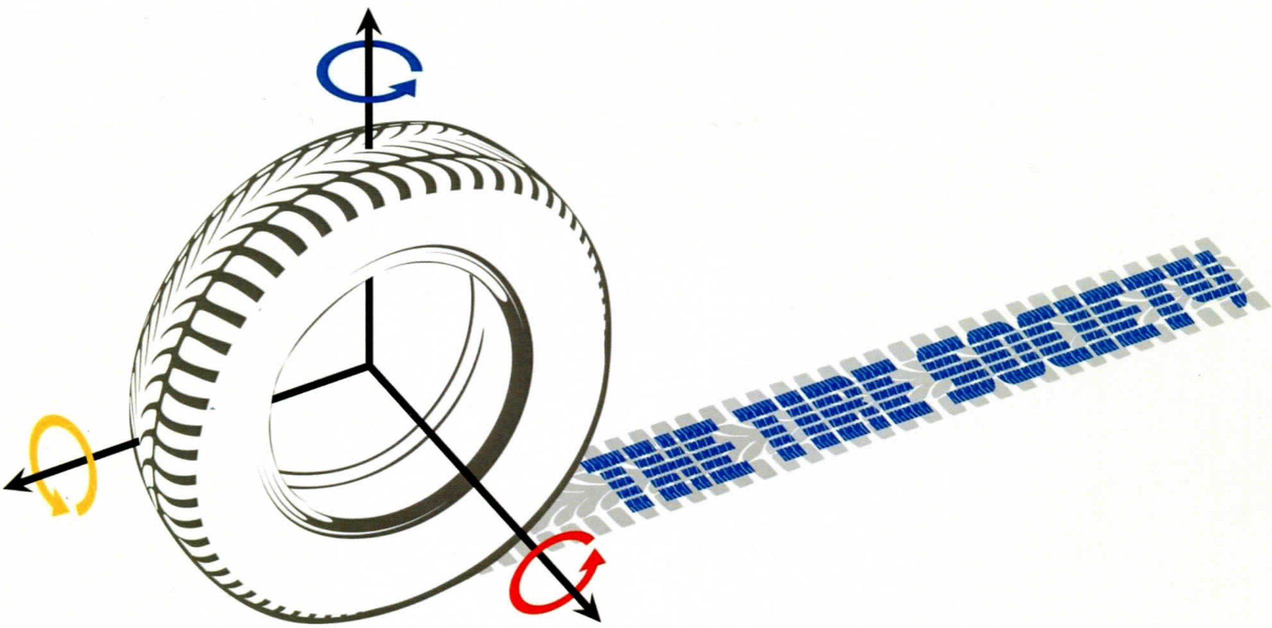
34th Annual Business Meeting and Conference on Tire Science and Technology

Program and Abstracts



September 9-10, 2015
Hilton Akron/Fairlawn Hotel
Akron, Ohio

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34th Annual Meeting and Conference on Tire Science and Technology

Day 1 - Wednesday September 9, 2015

All Sessions take place in *Akron/Summit Ballroom*

7:00 AM			Registration (*Fairlawn Hilton* until 5pm)	
8:00 AM	10		Welcome (*Akron/Summit Ballroom*)	Saied Taheri, President
8:10 AM	60		**Keynote Lecture:** Beyond Black and Round: Translating Tire Technology to Create a Connection with Today's Consumer	TJ Higgins, President, Consumer Tire Operations, Bridgestone Americas, Inc
9:10 AM	5		Opening Remarks	Anoop Varghese, Conference Chair
9:15 AM	5		**Session 1: Materials**	**Janice Tardiff**, *Ford Motor Company*
9:20 AM	25	1.1	Effect of Reinforcement Made of Dissimilar Materials on Tire Standing Wave	Mahmoud Assaad, *The Goodyear Tire & Rubber Company*
9:45 AM	25	1.2	Influence of Polymer Microstructure on the Characteristics of Silica-filled Rubber	Pim Warasitthinon, *Cooper Tire & Rubber Company*
10:10 AM	25	1.3	Fatigue Life Estimation of Rubber Component Under Stochastic Loading Condition	Hao Wang, *Tsinghua University*
10:35 AM	20		Break	
10:55 AM	5		**Session 2: Tire Vehicle Systems**	**Ric Mousseau**, *General Motors Corporation*
11:00 AM	25	2.1	Expansion of "ologic" Technology for Eco-friendly Vehicles	Isao Kuwayama, *Bridgestone Corporation*
11:25 AM	25	2.2	Vehicle and Suspension Influence on Vehicle Wheel Alignment Measurements	Peter Tkacik, *University of North Carolina - Charlotte*
11:50 AM	75		Lunch (*on your own*)	
1:05 PM	5		**Session 3: Student Session 1**	**Kory Smith**, *Bridgestone Americas Tire Operations, LLC*
1:10 PM	25	3.1	Rubber-Road Contact: Comparison of Physics-Based Theory and Indoor Experiments	Mehran Motamedi, *Virginia Tech*
1:35 PM	25	3.2	Investigation of Fill Factor in 2-wing Rotor Mixing of Rubber Using Computational Fluid Dynamics (CFD)	Pashupati Dhakal, *University of Akron*
2:00 PM	25	3.3	A Consistent Implementation of Inelastic Materials in Steady State Rolling	Mario Garcia, *Technische Universität Dresden*
2:25 PM	25	3.4	The Use of Three-dimensional Printing in Replicating Road Surface Roughness for Rubber Friction: A Feasibility Study	Mona Kanafi, *Aalto University*
2:50 PM	20		Break	
3:10 PM	5		**Session 4: Student Session 2**	**Michelle Hoo Fatt**, *University of Akron*
3:15 PM	25	4.1	Rolling Resistance Revisited	Yi Li, *Virginia Tech*
3:40 PM	25	4.2	Motorcycle Analytical Modelling Including Tyre-Wheel Non-Uniformities for Ride Comfort Analysis	Matheus Vallim, *Universidade Estadual de Campinas*
4:05 PM	25	4.3	A Computational Fluid Dynamics (CFD) Model for Investigating Air-Pumping Mechanisms in Air-Borne Tire Noise	Prashanta Gautam, *University of Akron*
4:30 PM	25	4.4	Molecular Dynamic Simulation of Mechanical Properties of Filled Polymer	Chi Ma, *University of Akron*
4:55 PM	50		Reception (*Conrad Ballroom, Lower Level*)	
5:45 PM	50		Banquet (*Conrad Ballroom, Lower Level*)	
6:35 PM	20		Awards	
6:55 PM	50		**Dinner Speaker:** NASA's Journey to Mars (*Conrad Ballroom*)	**Kathleen Schubert**, Deputy Chief, NASA
7:45 PM			Close of Day 1	

