profile connections - Pumping unit - Shaft hub - Spline connection - Stress and displacements

Classification Code: 446 Waterworks - 512.1.2 Petroleum Development Operations - 601.2 Machine Components - 601.3 Mechanisms - 602.1 Mechanical Drives - 1401.2 Hydraulic Equipment and Machinery
Database: Compendex
Data Provider: Engineering Village

13. Dynamic modelling and vibration analysis of parallel misaligned shaft system considering the spline time-varying meshing point

Li, Xinbin (1, 2); Liu, Jianyu (1, 2); Liu, Jing (1, 2); Xu, Yajun (1, 2); Pan, Guang (1, 2); Shi, Zhifeng (3)
Source: *Mechanical Systems and Signal Processing*, v 241, December 1, 2025; **ISSN:** 08883270, **E-ISSN:** 10961216; **DOI:** 10.1016/j.ymssp.2025.113425; **Article number:** 113425; **Publisher:** Academic Press
Author affiliation: (1) School of Marine Science and Technology, Northwestern Polytechnical University, Xi'an; 710072, China (2) Laboratory for Unmanned Underwater Vehicle, Northwestern Polytechnical University, Xi'an; 710072, China (3) School of Mechanical and Electrical Engineering, Lanzhou University of Technology, Lanzhou; 730050, China
Abstract: Involute spline couplings see extensive use in shaft system connections. In reality, parallel misalignment can cause changes in the meshing point positions of spline teeth. However, most previous works assume that parallel misalignment will not notably change the spline tooth meshing point position. This is unreasonable because the time-varying meshing position (TVMP) will alter the spline meshing force (SMF) and significantly affect the shaft system vibrations. Thus, a TVMP calculation model is derived in this paper. The spline tooth time-varying backlash and pressure angle models considering the TVMP are proposed. Moreover, the spline meshing stiffness (SMS) and deformation models considering TVMP are given. Furthermore, a shaft system dynamic model considering the TVMP is established. Spline meshing characteristics and shaft system vibrations verification experiments are carried out. A comparison of SMFs obtained by the methods with and without considering TVMP is conducted to highlight the importance of considering TVMP. Finally, the influence of parallel misalignment and rotating speed on the shaft system vibrations is evaluated. This paper can provide parallel misalignment control insights for the shaft system. © 2025 (41 refs)
Main heading: Dynamic models
Controlled terms: Alignment - Interpolation - Splines - Vibration analysis
Uncontrolled terms: Dynamic vibration - Dynamics models - Involute spline coupling - Involute splines - Parallel misalignment - Shaft system - Spline couplings - System vibrations - Time varying - Time-varying meshing point
Classification Code: 601.1 Mechanical Devices - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 941.5 Mechanical Variables Measurements - 1201.9 Numerical Methods - 1301.7 Statistical and Nonlinear Physics
Funding Details: Number: -, Acronym: NWPU, Sponsor: Northwestern Polytechnical University; Number: 524B2151,52525111, Acronym: NNSF, Sponsor: National Natural Science Foundation of China; Number: 24JRRA197, Acronym: -, Sponsor: -;
Funding text: Support provided by the National Natural Science Foundation of China under Contract No. 524B2151 and 52525111 , Innovation Foundation for Doctor Dissertation of Northwestern Polytechnical University , and the Gansu Youth Science and Technology Fund Program (NO. 24JRRA197).
Database: Compendex
Data Provider: Engineering Village

14. Analysis of Influencing Factors on the Stability of Supercritical Shaft Systems with Floating Spline Connection

Zhang, Lan (1); Song, Liyao (1); Xu, Kechang (1); Ding, Jiawei (1); Li, Jiangjian (2); Cao, Peng (3); Zhu, Rupeng (1); Wang, Dan (1); Chen, Weifang (1)
Source: *International Journal of Structural Stability and Dynamics*, 2025; **ISSN:** 02194554, **E-ISSN:** 17936764; **DOI:** 10.1142/S0219455427501409; **Article number:** 2750140; **Publisher:** World Scientific, Article in Press
Author affiliation: (1) National Key Laboratory of Science and Technology on Helicopter Transmission, Nanjing University of Aeronautics and Astronautics, Nanjing; 210016, China (2) Changhe Aircraft Industries Corporation Ltd, Jingdezhen; 360200, China (3) National Key Laboratory of Science and Technology on Helicopter Transmission, AECC Hunan Aviation, Powerplant Research Institute, Zhuzhou; 412002, China
Abstract: To enhance the stability of supercritical tail drive systems and prevent instability caused by self-excited vibrations in floating spline-connected drive systems under supercritical operating conditions, this study thoroughly investigates the correlation mechanism between key sensitive parameters and shaft system stability. A hybrid modeling approach combining the finite element method and the lumped mass method was employed to establish a dynamic model of the supercritical shaft system with floating spline connections, and its accuracy was validated through experiments. Based on Floquet theory, the influence of factors such as tooth surface lubrication conditions, load conditions on shaft system stability, and fitting clearance of the positioning segment on shaft system stability was analyzed. The results indicate that an increase in the tooth surface friction coefficient can induce instability in the supercritical tail drive shaft system, whereas increasing torque

