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Tire rubber material characterization for effective structural and fatigue modeling and analysis

Samuel Frimpong, Wedam Nyaaba and **Bruno Kansake**
Missouri University of Science and Technology, USA

Rubber, in its natural state, has the consistency of a heavy viscous fluid with little to no use in structural applications. However, when vulcanized with sulfur, particulate fillers, silica and other strength inducing ingredients, cross-links are formed and the highly amorphous state of the rubber is transformed into an elastic solid. Thus, vulcanized rubber, in the absence of cords, is a nanocomposite. While added fillers give rubber enhanced performance characteristics (stiffness and toughness properties), their presence influence the dynamic and damping behavior of rubber in a very complex and disproportionate fashion. Numerical modeling of rubber behavior for predictive analysis remains a formidable challenge amidst successes achieved thus far. The object of this paper is to implement existing rubber material constitutive models in characterizing tensile strength and fatigue test data of rubber specimens extracted from an off-road mining truck tire. Specifically, the paper highlights modeling strategies for rubber strain softening, nonlinear viscoelasticity, strain-induced crystallization, and fatigue crack growth rate using spreadsheets, and commercially available material calibration codes. The novelty of the study lies in the calibration approach adopted for the fatigue characterization of the experimental data. An example problem to show how the characterized materials are used in a finite element analysis of a model tire is provided. The results obtained indicate enhanced durability in strain-crystallizing elastomers.

Biography

Samuel Frimpong has obtained his PhD in 1992 from University of Alberta and MS in 1988 from University of Zambia. He has obtained his Post-graduate Diploma in 1986 and BS in 1985 from KN University of Science and Tech. of Ghana. He guided over 30 PhD and MS graduates, published 1 book, 3 book chapters, over 200 refereed journal and conference papers and given over 200 presentations. He is a Member of the APLU Board on Natural Resources, Vice Chair of the Minerals and Energy Resources Division of NASULGC, and a Member of the College of Reviewers for Canada Foundation for Innovation and Canada Research Chairs Program and ASCE-UNESCO Scientific Committee on Emerging Energy Technologies (ASCE-UNESCO SCEET). He served 5 years as a Member of CDC-NIOSH Research Advisory Board, 4 years as Co-chair of ASCE-UNESCO SCEET and 2 years on Japan's Global Warming Research Consortium. He is currently the Editor-In-Chief of the *Journal of Powder Metallurgy and Mining* and Editorial Board Member for the *International Journal of Mining*, *Reclamation and Environment*. He is a Registered Professional Engineer and a member of the Canadian Institute of Mining, Metallurgy and Petroleum, American Society for Mining, Metallurgy and Exploration, American Society of Civil Engineers, and the Society for Modeling and Simulation International.

frimpong@mst.edu

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