34th Annual Meeting and Conference on Tire Science and Technology

Day 2 – Thursday September 10, 2015

All Sessions take place in *Akron/Summit Ballroom*

7:15 AM			Registration (*Fairlawn Hilton* until noon)	
8:00 AM	5		Opening Remarks	Anoop Varghese, Conference Chair
8:05 AM	20		State of the Society	Saied Taheri, President
8:25 AM	5		**Session 5: Tire Performance**	**Jaehyung Ju**, *University of North Texas*
8:30 AM	25	5.1	Effect of Tyre Design Parameters Over Failure Pertaining to Overloading In Commercial Tyre Category	Abhishek Bhatnagar, *JK Tyre and Industries Ltd*
8:55 AM	25	5.2	Computing Tire Component Durability Via Critical Plane Analysis	Will Mars, *Endurica*
9:20 AM	20		Break	
9:40 AM	5		**Session 6: Tire Road Interaction**	**Dan Osborne**, *Michelin Americas Research and Development Corporation*
9:45 AM	25	6.1	Multiscale Simulation to Determine Rubber Friction on Asphalt Surfaces	Michael Kaliske, *Technische Universität Dresden*
10:10 AM	25	6.2	Analysis of Lateral Vibration for Tire Using Flexible Ring Model	Masami Matsubara, *Toyohashi University of Technology*
10:35 AM	25	6.3	Simulation of the Wear and Handling Performance Tradeoff Utilizing Multi-objective Optimization and Tame Tire	Jeffery Anderson, *Michelin Americas*
11:00 PM	25	6.4	Investigation on the effect of Tread Pattern on TBR Rolling noise	Yintao Wei, *Tsinghua University*
11:25 AM	25	6.5	Estimation of the Contact Patch Length and Normal Load Using Intelligent Tires	Seyedmeysam Khaleghian, *Virginia Tech*
11:50 AM	75		Lunch (*on your own*)	
1:05 PM	60		**Plenary Lecture:** Rubber Friction and Tire Dynamics (*Akron/Summit Ballroom*)	**Bo N J Persson**, Multiscale Consulting
2:05 PM	5		**Session 7: Simulations**	**Carlo Fabrizi**, *Bridgestone Europe*
2:10 AM	25	7.1	Frictional Heating With Application to Dry And Wet Rubber Friction	Bo N J Persson, *Multiscale Consulting*
2:35 PM	25	7.2	Tire Rolling Resistance Prediction – Improvement on Material Characterization	Roberto Lombardi, *Bridgestone Europe*
3:00 PM	25	7.3	Prediction of Uneven Tire Wear Using Wear Progress Simulation	Ryota Tamada, *Sumitomo Rubber Industries*
3:25 PM	25	7.4	Comparison of 2-Wing and 4-Wing Rotor Mixing of Rubber Using Computational Fluid Dynamics (CFD)	Suma Das, *University of Akron*
3:50 PM	20		Break	
4:10 PM	5		**Session 8: Emerging Technologies**	**Jim McIntyre**, *Camber Ridge, LLC*
4:15 PM	25	8.1	Robustness and Applicability of a Model-Based Tire State Estimator for an Intelligent Tire	Antoine Schmeitz, *TNO*
4:40 PM	25	8.2	Force and Moment Characteristics of a Rhombi Tessellated Non-Pneumatic Tyre	Anand Kumar, *Indian Institute of Technology - Madras*
5:05 PM	25	8.3	Read Range Sensitivity of RFID in Commercial Tires	Terence Wei, *Bridgestone Americas*
5:30 PM	10		Conference Closing Remarks	

About The Tire Society

The Tire Society was established to disseminate knowledge and to stimulate development in the science and technology of tires. These ends are pursued through seminars, technical meetings and publication of the journal, Tire Science and Technology. The Society is a not-for-profit Ohio corporation managed by a duly elected Executive Board of tire industry professionals who serve on a volunteer basis.

In addition to the Journal Editor, the associate editors volunteer time to contribute to the peer review process associated with publishing manuscripts in the Tire Science & Technology Journal:

The Tire Society Executive Board is also supported by an Advisory Board:

In addition to the Executive Board, many members volunteered their time to put together the 2015 conference.

CONFERENCE COMMITTEE:

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Co-Chair:	Kanwar B. Singh	*The Goodyear Tire & Rubber Company*

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Ric Mousseau	*General Motors Corp.*
Kory Smith	*Bridgestone Americas Tire Operations, LLC*
Michelle Hoo Fatt	*The University of Akron*
Jaehyung Ju	*University of North Texas*
Dan Osborne	*Michelin Americas R & D Corporation*
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The 2016 Conference
Conference Dates: September 13-14, 2016

Program Chair:	Kanwar B. Singh	*The Goodyear Tire & Rubber Company*
Co-Chair:	Joshua Herron	*Kenda Tires*

The 2016 conference committee would appreciate your assistance and suggestions. A call for papers will be issued to attendees of the 2015 conference and will be available online. Visit www.tiresociety.org for updates.

Keynote Address

TJ Higgins
President, Consumer Integrated Tire Division, U.S. & Canada
Bridgestone Americas Tire Operations (BATO)

TJ Higgins joined Bridgestone Americas in October 2014 to serve as President, Consumer Integrated Tire Division, U.S. and Canada. TJ leads a team which includes Bridgestone Retail Operations, original equipment sales and consumer tire replacement sales, as well as the company's Credit First National Association (CFNA).

Before joining Bridgestone, TJ served as the North America regional president for Pfizer Consumer Healthcare where he was responsible for leading the operations of recognizable brands and products such as Advil, Centrum, ChapStick, Robitussin and Emergen-C. TJ also previously held leadership positions at Merck and Vlasic Foods.

TJ graduated summa cum laude from Lehigh University with a bachelor's degree in accounting. He earned his MBA at Harvard University.

Title of Talk: Beyond Black and Round: Translating Tire Technology to Create a Connection with Today's Consumer

Aside from their round and black traits, tires remain a mystery to most consumers. Featuring more than 30 components and incredibly sophisticated technologies, today's tires perform so well drivers don't have to think about them. This impression is critical as the consumer's ambivalent mindset could permit the industry to spiral down toward commoditization. TJ Higgins, President, U.S. & Canada Integrated Consumer Tire Division, Bridgestone Americas Tire Operations, will challenge the present state of the industry with a strategic look at how to connect the technology that goes into a tire with a story and a message that truly influences the thinking of today's consumer.

Banquet Dinner Speaker

Kathleen Schubert
Deputy Chief, Exploration System Project
NASA Glenn Research Center

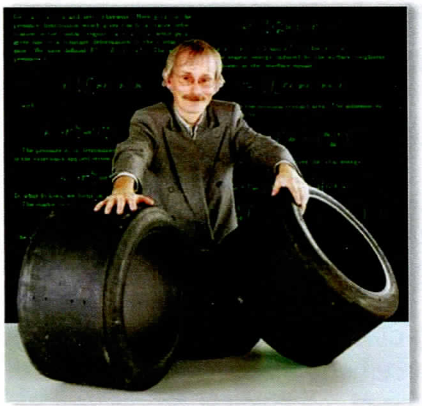
Kathleen Schubert currently serves as the Deputy Director for Safety and Mission Assurance at the National Aeronautics and Space Administration's John H. Glenn Research Center in Cleveland Ohio. In this position, she is responsible for establishing and assuring compliance with NASA's safety and mission assurance strategies, policies, and standards. Prior to this position, Ms. Schubert served in key leadership roles at both NASA Glenn Research Center and at the Johnson Space Center responsible for the development of the Service Module, a critical module that is part of NASA's newest spacecraft called Orion. Ms Schubert brings a wealth of knowledge and experience in space flight development and management, with demonstrated successes in building collaborations with complex and diverse technical teams across the project management, Safety & Mission Assurance, and engineering communities at NASA, and with NASA's industrial and international partners. Ms. Schubert is the recipient of the NASA Outstanding Leadership Medal, NASA Exceptional Service Medal, and the NASA Exceptional Achievement Medal.

NASA Glenn is engaged in research, technology and systems development programs supporting space propulsion, space power, space communications, aeronautical propulsion, microgravity sciences and materials. Ms. Schubert has served in a number of leadership positions since joining NASA in 1985. She is a native of Northeast Ohio and currently a resident of Medina Ohio. Ms. Schubert earned her Master's Degree in Electrical Engineering from Cleveland State University and a Bachelor's Degree in Electrical Engineering from Ohio Northern University.

Title of Talk: NASA's Journey to Mars

"NASA's Journey to Mars" will highlight NASA's efforts to build the next generation spacecraft called Orion, that will carry humans to destinations beyond Earth's orbit never before visited by humans, including an asteroid and Mars. The presentation will feature highlights from the first un-crewed test flight, Exploration Flight Test -1, a four-and-a-half-hour flight that was successfully flown in December 2014. The Orion test flight provided critical data necessary to prove out systems essential for crew safety in preparation for future missions that will travel farther into space than any other spacecraft built for humans has travelled in more than 40 years.

