



# On the tribo-dynamics of lubricated point contacts: modeling and experiment

S. Li · A. Kolivand · Z. Shi · A. Anisetti

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**Abstract** This study proposes a modeling methodology for the description of tribo-dynamic behavior of generic point contacts, considering surface defect/failure type of excitation. A twin-disk contact set-up is developed to experimentally determine the acceleration induced by lab-controlled groove surface feature present on one of the mating surfaces. The periodic passage of this artificial surface defect through lubricated contact zone leads to contact force fluctuation, and consequently normal direction dynamic relative displacement and relative velocity of the contact bodies. These dynamic responses impact the lubrication film thickness and flow, altering the tribological performance that governs the contact force. Implementing this interaction loop between dynamics and tribology, the computational simulations are shown to be able to yield fairly accurate predictions in comparison to the measured acceleration signals.

**Keywords** Point contact · Dynamics · Tribology · Surface defect · Surface failure

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## 1 Introduction

Dynamic responses, such as noise and vibration, are common in applications of high-speed rolling mechanical elements (gears and bearings for instance), whose cyclic contact actions are deemed to be the main sources of excitations [1–7]. From an interdisciplinary point of view, dynamic vibration has been shown to have large influence on tribological performance occurring at the interface of contacting components, including fluctuating normal force and lubricant viscosity [8, 9]. Although the physical interactions between tribology and dynamics are evident and substantial [9], a majority of works in the literature focused on only one way of impact. In the early 80s of last century, Wang and Cheng [10] numerically evaluated the thermal elastohydrodynamic lubrication (EHL) solutions of spur gear contacts subject to dynamic tooth force. Considering both normal and tangential vibrations, Yang et al. [11] investigated the responses in terms of lubrication film thickness, pressure, and temperature of a line contact. Both studies assumed perfectly smooth surfaces. Including surface roughness effects, Mohammadpour et al. [12] examined friction and efficiency of planetary gear systems through mixed thermal EHL analyses under dynamic condition. Joining a lumped parameter vibratory model to EHL governing equations, Li and Kahraman [8] demonstrated the unique transient gear EHL behavior under nonlinear dynamic

## Point Of Contacts

**Salvatore Nicosia, Bruno  
Siciliano, Antonio Bicchi, Paolo Valigi**

## **Point Of Contacts:**

**RAMSETE** Salvatore Nicosia, Bruno Siciliano, Antonio Bicchi, Paolo Valigi, 2003-07-01 Robotics applications initially developed for industrial and manufacturing contexts are now strongly present in several fields. Besides well known space and high technology applications, robotics for every day life and medical services is becoming more and more popular. As an example, robotic manipulators are particularly useful in surgery and radiation treatments; they could be employed for civil demining for helping disabled people and ultimately for domestic tasks, entertainment and education. Such a kind of robotic applications require the integration of many different skills. Autonomous vehicles and mobile robots in general must be integrated with articulated manipulators. Many robotic technologies: sensors, actuators and computing systems must be properly used with specific technologies: localisation, planning and control technologies. The task of designing robots for these applications is a hard challenge: a specific competence in each area is demanded in the effort of a truly integrated multidisciplinary design.

**Elastohydrodynamic Lubrication for Line and Point Contacts** Ilya I. Kudish, 2013-06-17  
Elastohydrodynamic Lubrication for Line and Point Contacts: Asymptotic and Numerical Approaches describes a coherent asymptotic approach to the analysis of lubrication problems for heavily loaded line and point contacts. This approach leads to unified asymptotic equations for line and point contacts as well as stable numerical algorithms for the solution of these elastohydrodynamic lubrication (EHL) problems. A Unique Approach to Analyzing Lubrication Problems for Heavily Loaded Line and Point Contacts. The book presents a robust combination of asymptotic and numerical techniques to solve EHL problems for lightly and heavily loaded line and point contacts. It also proposes a reasonably simple and naturally based regularization approach that produces stable solutions in heavily loaded EHL contacts. The book offers a clear understanding of the processes taking place in heavily loaded line and point EHL contacts as well as of the proper solution structure for EHL problems. It outlines concrete ways to determine important design parameters such as lubrication film thickness and frictional stresses and forces. The book establishes a close link between EHL problems for heavily loaded point and line contacts. Fine Tune Your Methods for Solving Elastohydrodynamic Lubrication Problems. In most cases, the equations in the book are derived from first principles. The author describes each of the asymptotic and numerical methods in detail, making it easier for readers to apply them to various problems. The problem solutions are presented in the form of simple analytical formulas, graphs and tables. Almost all the chapters include exercises that highlight key points and skills. Suitable for engineering and applied mathematics students, this is also a unique resource for researchers and practitioners who want to fine tune their solution methods and design better numerical methods to tackle elastohydrodynamic lubrication problems.