and reducing the fitting clearance of the positioning segment significantly suppresses shaft system instability. © 2027 World Scientific Publishing Company. (18 refs)
Main heading: Friction
Controlled terms: Finite element method - Interpolation - Splines - System stability - Vibrations (mechanical)
Uncontrolled terms: Floating spline - Self-excited vibrations - Shaft system - Stability analyze - Supercritical - Supercritical shaft system - Supercritical shafts - System's stabilities - Tail drive system - Teeth surface
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 961 Systems Science - 1201.9 Numerical Methods - 1301.1.1 Mechanics
Database: Compendex
Data Provider: Engineering Village

15. 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
Open Access type(s): All Open Access, Gold
Database: Compendex
Data Provider: Engineering Village

16. Precision Surface Finishing and Functional Performance Enhancement of Spline Shaft Using Magnetorheological Process

Singh, Manpreet (1, 2, 3)
Source: *JOM*, 2026; **ISSN:** 10474838, **E-ISSN:** 15431851; **DOI:** 10.1007/s11837-026-08157-0; **Publisher:** Springer, Article in Press
Author affiliation: (1) Baba Farid College of Engineering & Technology Bathinda, Punjab, Bathinda; 151001, India (2) Chitkara University Institute of Engineering and Technology, Punjab, Rajpura; 140401, India (3) Applied Science Research Centre, Applied Science Private University, Amman; 11931, Jordan
Abstract: The lifespan of a spline shaft during its operation is significantly affected by how pressure is distributed across its surface. Achieving a consistently smooth finish on the teeth of the spline shaft is highly beneficial because it promotes a uniform distribution of pressure. This uniformity helps to minimize stress concentrations, which typically lead to increased wear and a longer lifespan for the shaft. This study focuses on using a new magnetorheological (MR) method to finely finish the surface of spline shafts. A single electromagnetic MR finishing setup, using interchangeable tool cores, processes both the external and internal profiles of the spline shaft. Response surface methodology (RSM) was used to optimize process parameters for achieving the desired fine finish. Significant results were obtained: the external profile's surface roughness

was reduced from 0.27μm to 0.02 μm, and the internal profile's surface roughness was improved from 0.3 μm to 0.029 μm. To further evaluate the effectiveness of this MR finishing process, tests were conducted to analyze the surface characteristics and microhardness of the spline shaft. The findings indicate that the MR finishing process improves pressure distribution and extends the service life of the spline shaft. © The Minerals, Metals & Materials Society 2026. (27 refs)
Main heading: Surface roughness
Controlled terms: Finishing - Splines - Surface treatment
Uncontrolled terms: Finishing process - Functional performance - Lifespans - Magnetorheological - Magnetorheological finishing - Performance enhancements - Precision surface - Spline shafts - Surface finishing - Surface functional
Classification Code: 208 Coatings, Surfaces, Finishes, Films and Deposition - 208.1 Coating Techniques - 601.2 Machine Components - 602 Mechanical Drives and Transmissions
Database: Compendex
Data Provider: Engineering Village

17. Flow field design and process parameter experiments in electrochemical machining of involute internal spline (*Open Access*)