Plenary Lecture



Bo N J Persson
Multiscale Consulting, Jülich, Germany

Dr. Persson is a physicist working in the field of tribology; in particular, the tribology of soft materials. In 1980 he got a PhD in theoretical physics from Chalmers Technical University, Sweden. He started out in the field of ultra-high vacuum surface physics and has also performed research in biophysics (bionics) before turning to tribology problems around 1995. After spending two years as a postdoc at IBM Yorktown Heights, New York, and the IBM Zurich research labs, he is working as a research scientist at Research Center Jülich, Germany. One of Dr. Persson's most important contributions to tribology is a novel analytical contact mechanics theory for rough surfaces. This theory is of great practical use and has resulted in the interest from many industrial companies. Based on this theory he has developed computer software for many processes of industrial interest and formed the consulting company www.MultiscaleConsulting.com where the knowledge gained during many years of studies is transferred to industries. Dr. Persson has received many awards for his scientific discoveries, including the Walter Schottky Prize of the German Physical Society and the John Yarwood Memorial Medal of the British Vacuum Council. He has published about 400 papers in international peer-reviewed journals and is very well known for his book *Sliding Friction: Physical Principles and Application*.

Title of Talk: Rubber Friction and Tire Dynamics

Surface roughness has a big influence on the dry or lubricated contact between solids in stationary or sliding contact. Surface roughness often occurs over many decades in length scale, e.g., from nm to the linear size of the objects, which makes it a hard problem for numerical (e.g., finite element) methods. I have developed an analytical contact mechanics theory which can take into account all relevant length scales.

The theory is very flexible and can be applied not only to homogeneous elastic solids but can include layering, plasticity and viscoelasticity (which is important for rubber-like materials). Both dry and lubricated contact mechanics, with or without adhesion, can be studied using this approach. The theory predicts the area of real contact, the distribution of contact stresses and the distribution of interfacial separations which is important for the leak-rate of seals. It also predicts the viscoelastic contribution to rubber friction and can be used to obtain the Stribeck curves for lubricated contacts.

In this presentation I will describe the theory in some detail and present applications to rubber friction, where I will emphasize the fundamental role of frictional heating. I will show how the flash temperature in the rubber-road contact areas can be included in a simple hot-cold friction law. This friction law is used in a simple tire model for calculations of μ-slip curves and for simulations of ABS-braking.

Paper number 1.1

Effect of Reinforcement Made of Dissimilar Materials on Tire Standing Wave

Xianwei Meng[1], **Mahmoud C. Assaad[1]**, Romain Mersch[2] and Mahesh Kavaturu[1]

[1]The Goodyear Tire & Rubber Company, Innovation Center, Ohio, USA
[2]The Goodyear Tire & Rubber Company, Innovation Center, Luxembourg
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Tire reinforcing layers with cords oriented close to the tire rolling direction have a significant effect on the tire standing wave. In this study, a virtual reinforcement made of dissimilar materials was numerically optimized to obtain the desired high-speed mechanical properties using Explicit FEA simulation. The optimized reinforcement materials were then used in a tire construction to evaluate their impact on the tire standing wave. Simulated tire standing wave includes radial growth vs. speed, standing wave onset speed, and growth of standing wave amplitude vs. speed. In addition, the impact of the tire standing wave on the individual reinforcement's axial force and axial strain were also studied. The Explicit FEA tire model was able to capture the tire standing wave observed from the experiments.

is this a kevlar composite cord?
basic conclusions: stiffer cord is better
lower density is cheaper

Paper number 1.2

Influence of Polymer Microstructure on the Characteristics of Silica-filled Rubber

Nuthathai Warasitthinon, Yusheng Chen and Matthew S. Snider

Cooper Tire & Rubber Company, Ohio, USA
Email: npwarasitthinon@coopertire.com

Knowing the effect of microstructure of solution styrene butadiene rubber (SSBR) on filler-filler interaction is crucial to the understanding of structure-property relationships in silica-reinforced compounds. The properties of silica-reinforced rubber compounds are critical for tire performance. Higher silica loadings are used in tread compounds to obtain desirable performance characteristics such as wet traction and rolling resistance. A group of commercial SSBR polymers with similar microstructure were chosen for use in this study. A strain sweep of dynamic properties was obtained using an RPA (Rubber Processing Analyzer) to characterize filler-polymer interaction. Rheological, static and dynamic mechanical properties were investigated. Polymer microstructure was characterized using Nuclear Magnetic Resonance spectroscopy (NMR) technique.

Paper number 1.3

Fatigue Life Estimation of Rubber Component Under Stochastic Loading Condition

Hao Wang[1], Zhe Liu[1], Yintao Wei[1] and William V. Mars[2]

[1]Department of Automotive Engineering, Tsinghua University, Beijing China
[2]Endurica LLC, Ohio, USA
Email: wvmars@endurica.com

Rubber products such as tires and rubber shock absorbers usually work under random loading conditions. The durability analysis of these products becomes complicated considering the inconstant amplitudes and variable frequencies of the practical loads experienced by the rubber components. Traditional fatigue life prediction methods concentrate on the description of mechanical behavior of rubber material; few account for realistic service histories.

A new fatigue life evaluation approach for rubber components subjected to random loads is proposed in this research. The approach is based on fracture mechanics perspective, from which the fatigue behavior of rubber material is described. The CED criterion is applied in a conservative crack propagation model to determine the energy release rate, thus to compute the crack growth rate. On the other hand, a method to generate loading sequences in time-domain from the PSD function is introduced, which is essential for the fatigue life evaluation under random loading condition.

In order to verify this approach, a simple finite element model of rubber specimen is built in ABAQUS, with care taken to generate the loading sequences using two comparative methods. The lifetime results calculated for both loading cases are analyzed and compared from several aspects; similarity and some certain extent of consistency are observed from the comparison. Consequently the validity of our approach is soundly proved.

Paper number 2.1

Expansion of "ologic" Technology for Eco-friendly Vehicles

Isao Kuwayama, Hiroyuki Matsumoto and Hisashi Heguri

Bridgestone Corporation, Tokyo, Japan
Email: isao.kuwayama@bridgestone.com

In order to realize a substantially eco-friendly tire which simultaneously offers appreciable drivability and traction performance, authors have developed and proposed a large and narrow tire technology called "ologic" considering size and Inflation Pressure (IP) effects as one of the next generation tire technologies.

In this study, exclusive technologies in terms of tread pattern and belt construction considering a synergetic effect with compound and separation of lateral/longitudinal stiffness have been developed and evaluated through both numerical simulations and experimental analysis.

As a result, appreciable improvements in terms of ologic's advantages have been observed. By utilizing the exclusive technologies, an intermediate size of ologic tires is proposed as well for assisting adoption of ologic tires in next generation of eco-vehicles with a hope of developing a combined package of tire-suspension system and an ologic tire for making full use of the ologic's advantages.

Tall, narrow tires, High inflation 155/70 R19, 320 kPa

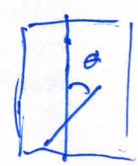
High modulus tread is used to increase "actual contact area"

use pinhole sipes and wider sipes to decrease compression stiffness of tread giving better enveloping of microtexture

belts are high angle (60-70 deg) with a high stiffness cap layer

lateral shrinkage becomes smaller as belt angle increases

more uniform contact pressure allows tire to stick for more of footprint, minimizing the slip region



Paper number 2.2

Vehicle and Suspension Influence on Vehicle Wheel Alignment Measurements

Peter Thomas Tkacik[1], Michael Casino[1], David Noakes[1], Nick Kauffman[1], Daniel Rohwedder[1], Jugal Popat[1], Aneesh Nabar[1], Tucker Bisel[2], Harsh Patel[1] and Zachary Merrill[3]

[1] The University of North Carolina at Charlotte, North Carolina, USA
[2]Clemson University, South Carolina, USA
[3]Michelin Americas Research and Development Corp. South Carolina, USA
Email: ptkacik@uncc.edu

Many things influence the measurement of vehicle wheel alignment including the alignment equipment, the vehicle, and measurement protocols and this paper looks into these various influential effects on the alignment measurement. 140+ wheel alignments were performed in our lab to characterize accuracy and repeatability of measurements on a range of vehicles and operators.

Wheel alignment technicians are called on to provide accurate measurements; however, if some protocols slow down a measurement, pressure may be on the technician to take short cuts. Some of these may be trivial and some are shown to be very sensitive. Vehicle variables include such things as effect of loading the vehicle with weights, inducing a toe-out preload force against the wheels, and reversing the alignment heads. Influence on the suspension parameters like camber, caster, toe, cross camber and cross caster variation are presented.

