SIMULIA

Abaqus Technology Brief

TB-11-RT-1
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Full Vehicle NVH Analysis with Rolling Tires

Summary

In a traditional automobile noise, vibration and harshness (NVH) analysis, stationary tires are defined and subjected to vertical dynamic loading. The actual operating conditions of a tire involve rolling however, and the vibration characteristics of rolling tires are considerably different from those of stationary tires.

Abaqus offers a methodology to include the pre-loading and gyroscopic effects of rolling tires in a forced response dynamic analysis of the moving vehicle. This article closely follows SIMULIA Technology Brief TB-08-TVC-1 and illustrates the use of substructures in a typical NVH analysis for a full vehicle model with steadily rolling tires.

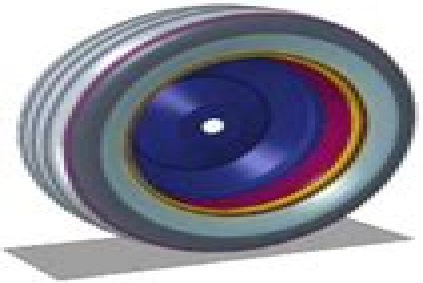
Background

Small amplitude vibrations of a tire on the road can be treated as a linear superposition of small amplitude steady state vibrations on a highly nonlinear base state. For stationary tires, this base state is the footprint configuration of the tire. The base state contains nonlinearities arising from the load-deflection behavior of various rubber compounds, contact between the tire and the road, reinforcement behavior, etc.

In a traditional NVH analysis, the tires are stationary and subjected to vertical load. However, the vibration characteristics of rolling tires depend on the rolling velocity and are considerably different from those of stationary tires. Specifically, the rolling condition contributes loads in the fore-aft direction as well as the vertical [Ref 1].

It is common practice to employ a mixed Eulerian-Lagrangian scheme to compute the steady state rolling configuration of the tire. This methodology uses a reference frame that is attached to the axle of the rotating tire. An observer in this frame sees the tire as points that do not move, although the material of which the tire is made moves through these points. Small amplitude vibrations can then be superposed on the rolling configuration corresponding to the velocity of interest.

The dynamic substructure of a rolling tire can be created and incorporated in a full vehicle assembly, thus eliminating the need to use a fully meshed representation of the tire. With these modeling capabilities, tire manufacturers can provide automotive designers with richer, more comprehensive numeric representations of their tire's behavior — without divulging their detailed tire FE models.



Key Abaqus Features and Benefits

- Symmetric model generation and symmetric results transfer
- A mixed Eulerian-Lagrangian scheme to compute the steady state rolling configuration of tires
- Dynamic substructures to account for pre-loading and gyroscopic effects of a rolling tire
- Subspace-based steady state dynamics for relatively inexpensive forced response prediction

The simulation presented here demonstrates the analysis methodology for including the effect of rolling tires on the vehicle forced frequency response. A dynamic substructure of a rolling tire FE model is created and assembled into a full vehicle model for NVH analysis. The automatic multi-level substructuring (AMS) eigensolver is used to extract the eigensolution of the vehicle assembly, which is then subsequently used in the steady-state dynamic analyses.

Finite Element Analysis Approach

The model under consideration represents a typical passenger car tire. The road is modeled as an analytical rigid surface. Contact is defined between this surface and the tire. A simple Mooney-Rivlin law is used for the strain energy potential of the various rubber materials. This simulation ignores the viscoelastic nature of the rubber. The plies and belts are modeled using rebar layers embedded in the surrounding rubber matrix. Linear elastic material properties are applied to the reinforcement fibers.