Huang, Yi (1, 2); Xu, Yan (2); Fang, Cong (3); Gong, Senlin (4); Wang, Xi (1); Speidel, Alistair (5); Chen, Xiaolong (5); Liu, Fengyuan (2)
Source: *International Journal of Advanced Manufacturing Technology*, v 143, n 5-6, p 2451-2471, March 2026; **ISSN:** 02683768, **E-ISSN:** 14333015; **DOI:** 10.1007/s00170-025-17366-x; **Publisher:** Springer Science and Business Media Deutschland GmbH
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Abstract: Machining complex internal structures in high-hardness materials poses significant challenges, as conventional cutting methods often suffer from excessive tool wear and extended production cycles. This study introduces a hybrid approach that combines rough electrochemical machining (ECM) with precision slotting to efficiently shape involute internal splines in intricate high-hardness components. To enhance electrolyte distribution and stabilize the spline ECM process, the electrolyte flow direction was first evaluated to identify the most effective orientation. Based on this preliminary assessment, three flow field optimisation methods—guided flow head, cathode working teeth, and circular rectifier—were developed and validated through simulation. Experimental setups featured two distinct cathode designs and a dedicated ECM fixture and system. Key process parameters, including electrolyte concentration and composition, machining voltage, and cathode feed rate, were experimentally evaluated to determine optimal conditions for spline ECM. The results demonstrated that an electrolyte concentration of 8% $NaNO_3$, a machining voltage of 12 V, and a cathode feed rate of 3.0 to 3.5 mm/min yielded optimal outcomes. Following precision slotting, the maximum tooth profile deviation was 20.7 μm and the maximum helical deviation was 8.5 μm, both meeting target accuracy requirements. Furthermore, the cumulative processing time per piece remained under 1 h, achieving high precision and efficiency in shaping semi-blind hole involute internal splines. This study provides valuable insights into flow field design and process parameter optimisation in spline ECM, highlighting the potential of this combined process for the scalable production of intricate internal cavity components from hard-to-machine materials. © The Author(s) 2026. (32 refs)
Main heading: Splines
Controlled terms: Cathodes - Cutting tools - Electric discharge machining - Electrochemical cutting - Electrolytes - Flow fields - Hardness - Slotting - Vanadium compounds
Uncontrolled terms: Cathode design - Design parameters - Electrochemical machining - Electrolyte concentration - Feedrate - Flow field simulation - Flow-field design - Internal splines - Process parameters
Classification Code: 202.3.6 Vanadium and Alloys - 214.1 Mechanical Properties of Materials - 301.1 Fluid Flow - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 603.1 Machine Tool Accessories - 604.1 Metal Cutting - 604.2 Machining Operations - 702.1 Electric Batteries - 714.1 Electron Tubes - 801.3.1 Electrochemistry - 802.2 Chemical Reactions - 804.2 Inorganic Compounds
Funding Details: Number: 2020YFB1713503, Acronym: NKRDPC, Sponsor: National Key Research and Development Program of China; Number: -, Acronym: NKRDPC, Sponsor: National Key Research and Development Program of China; Number: 20720190009, Acronym: -, Sponsor: Fundamental Research Funds for the Central Universities; Number: -, Acronym: -, Sponsor: Fundamental Research Funds for the Central Universities;
Funding text: This work was supported by the National Key Research and Development Project (2020YFB1713503) and the Fundamental Research Funds for the Central Universities under Grant (No. 20720190009).
Open Access type(s): All Open Access, Hybrid Gold, Green
Database: Compendex
Data Provider: Engineering Village