Temporal vehicle suspension measurement variability and the repeatability was assessed by measuring the alignment angles on a vehicle repeatedly on one test day and across weeks, months, and a year. The testing was performed on a Hunter ProAlign (with DSP700 sensors) wheel alignment machine. Measurements were made on a small front drive car (Mini Cooper), a rear drive full-sized car (Mercedes E-Class), two Sports cars (Porsche 911 and Honda S2000 CR), a race car (NASCAR Sprint Cup car), and an SUV (Acura MDX). The results in this paper report the variables influencing wheel alignment measurement.

Paper number 3.1

Rubber-Road Contact:
Comparison of Physics-Based Theory and Indoor Experiments

Mehran Motamedi, Saied Taheri and Corina Sandu

Virginia Tech, Virginia, USA
Email: motamedi@vt.edu

For tire designers, rubber friction is a topic of pronounced practical importance. Thus, development of a rubber-road contact model is of great interest. In this research, to predict the effectiveness of the tread compound in a tire as it interacts with the pavement, the physics-based multiscale rubber friction theories developed by B. Persson and M. Klüppel are studied. The strengths of each method are identified and incorporated into a consolidated model that is more comprehensive and proficient than any single existing physics-based approach.

In the present work, the friction coefficient is estimated for a summer tire tread compound sliding on sandpaper. The inputs to the model are the fractal properties of the rough surface and the dynamic viscoelastic modulus of rubber. The sandpaper surface profile is measured accurately using an optical profilometer. Two-dimensional parameterization is done using one-dimensional profile measurements. The tire tread compound is characterized via Dynamic Mechanical Analysis.

To validate the friction model, a laboratory-based rubber friction test equipment is designed and built that can measure the friction between a rubber sample and any arbitrary rough surface. The apparatus consists of a turntable that can have the surface characteristics of choice, and a rubber wheel in contact with the turntable. The wheel speed as well as the turntable speed can be controlled precisely to generate arbitrary values of longitudinal slip at which the dynamic coefficient of friction is measured. The correlation between the simulation and the experimental results is investigated.

questions
Measurement of test tire surface temp
Δ Temp front to rear
conditioning of test surface
E274 tire tread is NR

Paper number 3.2

Investigation of Fill Factor in 2-wing Rotor Mixing of Rubber Using Computational Fluid Dynamics (CFD)

Pashupati Dhakal, Suma R. Das and Abhilash J. Chandy

University of Akron, Ohio, USA
Email: achandy@uakron.edu

The industrial process of manufacturing tires brings together all the ingredients required to mix a batch of rubber compound in an operation called mixing. The development and use of mixing in mixing chamber equipped with a rotor has a significant impact on the process itself, and understanding mixing is important in terms of evaluating how material, mixer design, and operating variables (rpm, temperature, ram pressure, etc.) affect distribution, dispersion and coupling reaction. One of the most important factors to consider is the fill factor, which is the volume of the material relative to the volume of the chamber.

It is critical to determine the operating regime in terms of the level of mixing material in the chamber in order to satisfy all the mixing requirements of the process. Furthermore, the availability of modern high-performance computing resources and accurate mathematical models makes computational fluid dynamics (CFD) an important and necessary tool in understanding some of the complex physical and chemical phenomena associated with such industrial manufacturing problems.

The objective of this paper is to assess the effect of fill factor in a 2-wing rotor geometry employed for rubber compounds mixing in the tire manufacturing process and thereby determine the best fill factor with regard to providing the highest mixing efficiency. A series of 3D CFD simulations in a mixing chamber with different fill factors including 45%, 60%, 75%, 90% and 100%, stirred by counter-rotating rotors, are carried out using a CFD code. Flow patterns, mixing index, particle trajectories and statistics such as segregation scale, length of stretch and pairwise distribution are presented to understand the mixing process with a long-term goal of improving product quality and throughput. Results showed that major mixing mechanism is shear for most of the fill factors and 75% fill factor has the best distributive mixing characteristics among the fill factors studied here.

Paper number 3.3

A Consistent Implementation of Inelastic Materials in Steady State Rolling

Mario A. Garcia[1], Michael Kaliske[1], Jin Wang[2] and Grama Bhashyam[2]

[1] Institute for Structural Analysis (ISD), Technische Universität, Dresden, Germany
[2] ANSYS, Inc., Pennsylvania, USA
Email: Michael.kaliske@tu-dresden.de

Rolling contact is an important topic in tire design and reliable numerical simulations are required in order to improve the tire layout, performance and safety. This includes the consideration of as many significant characteristics of the materials as possible. An example is found in the nonlinear and inelastic properties of the rubber compounds.

For numerical simulations of tires, steady state rolling is an efficient alternative to standard transient analyses and this work makes use of an Arbitrary Lagrangian Eulerian (ALE) formulation for the computation of the inertia contribution. Since the reference configuration is neither attached to the material nor fixed in space, handling history variables of inelastic materials becomes a complex task. A standard viscoelastic material approach is implemented. In the inelastic steady state rolling case, one location in the cross-section is depending on all material locations on its circumferential ring. A consistent linearization is formulated taking into account the contribution of all finite elements connected in hoop direction. As an outcome of this approach, the number of non-zero values in the general stiffness matrix increases, producing a more populated matrix that has to be solved.

This implementation is done in the commercial finite element code ANSYS. Numerical results confirm the reliability and capabilities of the linearization for the steady state viscoelastic material formulation. A discussion on the results obtained, important remarks and an outlook of further research are closing this work.

The Use of Three-dimensional Printing in Replicating Road Surface Roughness for Rubber Friction: A Feasibility Study

Mona Mahboob Kanafi and Ari J. Tuononen

Aalto University, Aalto, Finland
Email: mona.mahboobkanafi@aalto.fi

Despite the significant attention gained by the three-dimensional printing technology in many research fields, it has not yet found its application in the areas of tyre-road friction and pavement engineering. This article demonstrates the feasibility of replicating the pavement texture by means of a 3D printer as a potential substrate for rubber friction.

The strength of this technology in creating customized roughness patterns is investigated in detail. First, an image-stitching algorithm was developed for our optical profiler and a large topography of an asphalt specimen was obtained in the laboratory. A replica of this topography was then manufactured via one of the latest 3D printing devices. The replication efficacy of this printed sample was examined with two optical profilers through the surface roughness power spectrum density (PSD). A high replication performance was found for wavelengths down to 0.5 mm, while the replica appeared smooth at very small length scales.

Next, printed samples with artificial surface patterns were generated by the random process theory and fractal modelling, with their roughness characteristics being carefully defined. The original asphalt specimen, its replica and the artificial samples were then subjected to sliding friction tests. The results implied different frictional behavior between the asphalt specimen and its replica, which was attributed to the severe wear of the rubber on the rougher asphalt substrate, as well as the difference in the thermal conductivity of the samples.

From the friction responses in the artificial geometries, an increase was acknowledged in the friction as the Hurst exponent increases in case of a fractal surface. The results also suggested that reducing the roll-off wavevector (q0) of a road pavement, i.e. an increase in the maximum aggregate size, reduces the friction coefficient of the pavement. The findings disclose the exceptional strength of this new manufacturing technique for studies on tyre-road interactions.

Paper number 4.1

Rolling Resistance Revisited

Yi li and Robert l. West

Department of Mechanical Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA
E-mail address: tuoleita@vt.edu

Rolling resistance defined in terms of energy loss per unit distance is well accepted by tire science and industry community. It has been thought that the dominant part of energy loss goes into heat due to viscoelastic material property of rubber compounds excluding the effect of air drag on a rolling tire. The corresponding methods have been developed to calculate rolling loss (rolling resistance) into heat from work done by tire forces and moments.

In this paper, we point out that a certain amount of energy in rolling loss computed in previous conventional way is used to compensate mechanical work actually, which is not necessarily converted into heat. The portion of this amount of energy within total rolling loss varies with the stiffness of given tire structure. This is easily ignored by researchers and engineers. Then a fact was proved mathematically that one cannot compute a rolling tire's hysteretic loss which turns into heat from tire forces and moments directly.