Elastohydrodynamics Ramsey Gohar, 2001 Elastohydrodynamic lubrication (EHL) is a difficult topic embracing several disciplines which can cause many problems for engineers and scientists. This up to date volume explains the subject both theoretically and experimentally. Moreover, with a refreshing approach and using several novel techniques of application, it

provides lucid coverage of new and important findings Here in one volume are the results of much research over the last forty years The author s clear explanation of the theory of EHL is authoritatively applied to a wide range of related topics with physical explanations wherever possible Many of the experimental techniques described were carried out at the Imperial College Lubrication Laboratory where the application of interferometry a means of measuring the EHL film thickness was pioneered      Basics of Precision Engineering Mr. Rohit Manglik,2024-07-16 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels      Interfacial Mechanics Jane Wang,Dong Zhu,2019-12-06 Understanding the characteristics of material contact and lubrication at tribological interfaces is of great importance to engineering researchers and machine designers Traditionally contact and lubrication are separately studied due to technical difficulties although they often coexist in reality and they are actually on the same physical ground Fast research advancements in recent years have enabled the development and application of unified models and numerical approaches to simulate contact and lubrication merging their studies into the domain of Interfacial Mechanics This book provides updated information based on recent research progresses in related areas which includes new concepts theories methods and results for contact and lubrication problems involving elastic or inelastic materials homogeneous or inhomogeneous contacting bodies using stochastic or deterministic models for dealing with rough surfaces It also contains unified models and numerical methods for mixed lubrication studies analyses of interfacial frictional and thermal behaviors as well as theories for studying the effects of multiple fields on interfacial characteristics The book intends to reflect the recent trends of research by focusing on numerical simulation and problem solving techniques for practical interfaces of engineered surfaces and materials This book is written primarily for graduate and senior undergraduate students engineers and researchers in the fields of tribology lubrication surface engineering materials science and engineering and mechanical engineering      *Magnetic And Superconducting Materials (In 2 Vols): Procs Of The First Regional Conference M* Akhavan,Jens Jensen,K Kitazawa,2000-09-27 The great breakthroughs in the science and technology of superconducting and magnetic materials in recent years promoted many outstanding representatives of various scientific disciplines physics chemistry and materials science to present their latest findings in a scientific atmosphere of the highest standard at the MSM 99 conference Over 200 eminent scientists from 50 countries gathered to discuss the physics materials science and application of magnetic and superconducting materials and to foster research and development collaborations between the scientists and technologists of the regional countries and also with the international scientific community The main topics of this book are the physics materials science and application of magnetic and superconducting materials having a close relationship between the strong correlated electron system and magnetism      Robot Mechanisms Jadran Lenarcic,Tadej