18. A modified dynamic model of rotor systems with spline coupling considering misalignment

Jiang, Yifan (1); Wang, Yifan (2); Hou, Lei (1); Zhang, Tao (2); Zhang, Zhibin (2); Zhang, Minghe (2); Lin, Rongzhou (1); Jin, Yuhong (1); Song, Jinzhou (1)
Source: *Engineering Failure Analysis*, v 170, March 15, 2025; **ISSN:** 13506307; **DOI:** 10.1016/j.engfailanal.2024.109251; **Article number:** 109251; **Publisher:** Elsevier Ltd
Author affiliation: (1) School of Astronautics, Harbin Institute of Technology, Harbin; 150001, China (2) Beijing Power Machinery Institute, Beijing; 100074, China
Abstract: This paper presents a modified modeling method for rotor systems connected by spline coupling. The new approach divides the spline coupling into multiple elements, and the nonlinear meshing forces of each element are directly incorporated into the system's dynamic model rather than being simplified into analytical stiffness, thus avoiding additional calculations and making the spline coupling model more refined. Based on the established dynamic model of the rotor system connected by spline coupling, the study investigates the system's amplitude-frequency characteristics, rotor orbits, and time histories, as well as the effects of rotational speed on meshing forces across the meshing teeth of the spline coupling's elements. Additionally, the study considers both parallel and angular misalignments of the spline coupling, examining their impact on the rotor system's dynamic characteristics and the meshing forces on the coupling's elements. The results indicate that misalignment increases the system's vibration amplitude and the maximum meshing force of the spline coupling, with angular misalignment causing a significantly uneven distribution of meshing forces along the axial direction of the spline coupling. Moreover, misalignment reduces the meshing clearance between the internal and external teeth of the spline coupling at critical speed, decreasing the maximum meshing force. The modified model proposed in this paper can be widely used to analyze the dynamic characteristics of the rotor system connected by spline coupling. © 2024 (46 refs)
Main heading: Splines
Controlled terms: Rotors - Vibration analysis
Uncontrolled terms: Angular misalignment - Coupling element - Dynamics characteristic - Dynamics models - Meshing forces - Misalignment - Model method - Modified model - Rotor systems - Spline couplings
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 941.5 Mechanical Variables Measurements
Funding Details: Number: 12422213,12372008, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: 2023YFE0125900, Acronym: NKRDPC, Sponsor: National Key Research and Development Program of China; Number: -, Acronym: NKRDPC, Sponsor: National Key Research and Development Program of China; Number: YQ2022A008, Acronym: -, Sponsor: Natural Science Foundation of Heilongjiang Province; Number: -, Acronym: -, Sponsor: Natural Science Foundation of Heilongjiang Province;
Funding text: The authors are very grateful for the financial support from the National Natural Science Foundation of China (Grant Nos.12422213, 12372008), the National Key R&D Program of China (Grant No. 2023YFE0125900), the Natural Science Foundation of Heilongjiang Province (Grant No. YQ2022A008).
Database: Compendex
Data Provider: Engineering Village

19. ANALYSIS OF VIBRATION CHARACTERISTICS OF MISALIGNED SPLINE COUPLING IN VEHICLE ELECTRIC DRIVE SYSTEM

Zuo, Shuguang (1); Zhang, Yuhao (1)
Source: *Proceedings of the International Congress on Sound and Vibration*, 2025, *Proceedings of the 31th International Congress on Sound and Vibration, ICSV 2025*; **E-ISSN:** 23293675; **ISBN-13:** 9788994021423; **Conference:** 31th International Congress on Sound and Vibration, ICSV 2025, July 6, 2025 - July 11, 2025; **Sponsor:** Polytec GmbH; **Publisher:** Society of Acoustics
Author affiliation: (1) School of Automotive Studies, Tongji University, Shanghai; 201804, China
Abstract: Involute splines are extensively applied in the automotive industry due to their strong load-bearing capacity, high alignment precision, and efficient manufacturing processes, making them a crucial component of electric drive systems. This paper investigates the rotor system, specifically the motor-reducer connected by splines, within a certain automotive electric drive system. A finite element model is established to determine the single-tooth meshing stiffness of the spline pair under misalignment conditions. Subsequently, through geometric derivation, the relative displacement along the meshing line for each pair of spline teeth under radial and torsional vibrations is obtained, and the normal meshing force for each tooth pair is calculated. This further leads to the determination of the components of the dynamic meshing force along the coordinate axes and the dynamic meshing torque of the spline pair. Using the lumped mass method, a six-degree-of-freedom translational-torsional model of the spline rotor system is developed. Finally, the study analyzes the impact of misalignment on the vibration characteristics of the spline rotor system, focusing on aspects such as radial vibration of the spline pair, normal meshing force of the spline teeth, components of the dynamic meshing force along the coordinate axes, and dynamic meshing torque. Under uniform backlash conditions, the aligned spline exhibits full tooth engagement with even load distribution across the teeth, resulting in no radial vibration. However, as misalignment increases, the spline pair

enters a state of partial tooth engagement, significantly affecting the load distribution and vibration characteristics of each tooth. (9 refs)
Main heading: Dynamic models
Controlled terms: Alignment - Automotive industry - Electric drives - Electric power plant loads - Interpolation - Loads (forces) - Rotors - Splines - Stiffness - Traction motors - Vibration analysis
Uncontrolled terms: Dynamic meshing - Dynamics models - Electric drive system - Involute splines - Meshing forces - Meshing stiffness - Misalignment - Rotor systems - Vibration - Vibration characteristics
Classification Code: 214 Materials Science - 408 Structural Design - 601.1 Mechanical Devices - 601.2 Machine Components - 601.3 Mechanisms - 602 Mechanical Drives and Transmissions - 602.1 Mechanical Drives - 662.1 Automobiles - 705.1 Electric Machinery - 705.3 Electric Motors - 706.1.2 Electric Power Distribution - 941.5 Mechanical Variables Measurements - 1201.9 Numerical Methods - 1301.7 Statistical and Nonlinear Physics
Database: Compendex
Data Provider: Engineering Village