A steady-state free rolling finite element tire model was provided to demonstrate our claim. These findings lead us to redefine the rolling resistance in a more effective way which was still from energy perspective and compatible with the most traditional way of definition from force notion. Moreover it can account for not only steady-state but also transient rolling tire even on non-flat road condition.

Paper number 4.2

Motorcycle Analytical Modelling Including Tyre-Wheel Non-Uniformities for Ride Comfort Analysis

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and Argemiro Luis de Aragão Costa[2]

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The transmission of vibrations in motorcycles and their perception by the passengers are fundamental in comfort analysis. Tyre non-uniformities can generate self-excitations at the rotational frequency of the wheel and contribute to the ride vibration environment. In this work a multi-body motorcycle model is built to evaluate the ride comfort with respect to tyre non-uniformities. The aim is to obtain a multi-degrees-of-freedom dynamic model that allows the tyre non-uniformities to predict the vertical force variations on the motorcycle. The motorcycle is a ten-degrees-of-freedom system, where each tyre-wheel is a four-degrees-of-freedom model. The tyre-wheel assemblies include two types of non-uniformities: lumped mass imbalance and radial run-out. Simulations of analytical model are compared with experimental tests.

Paper number 4.3

A Computational Fluid Dynamics (CFD) Model for Investigating Air-Pumping Mechanisms in Air-Borne Tire Noise

Prashanta Gautam, Kelly Gabor and Abhilash J. Chandy

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Email: achandy@uakron.edu

The reduction in powertrain noise over the last decade has led to an increased focus in reducing tire-road noise, largely due to the environmental concerns related to road traffic noise in industrial countries. Computational Fluid Dynamic (CFD) simulations conducted using ANSYS FLUENT, are presented here with the objective of understanding air-pumping and air turbulence noise generation mechanisms in tire-road contact. The CFD model employs a large eddy simulation (LES) turbulence modeling approach, where the filtered compressible Navier-Stokes equations are solved for two-dimensional (2D) tire geometries, and temporal and spatially accurate pressure fluctuations are utilized to determine sound pressure levels and dominant frequencies. The 2D tire geometry will be employed to study the noise effects resulting from single and multiple grooves with prescribed sidewall movement, which represents deformations due to the tire movement on a road surface.

Validation of the model will be conducted through qualitative and quantitative comparisons with previous computational and industry testing studies. These simulations are intended to provide a deeper understanding about the small-scale noise generation as well as the near- and far-field acoustics, thereby identifying control parameters that can help optimize the tire performance in terms of acoustics through novel and improved designs and paving the way for the automotive manufacturer to compare a variety of tires' noise and vibration characteristics without spending time and money for vehicle pass-by tests.

Paper number 4.4

Molecular Dynamic Simulation of Mechanical Properties of Filled Polymer

Chi Ma[1], Tuo Ji[2], Christopher G. Robertson[3], R Rajeshbabu[4], Jiahua Zhu[2] and Yalin Dong[1]

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Email: cm128@uakron.edu

A coarse-grained model has been built to study the effect of the interfacial interaction between filler and polymer on mechanical properties. The elastomer is modeled as bead-spring chain, and nano-fillers grafted with silane couplings are embedded into the polymer matrix. The potential parameters for polymer and fillers are chosen to maximally match Styrene Butadiene Rubber (SBR). Mechanical tensile tests are conducted for the cross-linked polymer as well as the filled polymer.

For the unfilled polymer, effects of crosslink density and temperature on the tensile behavior have been investigated and the molecular model is able to regenerate the similar stress-strain trends of experiments. For the filled polymer system, it is found that there is a critical value for the grafting density of silane to play a noticeable role in mechanical reinforcement. Only after reaching the critical value, it can then significantly enhance the mechanical property.

It is also revealed that there is no direct correlation between the mechanical reinforcement and the number of the independent polymer chains connected to fillers. Instead, the mechanical reinforcement is attributed to the suppression of mobility of polymer in the interfacial region resulting from the strengthened interaction through silane.

Effect of Tyre Design Parameters Over Failure Pertaining to Overloading in Commercial Tyre Category

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Asia is a huge tyre market with continuous growing challenges. Out of many challenges one of the most important is overloading trend as overloading will not only effect tyre mileage but many times tyre fail to perform. Tyres will not be able to sustain such overloads and finally end-up with premature failure. Because of this reason, cross ply tyres are still popular in Asian countries like India, Pakistan, Indonesia, China etc. Therefore this paper focuses on cross ply tyres for replacement market.

We cannot prevent tyre overloading as it is a market practice but we can co-relate some design aspects with tyre behavior under overloading. This paper will talk about the effect of tyre design parameters like shoulder drop, tyre cavity dimensions, tyre construction, filler profile, turn-up heights with respect to induced stresses in the tyre during overloading. The study will help us to maintain the tyre neutral profile undisturbed and finally resulting in an improved or optimized tyre design for overloading.

This paper summarizes simulation studies and some real time experiments. These are part of this paper in order to derive the exact conclusion for optimum tyre design for overloading application. This paper also gives certain aspects to avoid premature failures due to overloading.

Computing Tire Component Durability Via Critical Plane Analysis

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Tire developers are responsible to design against the possibility of crack development in each of the various components of a tire. The task requires knowledge of the fatigue behavior of each compound in the tire, as well as adequate accounting for the multiaxial stresses carried by tire materials. The analysis is illustrated here using the Endurica CL fatigue solver, for the case of a TBR tire operating at 837 kPa under loads ranging from 66% to 170% of rated load.

The fatigue behavior of the tire's materials is described from a fracture mechanical viewpoint, with care taken to specify each of the several phenomena (crack growth rate, crack precursor size, strain crystallization, fatigue threshold) that govern. The analysis of crack development is made by considering how many cycles are required to grow cracks of various potential orientations, at each element of the model. The most critical plane is then identified as the plane with the shortest fatigue life.

We consider each component of the tire, and show that where cracks develop from precursors intrinsic to the rubber compound (sidewall, tread grooves, innerliner) the critical plane analysis provides a comprehensive view of the failure mechanics. For cases where a crack develops near a stress singularity (ie belt-edge separation), the Critical Plane Analysis remains advantageous for design guidance, particularly relative to analysis approaches based upon scalar invariant theories (ie strain energy density) that neglect to account for crack closure effects.

Paper number 6.1

Multiscale Simulation to Determine Rubber Friction on Asphalt Surfaces

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The interaction between rubber and asphalt surfaces depends on the roughness characteristics of the road surface, as well as the contact pressure, slip velocity and temperature. A homogenization procedure of rubber friction, based on the finite element method, is presented, in order to gain a surface dependent friction field by numerical simulation. Furthermore, the method allows a deep insight into microscale phenomena, like real contact area, microscopic contact pressure or flash temperature.

Rubber undergoes large deformations in contact with rough surfaces. Therefore, the material characteristics of rubber need to be modelled with their whole complexity by hyperelasticity and viscoelasticity for finite deformations in dependence on temperature. Adhesion friction is a phenomenon associated with the real contact area and is included into the proposed methodology by a physically motivated, fracture mechanical approach. In addition, hysteresis friction, originated by energy dissipation inside the bulk material is also taken into account. The resulting macroscopic friction is validated by experiments based on a linear friction tester. Analytical state of the art solutions are compared to numerical results.

Paper number 6.2

Analysis of Lateral Vibration for Tire Using Flexible Ring Model

Masami Matsubara[1], Nobutaka Tsujiuchi[2] and Shozo Kawamura[1]

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Road noise is one of the noise, vibration and harshness (NVH) performance criteria for passenger cars. Road noise is evoked by contact phenomena between a car's tires and the road surface, and thus tire vibration characteristics impact the spectra of road noise. Road noise simulations can be used to predict the effects of whole - vehicle structure modifications in the early development stages, including tire dynamics.

A tire flexible ring model is utilized to analyze tire dynamics. The traditional models focused on radial vibrations. However, in the case of coupled vibration between the tire and the suspension, lateral vibration of the tire is more important. The tire vibration modes are lateral translational and bending modes about the exciting lateral vibration. A motion equation. of lateral vibration is not derived from a tire flexible ring model.