Full Vehicle Nvh Analysis With Rolling Tires

Michael Blundell,Damian Harty

Full Vehicle Nvh Analysis With Rolling Tires:

Vehicle/Tire/Road Dynamics Tan Li,2022-11-24 Vehicle Tire Road Dynamics Handling Ride and NVH presents the connection between NVH and conventional vehicle dynamics where both tire and road play a key role In this book there is a chapter for handling dynamics that provides an introduction to ride dynamics and a chapter for ride dynamics that provides an introduction to NVH presenting better coherence and synergy between these major areas of vehicle tire dynamics Accompanying the fundamental theories case studies are given to facilitate comprehension In addition to the experimental implementations the state of the art approaches to simulating vehicle tire dynamics are presented from the viewpoint of both industry and academia This new book bridges the gap for experts in tire or pavement NVH also tire pavement interaction noise and those who are experts in vehicle dynamics Conventional vehicle dynamics e g handling braking cornering is focused on low frequency performance while NVH noise vibration harshness is focused on high frequency performance There is also another area called ride comfort stability which focuses on mid frequency Presents a closed loop system for vehicle dynamics covering handling riden and NVH Provides insights into how intelligent tires will enhance autonomous vehicle control and optimize multiple performances especially for electric vehicles Demonstrates how pavement characteristics could greatly influence vehicle handling ride NVH and improve balance these performances **Analyse des gekoppelten Systems Reifen-Hohlraum-Rad-Radführung im Rollzustand und Entwicklung eines Rollgeräuschmodells** Stefanie Grollius,2014-05-19 In diesem Buch werden der komplizierte Rollzustand des gekoppelten Systems Reifen Hohlraum Rad Radf hrung der Kontakt mit der rauen Fahrbahn sowie die Schwingungsanregung des Reifens durch die Fahrbahn experimentell untersucht Die Erkenntnisse werden dazu genutzt ein Rollger uschmodell aufzubauen Dieses enth lt neben der Strukturdynamik von Reifen und Rad auch das Hohlraummedium und bildet die Wechselwirkungen mit der Radf hrung sowie die fahrbahnbedingte Schwingungsanregung ab **Model Validation and Uncertainty Quantification, Vol. 3** Roland Platz,Garrison Flynn,Kyle Neal,Scott Ouellette,2025-08-07 Model Validation and Uncertainty Quantification Volume 3 Proceedings of the 42nd IMAC A Conference and Exposition on Structural Dynamics 2024 the third volume of ten from the Conference brings together contributions to this important area of research and engineering The collection presents early findings and case studies on fundamental and applied aspects of Model Validation and Uncertainty Quantification including papers on Uncertainty Quantification in Dynamics Fusion of Test and Analysis Model Form Uncertainty Round Robin Challenge UQVI Uncertainty Quantification in Vibration Isolation Recursive Bayesian System Identification Virtual Sensing Realtime Monitoring Surrogate Modeling and Reduced Order Models **Tire Science & Technology** ,1998 *Structural Dynamics, Volume 3* Tom Proulx,2025-08-07 This the fifth volume of five from the 28th IMAC on Structural Dynamics and Renewable Energy 2010 brings together 146 chapters on Structural Dynamics It presents early findings from experimental and computational investigations of on a wide range of area within Structural Dynamics including studies such as Simulation