20. Piecewise Modification of Cycloidal Gear in RV Reducer: Application of Spline Interpolation Theory and Comparison with a Combination Modification Optimization Method (*Open Access*)

Gao, Song (1); Zhang, Yueming (1); Li, Yiwan (2); Ji, Shuting (1); Wei, Tengyue (1); Wang, Zhanli (1)
Source: *International Journal of Precision Engineering and Manufacturing*, v 26, n 1, p 195-208, January 2025; **ISSN:** 22347593, **E-ISSN:** 20054602; **DOI:** 10.1007/s12541-024-01107-3; **Article number:** 041003; **Publisher:** SpringerOpen
Author affiliation: (1) College of Mechanical & Energy Engineering, Beijing University of Technology, Beijing; 100124, China (2) Beijing Chietom-BJUT Intelligent Transmission Technology Research Institute Co., Ltd., Beijing; 110112, China
Abstract: Rotate vector (RV) reducers are typical deceleration elements with the outstanding characteristics of small size, compacted structure, strong load-bearing capacity, and low transmission error, which are widely applied in the fields of industrial robots, aerospace, and measurement instruments. The cycloidal gear, as the core component in the second-stage drive of RV reducer, its tooth profile directly determines the general performance of RV reducer such as meshing precision, load-bearing capacity, and riding stability. Therefore, it is necessary to explore the feasible methods and parameters for modification of cycloidal tooth profile. In this paper, taking the CRV-20E reducer as an object, firstly, a mathematical model for analyzing contact stress and load distribution on meshing surface was established. Secondly, based on genetic algorithm, a multi-objective optimization for cycloidal profile was applied with maximum contact stress and load distribution coefficient as objective functions, the optimal combination of modification parameters was obtained. Then, with the idea of piecewise modification and spline interpolation method, the cycloidal profile was separated into three segments of dedendum, working, and addendum, which ensures conjugated meshing in working segment, and the reserved gaps in dedendum and addendum can also be remained flexibility according to the specific requirements. The mechanism performance with cycloidal profiles modified by two proposed methods were systematically compared and discussed. Finally, the finite element simulation verification was carried out. The results indicated that both modification methods have specific advantages. This study provides a theoretical reference for designers in the field of gear profile optimization and underscores the critical implications for improving the overall efficiency and reliability of RV reducers in applications. (31 refs)
Main heading: Precision engineering
Controlled terms: Bearings (machine parts) - Electric load distribution - Gear teeth - Genetic algorithms - Interpolation - Multiobjective optimization - Speed reducers - Splines
Uncontrolled terms: Contact stress distributions - Cycloidal gear - Load-bearing capacity - Muti-objective optimization - Performance - Piece-wise - Piecewise modification - Rotate vector reducer - Spline interpolation - Tooth profile
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 706.1.2 Electric Power Distribution - 901 Engineering Profession - 1106 Computer Software, Data Handling and Applications - 1201.7 Optimization Techniques - 1201.9 Numerical Methods
Funding Details: Number: 51905009, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: -, Acronym: NSFC, Sponsor: National Natural Science Foundation of China; Number: 20311802D, Acronym: -, Sponsor: -; Number: 2023YFB4704200,YFB4704200, Acronym: NKRDPC, Sponsor: National Key Research and Development Program of China; Number: -, Acronym: NKRDPC, Sponsor: National Key Research and Development Program of China;
Funding text: This research is supported by National Natural Science Foundation of China Grant Number 51905009; Key R&D Projects in Hebei Province of China Grant Number 20311802D; National Key Research and Development Program of China Grant number 2023YFB4704200.National Natural Science Foundation of China,51905009, Shuting Ji, Key R & D Projects in Hebei Province of China,20311802D, Shuting Ji, National Key Research and Development Program of China,2023YFB4704200,Shuting Ji
Open Access type(s): All Open Access, Green
Database: Compendex
Data Provider: Engineering Village