This paper presents a new tire flexible ring model and the motion equation. of the lateral vibration of the tire. First, we developed a tire vibration model based on a thin cylindrical shell theory. The basic equation, including the effect of the initial tension caused by centrifugal and Coriolis forces due to rotation, was derived by the thin cylindrical shell theory and Lagrange equation. Second, we performed an experimental modal analysis in non-rolling tire condition. The theoretical values of natural frequencies were compared with the experimental data. Finally, we present the results of the theoretical analysis for non-rolling and rolling tires. The same shape of traveling-wave modes occurred for rolling tires, and the excitation frequency of the forward wave was different from that of the backward wave.

Paper number 6.3

Simulation of the Wear and Handling Performance Tradeoff Utilizing Multi-objective Optimization and Tame Tire

Jeffery R. Anderson[1], Erin McPillan[1] and Beshah Ayalew[2]

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Optimization is a key tool used by automakers in order to efficiently design and manufacture vehicles today. During vehicle design, much effort is placed to efficiently simulate and optimize as many vehicle parameters as possible in order to save development costs during physical testing. One area of vehicle development that heavily relies on physical testing and subjective driver feedback is the tire design process.

Optimizing tire parameters relies either on this subjective feedback from trained driver, or utilization of existing tire data or scaling of a reference tire model in order simulate the desired design change and provide feedback. This data is often difficult to obtain and/or properly scale to represent the appropriate design changes. Michelin's TameTire model is a force and moment tire model that includes thermal tire effects and is physically derived, which allows quick access to scaling factors to change a tire's behavior based on pertinent tire design changes such as tread depth and tread stiffness. In this paper, a multi-objective optimization is performed to observe the tradeoff between tire wear and handling performance utilizing the scaling factors available in the TameTire model.

J Buisson Michelin method of tire characterization
Dacha 2006

Investigation on the effect of Tread Pattern on TBR Rolling Noise

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This paper investigates the influence of tread pattern on the truck and bus radial tires noise generation. First, the vibration noise of three tires with different tread patterns are simulated based on the mixed Lagrangian-Eulerian (MLE) method proposed by the authors. Then the total rolling noise for all tires are measured in the semi-anechoic chamber. Thus the contribution of the vibration noise to the total rolling noise of tires can be calculated. With this approach, three tires with typical patterns are studied to find the relationship between the contribution of the vibration noise and the tire pattern structure. It can be found that for the tire with block patterns, the contribution of the vibration noise is larger than those who have continuous patterns. Thus the total rolling noise of the block pattern tire can be approximated by the vibration noise and can be predicated by the MLE method.

Paper number 6.5

Estimation of the Contact Patch Length And Normal Load Using Intelligent Tires

Seyedmeysam Khaleghian[1], Omid Ghasemalizadeh[1], Saied Taheri[2]

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Tire-road friction estimation is one of the most popular problems for the tire and vehicle industry. Accurate estimation of the tire-road friction leads to better performance of the traction and ABS controllers, which reduces the number of accidents. Several researchers have worked in the field of friction estimation and many tire models have been developed to predict the tire road friction.

In this article, an intelligent tire based algorithm is proposed to estimate the contact patch length and use it to estimate the normal force. A portable quarter car model has been designed and built by the Center for Tire Research (CenTiRe) and has been assembled in a trailer which is pulled by a truck. The quarter car model test rig has been equipped with different sensors; a six degree of freedom force hub to measure tire forces and moments in all three directions, high accuracy encoder to measure the angular velocity of the wheel and VBOX which is a GPS based device to estimate the longitudinal speed of the trailer. Also there is a tri-axial accelerometer inside the tire which monitors the interaction between tire and ground. It also has the normal force controller and manual braking system.

A set of tests with different tire pressure and different applied normal force are performed at different speeds. Using the acceleration signal and the wheel angular velocity data, the contact patch length can be estimated. Using the estimated contact patch length along with the tire pressure as the inputs, a neural network is trained to estimate the tire normal force. The Proposed method is validated using data from a different set of tests with random tire pressures and random speeds.

Frictional Heating With Application To Dry And Wet Rubber Friction

G. Fortunato, V. Ciaravola, A. Furno[1], M. Scaraggi[2],
B. Lorenz[2] and **B.N.J. Persson[2]**

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In rubber friction studies it is often observed that the kinetic friction coefficient μ depends on the nominal contact pressure p. We discuss several possible origins of the pressure dependency of μ: (a) saturation of the contact area (and friction force) due to high nominal squeezing pressure, (b) non-linear viscoelasticity, (c) non-randomness in the surface topography, in particular the influence of the skewness of the surface roughness profile, (d) adhesion, (e) macroasperity-stick-slip and (f) frictional heating. We show that in most cases the non-linearity in the $\mu(p)$ relation is mainly due to process (f) (frictional heating), which softens the rubber, increases the area of contact, and (in most cases) reduces the viscoelastic contribution to the friction. In fact, since the temperature distribution in the rubber at time t depends on on the sliding history (i.e., on the earlier time t' < t), the friction coefficient at time t will also depend on the sliding history, i.e. it is, strictly speaking, a time integral operator.

The energy dissipation in the contact regions between solids in sliding contact can result in high local temperatures which may strongly affect the area of real contact and the friction force (and the wear-rate). This is the case for rubber sliding on road surfaces at speeds above 1 mm/s. In Ref. [14] we have derived equations which describe the frictional heating for solids with arbitrary thermal properties. In this paper the theory is applied to rubber friction on road surfaces. Numerical results are presented and compared to experimental data. We observe good agreement between the calculated and measured temperature increase.

[14]: G. Fortunato, V. Ciaravola, A. Furno, B. Lorenz, B. N. J. Persson, J. Phys.: Condens. Matter 27, (2015) 175008

Read this

Paper number 7.2

Tire Rolling Resistance Prediction – Improvement on Material Characterization

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Email: Roberto.Lombardi@bridgestone.eu

The viscoelastic behavior of a filled natural rubber is investigated under multi-axial loading condition. Within the framework of finite strain viscoelasticity a phenomenological approach is adopted to describe the time-dependent material behavior. The constitutive model used assumes an additive decomposition of stress into equilibrium and a non-equilibrium part. The first one is defined by the Extended Tube Model of rubber elasticity where the parameters of its hyperelastic potential are calculated from quasi-static experiments. The non-equilibrium part is defined by a set of non-linear springs and dashpots whose parameters are estimated from a biaxial stress relaxation test. Successively, the simulations are compared to the results of experiments with different loads showing the difference in prediction between mono and multiaxial model on hysteresis behavior.

Prediction of Uneven Tire Wear Using Wear Progress Simulation

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Tire wear performance is very important in terms of safety and economic benefit for customers and environmental conservation. Tire wear performance can be sorted into "Global" or "Local" wear. "Local" wear means uneven tire wear, for example, Heel/Toe wear, One-sided shoulder wear, Feather edge wear, etc. This uneven wear decreases tire life locally, and has the potential for causing a noise problem. So it is very important to improve uneven wear performance for long life tire. But, it is difficult to correctly evaluate the uneven tire wear performance of a brand-new tire, because the tire wear performance changes with tire pattern shape transformation as it wears. So, if we experimentally evaluate uneven wear performance accurately, we have to do time-consuming tire road tests. Therefore, we need a prediction method for uneven wear.

In this paper, we introduce "Wear Progress Simulation" developed in order to evaluate Heel/Toe wear performance, which occurs in the shoulder blocks. This method involves "wearing-out the FE tire model" using wear energy calculated from tire rolling simulation. By this method, we can observe the transformation of tire pattern shape and wear energy distribution. As a result, we can estimate the difference of Heel/Toe wear performance among tires by our developed simulation.