and Validation of ODS Measurements made Using a Continuous SLDV Method on a Beam Excited by a Pseudo Random Signal Comparison of Image Based Laser and Accelerometer Measurements Modal Parameter Estimation Using Acoustic Modal Analysis Mitigation of Vortex induced Vibrations in Long span Bridges and Vibration and Acoustic Analysis of Brake Pads for Quality Control **Road and Off-Road Vehicle System Dynamics Handbook** Gianpiero Mastinu,Manfred Ploechl,2014-01-06 Featuring contributions from leading experts the Road and Off Road Vehicle System Dynamics Handbook provides comprehensive authoritative coverage of all the major issues involved in road vehicle dynamic behavior While the focus is on automobiles this book also highlights motorcycles heavy commercial vehicles and off road vehicles The authors of the individual chapters both from automotive industry and universities address basic issues but also include references to significant papers for further reading Thus the handbook is devoted both to the beginner wishing to acquire basic knowledge on a specific topic and to the experienced engineer or scientist wishing to have up to date information on a particular subject It can also be used as a textbook for master courses at universities The handbook begins with a short history of road and off road vehicle dynamics followed by detailed state of the art chapters on modeling analysis and optimization in vehicle system dynamics vehicle concepts and aerodynamics pneumatic tires and contact wheel road off road modeling vehicle subsystems vehicle dynamics and active safety man vehicle interaction intelligent vehicle systems and road accident reconstruction and passive safety Provides extensive coverage of modeling simulation and analysis techniques Surveys all vehicle subsystems from a vehicle dynamics point of view Focuses on pneumatic tires and contact wheel road off road Discusses intelligent vehicle systems technologies and active safety Considers safety factors and accident reconstruction procedures Includes chapters written by leading experts from all over the world This text provides an applicable source of information for all people interested in a deeper understanding of road vehicle dynamics and related problems Ein Beitrag zur Auflösung des Zielkonfliktes zwischen fahrdynamik-, fahrkomfort- und energieeffizienzprägenden Reifencharakteristika Florian Birnbaum,2024-12-23 In fr hen Phasen des Fahrzeugentwicklungsprozesses ist zur Ableitung von Komponentenzielen f r den Reifen die Kenntnis von zwischen fahrdynamik fahrkomfort und energieeffizienzpr genden Reifencharakteristika bestehenden Wechselwirkungen von elementarer Bedeutung Allerdings sind die potentiell resultierenden Zielkonflikte in der Eigenschaftsableitung nach dem Stand der Technik unzureichend verstanden Im Rahmen der vorliegenden Arbeit wird daher eine Methodik vorgestellt die den Einfluss von konstruktiven und materialtechnischen Reifenparametern auf objektive Komponenten und Gesamtfahrzeugkennwerte anhand von physisch aufgebauten Versuchsreifen einer Reifendimension untersucht Dazu werden zun chst die Reifenkennwerte welche Fahrdynamik Fahrkomfort und Energieeffizienz pr gen gegen bergestellt Das Laufstreifenelastomer bestimmt neben den maximalen Reibwerten den Rollwiderstandskoeffizient ma geblich Neben dem Laufstreifen wird die Kraft bertragung im Linearbereich durch die Steifigkeit der Reifenaufbaukonstruktion gepr gt Dementsprechend ist ein stark ausgepr gter Zielkonflikt zwischen Rollwiderstand Schr glaufsteifigkeit und Reibwerten

ersichtlich Im Gegensatz dazu zeigen die untersuchten komfortrelevanten Reifeneigenschaften wesentlich geringere Unterschiede auf Anschlie end werden auf Gesamtfahrzeugebene die Auswirkungen von konstruktiven und materialtechnischen Reifenparametern in Versuch und Simulation umfassend analysiert Die objektiven Kennwerte der Fahrdynamik werden im Linear und Grenzbereich ma geblich vom Reifenverhalten gepr gt In Abweichung dazu zeigt der mechanische Gesamtfahrzeugkomfort wesentlich geringere Wechselwirkungen zu den untersuchten Reifenparametern auf Basierend auf den identifizierten Zusammenh ngen wird ein Ansatz zur Minimierung des aufgezeigten Zielkonfliktes vorgestellt Anhand der aufgebauten Spezifikationen ist ableitbar dass Reifen mit rollwiderstandsoptimierten Laufstreifen den Linearbereich der Fahrdynamik durch eine steifere Aufbaukonstruktion positiv beeinflussen k nnen Auf Grundlage dieses Wirkkettenverst ndnisses wird ein Reifenmodell mit physikalischem Ansatz entwickelt welches einflussreiche Reifenkennwerte des untersuchten Zielkonfliktes abbildet Dazu wird die horizontale Kraft bertragung zwischen Reifen und Fahrbahn mittels eines Borstenmodells mit flexibler Aufbaukonstruktion dargestellt Die Kontaktl nge der Rollwiderstand sowie das Umschlie ungsverhalten des Reifens von singul ren Hindernissen wird durch ein flexibles G rtelringmodell repr sentiert Basierend auf der durchgef hrten Analyse ist demnach ein Beitrag zur zielgerichteten Ableitung von Reifeneigenschaften geschaffen worden wodurch folglich eine Einsparung von Entwicklungszeit und kosten ber die gesamte Reifenentwicklung erm glicht wird **Automotive Tire Noise and Vibrations** Xu Wang,2020-07-29 Automotive Tire Noise and Vibrations Analysis Measurement and Simulation presents the latest generation mechanisms of tire road noise The book focuses not only on tire road noise issues from the tire road structures materials and dynamics but also from a whole vehicle system The analyses cover finite element modeling mathematical simulations and experimental tests including works done to mitigate noise This book provides a summary of tire noise and vibration research with a focus on new simulation and measurement techniques Covers new measurements techniques and simulation strategies that are critical in accurately assessing tire noise and vibration Provides recent simulation progress and findings of CAE on analysis of generation mechanisms of the tire road noise Features a Statistical Energy Analysis SEA and model of a multilayer trim to enhance the sound absorption of tire road noise *Highway Safety Literature* ,1982 **Federal Register** ,2012-10 **Vehicle Noise and Vibration Refinement** Xu Wang,2010-03-12 High standards of noise vibration and harshness NVH performance are expected in vehicle design Refinement is therefore one of the main engineering design attributes to be addressed when developing new vehicle models and components Vehicle noise and vibration refinement provides a review of noise and vibration refinement principles methods advanced experimental and modelling techniques and palliative treatments necessary in the process of vehicle design development and integration in order to meet noise and vibration standards Case studies from the collective experience of specialists working for major automotive companies are included to form an important reference for engineers practising in the motor industry who seek to overcome the technological challenges faced