Bajd, Michael M. Stanišić, 2012-06-12 This book provides a comprehensive introduction to the area of robot mechanisms primarily considering industrial manipulators and humanoid arms The book is intended for both teaching and self study Emphasis is given to the fundamentals of kinematic analysis and the design of robot mechanisms The coverage of topics is untypical The focus is on robot kinematics The book creates a balance between theoretical and practical aspects in the development and application of robot mechanisms and includes the latest achievements and trends in robot science and technology Noise In Physical Systems And 1/f Fluctuations - Proceedings Of The 13th International Conference Vytautas Bareikis, Ramunas Katilius, 1995-04-26 The volume constitutes the proceedings of the 13th International Conference on Noise in Physical Systems and 1/f Fluctuations ICNF 95 held in Palanga Lithuania in the period 29 May 3 June 1995 International conference of fluctuation phenomena has a rich history Previous ones were held in St Louis USA 1993 Kyoto Japan 1991 Budapest Hungary 1989 Montreal Canada 1983 etc The conference proved to be successful in bringing together specialists in fluctuation phenomena in very different areas and providing a bridge linking theorists and applied scientists involved in the design of new generation of electronic devices Correspondingly the volume covers fundamental aspects of noise in various fields of science and modern technology Mesoscopic fluctuations noise in high temperature superconductors in nanoscale structures in optoelectronic and microwave devices fluctuation phenomena in biological systems and human body are in the spotlight *Terahertz (THz), Mid Infrared (MIR) and Near Infrared (NIR) Technologies for Protection of Critical Infrastructures Against Explosives and CBRN* Mauro Fernandes Pereira, Apostolos Apostolakis, 2021-04-30 Critical infrastructures are targets for terrorism and deliver a valuable vector through which the proliferation of CBRN and explosive precursors can be detected Recent technological breakthroughs notably in the field of near infrared NIR mid infrared MIR Terahertz THz and Gigahertz GHz sources and detectors have led to rugged commercial devices capable of standoff sensing a range of these dangerous substances However at the same time criminal and terrorist organizations have also benefited from the availability of technologies to increase the threat they pose to the security of citizens and a concerted effort is needed to improve early detection measures to identify activities such as the production of homemade explosives or CBRN that can be potentially dangerous to society The key global technological bottleneck to be overcome is the current lack of integration and networking of mature detection technology into early warning systems for critical infrastructures Thus this book brings together complementary information connecting the research of leading teams working on critical Infrastructure protection with academic developers and industrial producers of state of the art sensors *Functional Nanostructures and Sensors for CBRN Defence and Environmental Safety and Security* Anatolie Sidorenko, Horst Hahn, 2020-03-17 Over the last decade techniques for materials preparation and processing at nanometer scale have advanced rapidly leading to the introduction of novel principles for a new generation of sensors and detectors At the same time the chemical industry transport and agriculture produce huge amounts of dangerous waste gases and liquids leading to soil air and water

contamination One more modern threat international terrorism demands that scientists make efforts to apply new principles and technologies to protect society against chemical biological radiological and nuclear CBRN attacks and to develop novel effective technologies for the remediation of large contaminated areas Accordingly the main goal of this book is to bring together experts theorists experimentalists engineers and technologists for an extensive discussion covering novel principles for functional nanostructures and detector fabrication and implementation the development of novel technologies for the deactivation of CBRN agents their experimental realization and their application in novel monitoring and control systems and technological processes for soil and water remediation with a view to environmental protection and defence against CBRN based terrorism In keeping with the book s main goal the following topics are highlighted and discussed Sensors and detectors detection of chemicals principles of artificial nose and chemical micro lab on a chip design surface and underground water quality monitoring systems molecular electronics superconducting electronic devices quantum detectors and Qubits Environmental protection and CBRN detection of infrared microwave X ray and terahertz radiation Principles for novel IR UV and Terahertz wave devices for the detection of low contrast objects Novel technological processes for CBRN destruction and deactivation All these topics are strongly interrelated both with regard to fundamental aspects and to fabrication and implementation technologies in addition they are highly promising for application in novel functional devices computer logics sensing and detection of low concentration chemicals weak and extremely weak magnetic and microwave fields infrared and ultraviolet radiation Given its scope the book will be a useful and interesting guide for a broad readership of engineers scientists PhD students and experts in the area of defence against environmental terrorism

Advances in Research and Applications: Semiconductor Heterostructures and Nanostructures, 1991-05-01 The explosion of the science of mesoscopic structures is having a great impact on physics and electrical engineering because of the possible applications of these structures in microelectronic and optoelectronic devices of the future This volume of Solid State Physics consists of two comprehensive and authoritative articles that discuss most of the physical problems that have so far been identified as being of importance in semiconductor nanostructures Much of the volume is tutorial in character while at the same time time presenting current and vital theoretical and experimental results and a copious reference list so it will be essential reading to all those taking a part in the research and development of this emerging technology