Dong Zheng - FEA investigation of malwear, TSCTA

Paper number 7.4

Comparison of 2-Wing and 4-Wing Rotor Mixing of Rubber Using Computational Fluid Dynamics (CFD)

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In recent years, there has been an increasing demand for efficient mixers with high-quality mixing capabilities in the rubber product industry including fuel-efficient tires. Depending on the functional characteristics of the tire and thus the compounding ingredients, different types of mixers can be used for the rubber mixing process. Hence, the choice of an appropriate mixer is critical in achieving the proper distribution and dispersion of fillers in rubber, and a consistent product quality, as well as the attainment of high productivity. With the availability of high-performance computing resources and high-fidelity computational fluid dynamics tools over the last two decades, understanding the flow phenomena associated with complex rotor geometries such as the 2- and 4-wing rotors has become feasible.

The objective of this paper is to compare and investigate the flow and mixing dynamics of rubber compounds in partially-filled mixing chambers stirred with three types of rotors: the 2-wing, 4-wing A and the 4-wing B rotors. As part of this effort, all the 3D simulations are carried out with a 75% fill factor and a rotor speed of 20 RPM using a CFD code. Mass flow patterns, velocity vectors, particle trajectories and other mixing statistics such as cluster distribution index and length of stretch, are presented here. All the results showed consistently that the 4-wing rotor was superior in terms of dispersive and distributive mixing characteristics, compared to the other rotors. The results also helped understand the mixing process and material movement, thereby generating information that could potentially improve the productivity and efficiency of a tire manufacturing process.

Robustness and Applicability of a Model-Based Tire State Estimator for an Intelligent Tire

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Tire states can be estimated by measuring the tire contact patch shape as it varies with vertical load, longitudinal and lateral slip, etc. In this study, a miniature tri-axial accelerometer is used to measure the centripetal accelerations at the tire inner liner. A Tire State Estimator (TSE) algorithm is developed to transform the measured accelerations to actual tire states, in this case vertical load. The approach used for the TSE is the Extended Kalman Filter (EKF), but an additional peak detection algorithm is used to synchronize the simulation model with the measurement signal before applying the EKF. The simulation model used in the EKF is an empirical model that describes the basic shape of the centripetal acceleration signal.

The applicability of the estimator is assessed by considering accuracy and robustness for several tire operating conditions: vertical load, velocity, inflation pressure, sideslip, camber and braking. It is concluded that the TSE exhibits accurate vertical load estimation even in cases of varying load and velocity. Further, it is concluded that the vertical load estimation is robust for (pure) camber changes and (pure) longitudinal force disturbances. For relatively high lateral forces as result of sideslip, the estimation error is larger. The current estimator appears to be not robust for inflation pressure changes, but this can be solved by adding an inflation pressure sensor. Similarly, extension of the estimator to estimate lateral force by adding a second accelerometer, not only gives an additional state, but also adds the possibility to improve the vertical load estimation. Finally, it is demonstrated that the TSE is able to perform in real-time and shows fast convergence capabilities for cases when the initial vertical load and/or sensor position are unknown, or when moving away from situations in which the signal to noise ratio is poor.

Paper number 8.2

Force and Moment Characteristics of a Rhombi Tessellated Non-Pneumatic Tyre

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There has been a recent spurt of activities in the design of Non-Pneumatic Tyres (NPTs). The validation of a NPT's design is incomplete unless its performance is compared with an equivalent pneumatic tyre. Apart from its static behavior, an evaluation of the tyre's performance can be done by observing its Force and Moment (F&M) characteristics. In the present work, an NPT has been designed with an aperiodic rhombi tessellated spoke acting as the load bearing member, where the 'unit cell' design is based on the vertical, circumferential and lateral stiffness offered by the structure.

A 3D Finite Element (FE) model has been used to capture the mechanics of load distribution in the spoke, contact patch and variation of contact pressure distribution when the tyre is subjected to different operating conditions. SIMULIA/Abaqus has been used to conduct static loading, acceleration/braking and cornering analyses. The F&M characteristics have been extracted from these simulations and compared with those of a 165/70R14 passenger car tyre. The variation in the vertical and circumferential stiffness, based on the spoke geometry has also been highlighted. The use of conventional pneumatic tyre's belts to alter the NPT's lateral stiffness, despite the tyre behaving like a 'bottom loader', adds uniqueness to the design. The NPT's capability to match the pneumatic tyre's performance and the variability observed in the tyre's F&M characteristics, reiterate the freedom available in NPT design, thus providing the opportunity to have similar tyres with varying performance characteristics.

Paper number 8.3

Read Range Sensitivity of RFID in Commercial Tires

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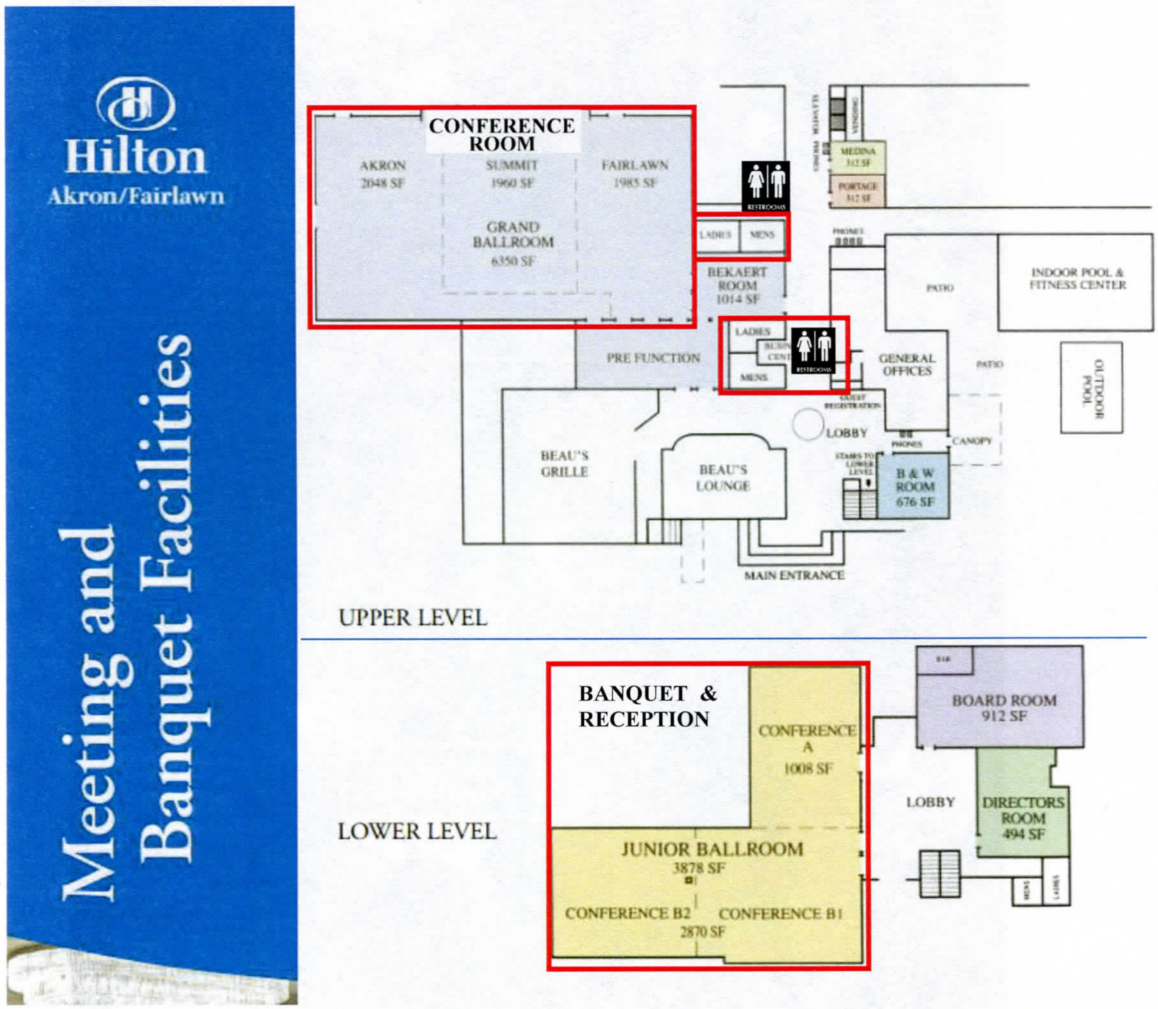
RFID is a commonly used technology in retail stores, highway toll payment transceivers, payment cards for mass transit systems, electronic access cards for office buildings, and many other applications. Usage of RFID in tires can be used to increase efficiencies of tracking manufacturing, distribution, retreading and tire usage, resulting in reduced costs. Previous research has shown difficulty in obtaining a useful read range from RFID tags in tires, although most of these studies have involved passenger car tires that do not have steel body plies.

