Mathematical Analysis of Self-Heating in Materials with High Dissipation

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Abstract

Self-heating in materials with high energy dissipation such as polymers and polymer composites under vibrational cyclic loading can lead to catastrophic failure known as "heat explosion". Predicting safe temperature increases is essential for critical structural applications. The properties of many polymer materials are strongly temperature dependent, thus emphasizing the importance of heat generation from mechanical vibrations. The analysis is based on the model predicting stress induced heat increase for viscoelastic materials under cyclic loading conditions. A set of stress-strain and creep experiments on PMMA at ambient and elevated temperatures was performed together with the mechanical engineering department. The data was used to determine the model parameters for viscoelastic mechanical stresses. Additional data from experimental testing of PMMA under vibrational loading has been analyzed and used to verify the developed model.

Keywords
self-heating phenomenon, polymers, viscoelasticity, heat transfer equation

Acknowledgements
The team would like to thank and acknowledge the International Center for Automotive Research, the School of Mathematical and Statistical Sciences, the Mechanical Engineering Department, and the Creative Inquiry and Undergraduate Research Program at Clemson University for their support and funding on this project.

Biographies
Dr. Irinia Viktorova obtained her master's at Moscow State University, Department of Mathematics and Mechanics in 1977 and received her Ph.D. in Mechanical Engineering at Russian Academy of Sciences in 1983. Her research interest is mathematical modeling of delayed fracture of time dependent materials, especially viscoelastic composite structured materials with due environmental effects. She has over a 100 publications and presentations at various international conferences and symposiums. She has been in Clemson since 1992. She has taught various calculus and differential equations courses for many years as well as upper level undergraduate and numerous Creative Inquiry classes.

Dr. Leo Rebholz is a Professor of Mathematical Sciences at Clemson University, with research interests in numerical analysis, PDEs, CFD, turbulence, numerical linear algebra, model reduction, data assimilation and nonlinear solvers. He received his PhD in mathematics from the University of Pittsburgh in 2006, studying numerical analysis under the direction of Prof. William Layton. After Pitt, he spent two years as a Senior Mathematician at Bechtel Bettis Atomic Power Laboratory, working on dynamical system model reduction. In 2008, he began a tenure track job at Clemson and has been there ever since. He has published 3 books and over 100 journal articles and has advised 9 PhD students.

Victoria Luongo is a senior undergraduate student in the Honors College at Clemson University. She is simultaneously pursuing her bachelor's and master's degree in mathematical sciences with an emphasis in applied and computational mathematics.

Abdullah Kose is a master's student in the automotive engineering program at Clemson University. He holds a Bachelor of Science degree in mechanical engineering from Rensselaer Polytechnic Institute and has worked for companies like Borg-Warner, Snap-On Tools, and BMW.