**Nanomaterials and Nanocomposites, Nanostructure Surfaces, and Their Applications** Olena Fesenko, Leonid Yatsenko, 2020-11-25 This book highlights some of the latest advances in nanotechnology and nanomaterials from leading researchers in Ukraine Europe and beyond It features contributions presented at the 7th International Science and Practice Conference Nanotechnology and Nanomaterials NANO2019 which was held on August 27-30 2019 at Lviv Polytechnic National University and was jointly organized by the Institute of Physics of the National Academy of Sciences of Ukraine University of Tartu Estonia University of Turin Italy and Pierre and Marie Curie University France Internationally recognized experts from

a wide range of universities and research institutions share their knowledge and key findings on material properties behavior and synthesis This book s companion volume also addresses topics such as nano optics energy storage and biomedical applications

**Computer Aided Innovation of New Materials II** M. Doyama,J. Kihara,Mana Tanaka,R. Yamamoto,2017-01-31 With advanced materials being in the midst of a widely acknowledged revolution there is relentless pressure on scientists and engineers to be on the cutting edge of emerging theories and design methodologies The 379 papers in this two part volume bring together the experience of specialists in the entire field of applications of Materials Science This multidisciplinary meeting was held to bring together workers in a wide range of materials science and engineering activities who employ common analytical and experimental methods in their day to day work The results of the meeting are of worldwide interest and will help to stimulate future research and analysis in this area

*Difficult Engineering Concepts Better Explained: Statics And Applications* Jay F Tu,2020-07-21 Engineering statics discusses proper ways of conducting force analysis This unique compendium treats fundamental force analysis in a systematic and comprehensive manner The indispensable volume is suitable for undergraduate students to learn the subject in greater depth for graduate students to review essential skills in force analysis correctly and for practicing engineers to review and refresh key concepts This useful reference text also presented numerous application examples for readers in solving daily practical problems

Algorithms for Robotic Motion and Manipulation Jean-Paul Laumond,Mark Overmars,1997-02-11 This volume deals with core problems in robotics like motion planning sensor based planning manipulation and assembly planning It also discusses the application of robotics algorithms in other domains such as molecular modeling computer graphics and image analysis Topics Include Planning Sensor Based Motion Planning Control and Moti

*Finite Element Modeling of Elastohydrodynamic Lubrication Problems* Wassim Habchi,2018-07-23 Covers the latest developments in modeling elastohydrodynamic lubrication EHL problems using the finite element method FEM This comprehensive guide introduces readers to a powerful technology being used today in the modeling of elastohydrodynamic lubrication EHL problems It provides a general framework based on the finite element method FEM for dealing with multi physical problems of complex nature such as the EHL problem and is accompanied by a website hosting a user friendly FEM software for the treatment of EHL problems based on the methodology described in the book Finite Element Modeling of Elastohydrodynamic Lubrication Problems begins with an introduction to both the EHL and FEM fields It then covers Standard FEM modeling of EHL problems before going over more advanced techniques that employ model order reduction to allow significant savings in computational overhead Finally the book looks at applications that show how the developed modeling framework could be used to accurately predict the performance of EHL contacts in terms of lubricant film thickness pressure build up and friction coefficients under different configurations Finite Element Modeling of Elastohydrodynamic Lubrication Problems offers in depth chapter coverage of Elastohydrodynamic Lubrication and its FEM Modeling under Isothermal Newtonian and

Generalized Newtonian conditions with the inclusion of Thermal Effects Standard FEM Modeling Advanced FEM Modeling including Model Order Reduction techniques and Applications including Pressure Film Thickness and Friction Predictions and Coated EHL This book Comprehensively covers the latest technology in modeling EHL problems Focuses on the FEM modeling of EHL problems Incorporates advanced techniques based on model order reduction Covers applications of the method to complex EHL problems Accompanied by a website hosting a user friendly FEM based EHL software Finite Element Modeling of Elastohydrodynamic Lubrication Problems is an ideal book for researchers and graduate students in the field of Tribology