In this work, commercially available RFID tags with helical dipole antennas were embedded into commercial tires of four different sizes. The difference in size between the largest and smallest tire used was 10%. These commercial tires have steel belts as well as steel body plies. Other than dimensions, all of the tires had identical tire constructions and used the same rubber compounds. Identical tags were embedded at the same location in all tires. Measurements were performed on multiple tires per size, which show that the read range of the helical dipole antenna has a high sensitivity to tire size. Sensitivity of read range due to tire size is undesirable, because it means that sufficient read range may not be achieved in all tire constructions with the same tag.

Venue Map


Hilton
Akron/Fairlawn
Meeting and Banquet Facilities
CONFERENCE ROOM
AKRON 2048 SF
SUMMIT 1960 SF
FAIRLAWN 1985 SF
GRAND BALLROOM 6350 SF
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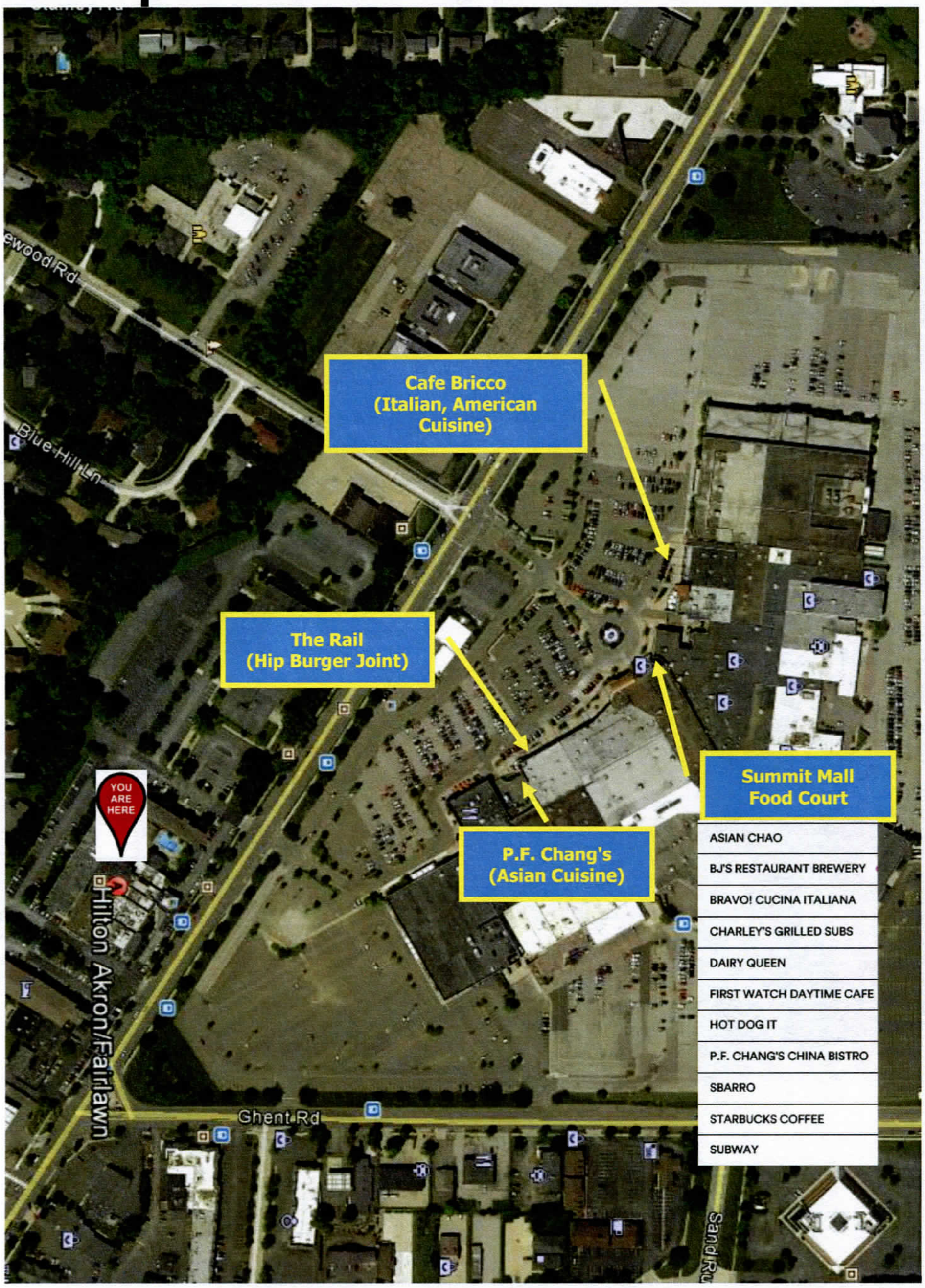
LADIES
MENS
MEDINA 312 SF
PORTAGE 312 SF
BEKAERT ROOM 1014 SF
PATIO
INDOOR POOL & FITNESS CENTER
OUTDOOR POOL
PRE FUNCTION
GENERAL OFFICES
LOBBY
CANOPY
BEAU'S GRILLE
BEAU'S LOUNGE
B & W ROOM 676 SF
MAIN ENTRANCE
UPPER LEVEL
BANQUET & RECEPTION
CONFERENCE A 1008 SF
BOARD ROOM 912 SF
LOBBY
DIRECTORS ROOM 494 SF
JUNIOR BALLROOM 3878 SF
CONFERENCE B2
CONFERENCE B1
2870 SF
LOWER LEVEL

Restaurant Options Near the Conference Venue



The Tire Society, Inc.

34th Annual Business Meeting and Conference on Tire Science and Technology

September 9-10, 2015
Hilton Akron/Fairlawn Hotel
Akron, Ohio

Schedule Overview (detailed schedule inside)

Day 1 - Wednesday, Sept 9

7:00a....***Registration:*** Foyer (all day)

Day 1 Presentations:
Akron/Summit Ballroom

8:00a....***Welcome:*** *Saied Taheri, President*

8:10a....***Keynote Address :*** *TJ Higgins, President, Consumer Tire Operations, Bridgestone Americas, Inc., Title of Talk: Beyond Black and Round: Translating Tire Technology to Create a Connection with Today's Consumer*

9:10a... **Opening:** *Anoop Varghese, Conference Chair*

9:15a.... **Materials**
3 Presenters

10:35a... ***Break / Refreshments***

10:55a...**Tire Vehicle Systems**
2 Presenters

11:50a... ***Lunch:*** *On your own*

1:05p ...**Student 1**
4 Presenters

2:50p ...***Break / Refreshments***

3:10p ...**Student 2**
4 Presenters

4:55p ...Reception: Conrad Ballroom

5:45p ...Banquet : Conrad Ballroom

6:35p ...**Best Paper Awards**
6:55p... Dinner Speaker: *Kathleen Schubert, Title: NASA's Journey to Mars*

7:45p End of Day 1

Day 2 - Thursday, Sept 10

8:00a... ***Registration*** (half day)

Day 2 Presentations:
Akron/Summit Ballroom

8:00a... ***Opening:*** *Anoop Varghese, Conference Chair*

8:05a.....**State of Society:** *Saied Taheri, President*

8:25a... **Tire Performance**
2 Presenters

9:20a... ***Break / Refreshments***

9:40a... **Tire Road Interaction**
5 Presenters

11:50a... ***Lunch:*** *On your own*

1:05p... **Plenary Lecture:** *Bo N J Persson, Title: Rubber Friction and Tire Dynamics*

2:05p... **Simulations**
4 Presenters

3:50p... ***Break***

4:10p...**Emerging Technologies:**
.... 3 Presenters

5:30p... **Closing Remarks**