21. Strength Analysis of Transmission Shaft Spline Pair Under Wide-Area Load (*Open Access*)

Bian, Jixuan (1); Wang, Cheng (1); Sun, Xueyan (1); Wang, Guodong (2); Hou, Wei (1); Zhang, Peng (3)
Source: *Lecture Notes in Mechanical Engineering*, p 1239-1254, 2025, *Mechanical Design and Simulation: Exploring Innovations for the Future - Proceedings of the 4th International Conference on Mechanical Design and Simulation*; **ISSN:** 21954356, **E-ISSN:** 21954364; **ISBN-13:** 9789819778867; **DOI:** 10.1007/978-981-97-7887-4_109; **Conference:** 4th International Conference on Mechanical Design and Simulation, MDS 2024, February 29, 2024 - March 2, 2024; **Publisher:** Springer Science and Business Media Deutschland GmbH
Author affiliation: (1) China North Vehicle Research Institute, Beijing; 100072, China (2) Inner Mongolia First Machinery Group Corporation, Inner Mongolia, Baotou; 014030, China (3) Harbin First Machinery Group Corporation, Heilongjiang, Harbin; 150056, China
Abstract: In this paper, the left, middle and right spline pair of transmission shaft is taken as the research object, and the geometric model after parametric modeling is imported into finite element software to obtain the distribution law of equivalent stress, bending stress, contact stress and relative slip of involute spline pair. The effects of contact length, number of teeth, modulus and friction factors on involute spline are studied, to provide reference for the design and engineering application of involute spline pair of transmission shaft for power split transmission. © The Author(s) 2025. (10 refs)
Main heading: Splines
Uncontrolled terms: Contact characteristics - Distribution law - Equivalent stress - Finite element software - Geometric models - Involute splines - Parametric models - Research object - Strength analysis - Transmission shafts
Classification Code: 601.2 Machine Components - 602 Mechanical Drives and Transmissions
Open Access type(s): All Open Access, Hybrid Gold
Database: Compendex
Data Provider: Engineering Village

22. Tooth design and verification of face spline transmission in hub bearing (*Open Access*)

Xiong, Wei (1); Di Deng, Zhong (1); Li, Jun (1); Wang, You (1); Zhang, Hai Bo (1); Mei, Song (2)
Source: *Journal of Vibroengineering*, v 27, n 1, p 172-187, February 1, 2025; **ISSN:** 13928716; **DOI:** 10.21595/jve.2025.24383; **Publisher:** EXTRICA
Author affiliation: (1) School of Mechanical Engineering, Hubei University of Arts and Science, Xiangyang, China (2) Hubei New Torch Science and Technology Co., Ltd., Xiangyang, China
Abstract: The hub bearing with face spline transmission is a new type of hub bearing. The design method and standards are lack. In this work, the geometric relationship of the tooth profile parameters and the meshing situation are derived for the hub bearing face spline. The outer diameter D, number of teeth Z, and face tooth profile angle ϕ are key design parameters. The verification conditions for preload, extrusion stress, tooth root bending stress, and shear stress are established based on strength theory and assumption of uniform load distribution. To validate the design, a case study is conducted on the hub bearing face spline in a certain vehicle model, with theoretical calculation and simulation of stress by using Finite Element Method. The present FEM results compare well with those of the literature data. Finally, through the incorporation the torque strength and durability tests of the face spline, the reliability of the design theory in this work is confirmed. The results indicates that, the tooth tip fillet r1 has a significant impact on the meshing area, the maximum principal stress near the tooth root is highest at the arc of the tooth root, proving that the selection of the dangerous section is appropriate. The work has value in promoting the development of automotive wheel hub bearings. © 2025 Wei Xiong, et al. (21 refs)
Main heading: Shear stress
Controlled terms: Splines
Uncontrolled terms: Design method - Design standard - Face spline - Geometric relationships - Hub bearing - Outer diameters - Profile parameters - Tooth profile - Tooth root - Verification condition
Classification Code: 214.1.1 Stress and Strain - 601.2 Machine Components - 602 Mechanical Drives and Transmissions
Funding Details: Number: 2024AFD031, Acronym: -, Sponsor: -; Number: D20232603, Acronym: -, Sponsor: -; Number: 2022ABH006560, Acronym: -, Sponsor: -;
Funding text: The authors would like to thank Hubei Provincial Natural Science Foundation Project of China for the financial and technological support given to this study through the project \u201CMicro motion wear mechanism and fatigue prediction of electric vehicle drive connections under complex operating conditions\u201D (Grant numbers 2024AFD031). The authors would like to thank the Key Project of Scientific Research Plan of Hubei Provincial Department of Education of China (Grant numbers D20232603). The authors would like to thank the Xiangyang City Research and Development Project (Grant numbers 2022ABH006560). Author Wei Xiong has received research support from Hubei New Torch Technology Co., Ltd.
Open Access type(s): All Open Access, Gold
Database: Compendex