in developing quieter more comfortable cars The reader will be able to develop an in depth knowledge of the source and transmission mechanisms of noise and vibration in motor vehicles and a clear understanding of vehicle refinement issues that directly influence a customer s purchasing decision Reviews noise and vibration refinement principles methods and modelling techniques necessary in vehicle design development and integration in order to meet noise and vibration standards Outlines objectives driving development and the significance of vehicle noise and vibration refinement whilst documenting definitions of key terms for use in practice Case studies demonstrate measurement and modelling in industry and illustrate key testing methods including hand sensing and environmental testing **Experimental Vibro-acoustics** Joshua Meggitt,Andrew Moorhouse,2025-07-01 Experimental Vibro acoustics is the first comprehensive practical engineering guide for the effective use of measured vibro acoustic data in a component based approach to the analysis simulation virtual prototyping and digital twinning of machines and mechanical systems The book provides practical techniques which cover measurement data processing and uncertainties and includes many tricks of the trade It also includes a range of case studies and a detailed walk through example in a tutorial style Further it focuses on the in situ blocked force method now a full international standard through which many of the developments in the component based approach have been based This book is essential for design engineers in vibration acoustics and structural dynamics diagnosing and troubleshooting vibro acoustic problems in machines and mechanical systems as well as simulation of existing and virtual assemblies It extends beyond the core of the automotive industries to new applications in air rail and marine transport as well as for domestic and industrial equipment and buildings and is relevant to both researchers and industrial engineers *The Multibody Systems Approach to Vehicle Dynamics* Michael Blundell,Damian Harty,2004-08-21 Multibody Systems Approach to Vehicle Dynamics aims to bridge a gap between the subject of classical vehicle dynamics and the general purpose computer based discipline known as multibody systems analysis MBS The book begins by describing the emergence of MBS and providing an overview of its role in vehicle design and development This is followed by separate chapters on the modeling analysis and post processing capabilities of a typical simulation software the modeling and analysis of the suspension system tire force and moment generating characteristics and subsequent modeling of these in an MBS simulation and the modeling and assembly of the rest of the vehicle including the anti roll bars and steering systems The final two chapters deal with the simulation output and interpretation of results and a review of the use of active systems to modify the dynamics in modern passenger cars This book intended for a wide audience including not only undergraduate postgraduate and research students working in this area but also practicing engineers in industry who require a reference text dealing with the major relevant areas within the discipline Full of practical examples and applications Uses industry standard ADAMS software based applications Guides readers from modelling suspension movement through to full vehicle models able to perform handling manoeuvres