**Algorithms and Computation** Toshihide Ibaraki, Naoki Katoh, Hirotaka Ono, 2003-11-24 This volume contains the proceedings of the 14th Annual International Symposium on Algorithms and Computation ISAAC 2003 held in Kyoto Japan 15-17 December 2003 In the past it was held in Tokyo 1990 Taipei 1991 Nagoya 1992 Hong Kong 1993 Beijing 1994 Cairns 1995 Osaka 1996 Singapore 1997 Taejeon 1998 Chennai 1999 Taipei 2000 Christchurch 2001 and Vancouver 2002

ISAAC is an annual international symposium that covers the very wide range of topics in algorithms and computation The main purpose of the symposium is to provide a forum for researchers working in algorithms and the theory of computation where they can exchange ideas in this active research community In response to our call for papers we received unexpectedly many submissions 207 papers The task of selecting the papers in this volume was done by our program committee and referees After a thorough review process the committee selected 73 papers The selection was done on the basis of originality and relevance to the field of algorithms and computation We hope all accepted papers will eventually appear in scientific journals in more polished forms The best paper award was given for On the Geometric Dilation of Finite Point Sets to Annette Ebbens Baumann Ansgar Grune and Rolf Klein Two eminent invited speakers Prof Andrew Chi Chih Yao of Princeton University and Prof Takao Nishizeki of Tohoku University contributed to this proceedings

**Control of Semiconductor Interfaces I.** Ohdomari, M. Oshima, A. Hiraki, 2017-05-03 This book focuses exclusively on control of interfacial properties and structures for semiconductor device applications from the point of view of improving and developing novel electrical properties The following topics are covered metal semiconductors semiconductor hetero interfaces characterization semiconducting new materials insulator semiconductor interfaces in device control of interface formation control of interface properties contact metallization A variety of up to date research topics such as atomic layer epitaxy atomic layer passivation atomic scale characterization including STM and SR techniques single ion implementation self organization crystal growth in situ measurements for process control and extremely high spatial resolution analysis techniques are also included Furthermore it bridges the macroscopic mesoscopic and atomic scale regimes of semiconductor interfaces describing the state of the art in forming controlling and characterizing unique semiconductor interfaces which will be of practical importance in advanced devices Intended for both technologists who require an up to date assessment of methods for interface formation processing and characterization and solid state researchers who desire the latest developments in understanding the basic mechanisms

of interface physics chemistry and electronics this book will be a welcome addition to the existing literature      **Strongly Correlated Systems** Adolfo Avella, Ferdinando Mancini, 2014-10-01 The continuous evolution and development of experimental techniques is at the basis of any fundamental achievement in modern physics Strongly correlated systems SCS more than any other need to be investigated through the greatest variety of experimental techniques in order to unveil and crosscheck the numerous and puzzling anomalous behaviors characterizing them The study of SCS fostered the improvement of many old experimental techniques but also the advent of many new ones just invented in order to analyze the complex behaviors of these systems Many novel materials with functional properties emerging from macroscopic quantum behaviors at the frontier of modern research in physics chemistry and materials science belong to this class of systems The volume presents a representative collection of the modern experimental techniques specifically tailored for the analysis of strongly correlated systems Any technique is presented in great detail by its own inventor or by one of the world wide recognized main contributors The exposition has a clear pedagogical cut and fully reports on the most relevant case study where the specific technique showed to be very successful in describing and enlightening the puzzling physics of a particular strongly correlated system The book is intended for advanced graduate students and post docs in the field as textbook and or main reference but also for any other researcher in the field who appreciates consulting a single but comprehensive source or wishes to get acquainted in a as painless as possible way with the working details of a specific technique      Numerical Modeling in Micromechanics via Particle Methods H. Konietzky, 2017-11-01 Particle methods have seen increasing use in several engineering and scientific fields both because of their unique modelling capabilities and the availability of the necessary computational power This title focuses on their theory and application

## **Point Of Contacts** Book Review: Unveiling the Power of Words

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