Data Provider: Engineering Village

23. Research on module development for tooth flank topography measurement of rectangular spline gauges based on a gear measuring instrument (*Open Access*)

He, Min (1); Zhou, Jin (2); Li, Xiaoming (3); Yang, Zhuang (1); Peng, Yuanhui (1); Tian, Li (1)
Source: *Journal of Physics: Conference Series*, v 3193, n 1, 2026; **ISSN:** 17426588, **E-ISSN:** 17426596; **DOI:** 10.1088/1742-6596/3193/1/012008; **Article number:** 012008; **Conference:** 2025 7th International Conference on Mechanical Engineering and Automation, MEA 2025, December 19, 2025 - December 21, 2025; **Publisher:** Institute of Physics
Author affiliation: (1) The National institute of measurement and testing technology, Chengdu; 610021, China (2) Chongqing Academy of Metrology and Quality inspection, Chongqing; 401121, China (3) Hanjiang Tools Limited Liability Company, Hanzhong; 723002, China
Abstract: Rectangular spline gauges are widely used in military and civilian fields, such as aircraft, armored tanks, armed helicopters, automobiles, and engineering machinery, serving as irreplaceable transmission components.With the rapid development of the major equipment manufacturing industry in China, the measurement of tooth flank topography features of rectangular spline gauges - such as tooth alignment error, adjacent pitch error, and cumulative pitch error, which affect force transmission has gradually come into the focus of precision measurement.However, there is currently no dedicated measuring equipment for rectangular spline gauges in the metrology field. Leveraging the similarity between spline and gear transmission principles, this applied case study proposes the development of an automated measurement software module based on a gear measuring instrument. This module enables the measurement of tooth flank topography features of rectangular spline gauges, thereby providing a high-precision metrological solution for such gauges. © 2026 Published under licence by IOP Publishing Ltd. (10 refs)
Main heading: Topography
Controlled terms: Errors - Gages - Gear teeth - Gear transmissions - Military helicopters - Splines - Tanks (military) - Transmissions
Uncontrolled terms: Armed helicopter - Engineering machinery - Flank topographies - Gear measuring instruments - Measurements of - Module development - Pitch errors - Tooth flank - Topography measurement - Transmission components
Classification Code: 214 Materials Science - 404.1 Military Engineering - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 602.2 Mechanical Transmissions - 652.4 Helicopters - 662.3 Automobile Components and Materials - 663.1 Heavy Duty Motor Vehicles - 731.1.1 Error Handling - 942.1.7 Special Purpose Instruments
Funding Details: Number: 2024MK106, Acronym: -, Sponsor: -;
Funding text: Foundation Items: Science and Technology Program of State Administration for Market Regulation(2024MK106).
Open Access type(s): All Open Access, Gold
Database: Compendex
Data Provider: Engineering Village

24. Research of Automatic Identification of Cervical Margin Line of Isolated Teeth Based on Multi-Feature Fusion

Yao, Jing (1); Liu, Baolong (1)
Source: *2025 8th International Conference on Computer Network, Electronic and Automation, ICCNEA 2025*, 2025, *2025 8th International Conference on Computer Network, Electronic and Automation, ICCNEA 2025*; **ISBN-13:** 9798331537692; **DOI:** 10.1109/ICCNEA66167.2025.11212110; **Conference:** 8th International Conference on Computer Network, Electronic and Automation, ICCNEA 2025, September 19, 2025 - September 21, 2025; **Sponsor:** State and Provincial Joint Engineering Lab. of Advanced Network, Monitoring and Controls; Xi#an Technological University; **Publisher:** Institute of Electrical and Electronics Engineers Inc.
Author affiliation: (1) School of Computer Science and Engineering, Xi'an Technological University, Xi'an, China
Abstract: With advancements in digital dentistry, this paper introduces a multi-feature fusion clustering method for automated cervical margin line extraction in isolated teeth of different materials. Unlike traditional approaches, it combines PCA surface variation and FPFH descriptors through weighted fusion to enhance feature representation, enabling precise point cloud segmentation into two clusters with K-means. The cervical margin is then refined using normal vector angle threshold optimization and cubic B-spline curve fitting. Quantitative evaluation based on crown length measurements shows maximum deviations of 0.15-0.25 for resin teeth and 0.20-0.35 mm for gypsum models compared to ground truth. These results validate the method's effectiveness in automated cervical line detection, supporting its use in digital crown design and dental carving assessment. © 2025 IEEE. (10 refs)
Main heading: Curve fitting
Controlled terms: Automatic identification - Biomedical engineering - Cluster analysis - Dental materials - Dentistry - Information fusion - Interpolation - K-means clustering - Splines