Advanced Tire Mechanics Yukio Nakajima,2019-04-03 This book highlights the mechanics of tire performance offering

detailed explanations of deriving basic equations for the fundamental properties of tires and discussing ways to improve tire performance using these equations It also compares the theory with practical measurements The book commences with composite mechanics which is the fundamental theory for belt and carcass tires and covers classical modified and discrete lamination theory It then addresses the theory of tire shape and spring properties and the mechanics of tread pattern contact properties as was well as the performance of various tires This comprehensive book is a valuable resource for engineers involved in tire design and offers unique insights and examples of improvement of tire performances **Objective Tyre Development : Definition and Analysis of Tyre Characteristics and Quantification of their Conflicts** Peckelsen, Ulrico,2017-12-04 The present work focuses on tyres for passenger cars especially on its influence on power loss lateral dynamics ride comfort and interior noise The objective of the work is the quantification of conflicts between four selected requirements considering the physical constraints given by the tyre The method proposed in the present book is based on a set of functional tyre characteristics a physical tyre model and a procedure for identifying and quantifying the conflicts

Engine Testing A. J. Martyr,M.A. PLINT,2012-04-18 Engine Testing is a unique well organized and comprehensive collection of the different aspects of engine and vehicle testing equipment and infrastructure for anyone involved in facility design and management physical testing and the maintenance upgrading and trouble shooting of testing equipment Designed so that its chapters can all stand alone to be read in sequence or out of order as needed Engine Testing is also an ideal resource for automotive engineers required to perform testing functions whose jobs do not involve engine testing on a regular basis This recognized standard reference for the subject is now enhanced with new chapters on hybrid testing OBD on board diagnostics and sensor signals from modern engines One of few books dedicated to engine testing and a true recognized market leader on the subject Covers all key aspects of this large topic including test cell design and setup data management and dynamometer selection and use with new chapters on hybrid testing OBD on board diagnostics and sensor signals from modern engines Brings together otherwise scattered information on the theory and practice of engine testing into one up to date reference for automotive engineers who must refer to such knowledge on a daily basis Engine Testing Anthony Martyr,Michael Alexander Plint,2007 This book brings together the large and scattered body of information on the theory and practice of engine testing to which any engineer responsible for work of this kind must have access Engine testing is a fundamental part of development of new engine and powertrain systems as well as of the modification of existing systems It forms a significant part of the practical work of many automotive and mechanical engineers in the auto manufacturing companies their suppliers suppliers specialist engineering services organisations the motor sport sector hybrid vehicles and tuning sector The eclectic nature of engine powertrain chassis and whole vehicle testing makes this comprehensive book a true must have reference for those in the automotive industry as well as more advanced students of automotive engineering

Sound-Engineering im Automobilbereich Klaus Genuit,2010-12-17 Aufgrund steigender Komfortanspr che der

Kunden im Automobilbereich gewinnen Noise Vibration Harshness NVH Sound Design und Fahrkomfort an Bedeutung Fahrzeugakustik wird zu einem wichtigen Aufgabenfeld in der Automobilentwicklung Ingenieure in der Branche Automobilhersteller und Zulieferer arbeiten von der Konzeptphase ber die Komponenten und Fahrzeugentwicklung bis hin zur Serienphase zusammen an der Optimierung dieser Themengebiete Dabei muss in der industriellen Praxis die Fahrzeugakustik stets integrativ im Kontext weiterer Entwicklungsfelder wie Antrieb Aerodynamik Design Package Fahrwerk Sicherheit behandelt werden sie entzieht sich einer isolierten Betrachtung Die Leser erhalten mit diesem berblickswerk die M glichkeit sich dem Thema schnell anzun hern auf Grundlagen und Details gezielt zugreifen zu k nnen und die f r die berufliche Praxis notwendige Kompetenz aufzubauen Die Autoren behandeln sowohl die Fahrzeuginnenger usche als auch und Fahrzeugau enger usche Hilfreiche akustische Beispiele auf extras springer com abrufbar unterst tzen die textlichen Ausf hrungen *The Chartered Mechanical Engineer* ,1971 **PIB Summary 2019 Exams Exclusive Vol-1st** Dheeraj Sharma,Exams Exclusive,2020-02-02 2nd Edition of PIB Dedicated to Learner s In this Book we cover most important News from PIB Vol 1st Jan_2019 to June_2019 with detailed Analysis Helpful in preparation of UPSC CSE IAS NDA CDS and many other Exams

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