Uncontrolled terms: Automatic identification - B spline curve - Cervical margin - Clustering methods - Feature descriptors - FPFH feature descriptor - K-means - Multi-feature fusion - Point-clouds - Surface variational
Classification Code: 101.1 Biomedical Engineering - 101.2.2 Dental Equipment and Supplies - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 731 Automatic Control Principles and Applications - 903.1 Information Sources and Analysis - 1101.2 Machine Learning - 1201.9 Numerical Methods
Funding Details: Number: 21JC013, Acronym: -, Sponsor: Education Department of Shaanxi Province; Number: -, Acronym: -, Sponsor: Education Department of Shaanxi Province;
Funding text: This research was generously supported by the Science and Technology Program of the Shaanxi Provincial Department of Education (21JC013). We are particularly indebted for the invaluable support that facilitated the provision of essential resources, enabling the smooth advancement of our research. Moreover, we wish to extend our heartfelt gratitude to the Shaanxi Provincial Department of Education for their invaluable guidance and support throughout the research process, which significantly contributed to the efficient and successful execution of this study.
Database: Compendex
Data Provider: Engineering Village

25. Dynamic modelling and analysis of the floating spline with locating surfaces, O-rings, and misalignment

Zhang, Chao (1); Che, Xiaoyu (2); Wu, Yuping (3); Yan, Weiping (4); Zhu, Rupeng (4); Wang, Dan (4); Jiang, Dong (1)
Source: *Mechanical Systems and Signal Processing*, v 253, June 1, 2026; **ISSN:** 08883270, **E-ISSN:** 10961216; **DOI:** 10.1016/j.ymssp.2026.114331; **Article number:** 114331; **Publisher:** Academic Press
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Abstract: Dynamic performances of floating splines are directly related to the safe operation of helicopter transmission systems. The dynamic behaviour analysis of floating splines should comprehensively consider the coupling effects of O-rings, locating surfaces, and misalignment. Currently, this type of spline dynamic model is not yet available. Considering the locating surface rub-impact, misalignment, vibration displacement, this study modeled the meshing state of spline teeth and reserved clearance of locating surfaces, simplified O-rings into mechanical Voigt models, and then proposed a general floating spline dynamic model. By coupling the floating spline to the spline-rotor system, the equation of motion for the spline-rotor system is obtained, whose accuracy was verified through dynamic experiments on the spline-rotor system dynamic experimental rig. Detailed effect mechanisms of locating surfaces, O-rings, misalignment, and vibration displacement on the spline-rotor system were revealed. The floating spline dynamic model proposed in this paper can accurately determine whether locating surfaces are rub-impact or not, which can provide theoretical basis for the dynamic design of floating splines and related rotor systems. © 2026 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies. (60 refs)
Main heading: Equations of motion
Controlled terms: Alignment - Data mining - Dynamic models - Interpolation - Location - Transmissions - Vibrations (mechanical)
Uncontrolled terms: Dynamics analysis - Dynamics models - Locating surfaces - Misalignment - Modeling - Modelling and analysis - O-Rings - Rotor systems - Rub impact - Vibration displacements
Classification Code: 601.1 Mechanical Devices - 601.2 Machine Components - 602 Mechanical Drives and Transmissions - 602.2 Mechanical Transmissions - 912 Industrial Engineering and Management - 1106.2.1 Data Mining - 1201.2 Calculus and Analysis - 1201.9 Numerical Methods - 1301.1.1 Mechanics - 1301.7 Statistical and Nonlinear Physics
Funding Details: Number: 52572412 and 52505047, Acronym: -, Sponsor: National Natural Science Foundation of China; Number: GZJJ-KF-2025-01, Acronym: -, Sponsor: National Natural Science Foundation of China;
Funding text: The authors are grateful to the financial supports from National Natural Science Foundation of China (Grant NO. 52572412 and 52505047) and National Key Laboratory of Science and Technology on Advanced Light-duty Gas-turbine (GZJJ-KF-2025-01).
Database: Compendex
Data Provider: Engineering Village