Chapter

Introductory Chapter: Introduction to Thermomechanics Problems

Jerzy Winczek

1. Introduction

Thermomechanics is a scientific discipline which investigates the behavior of bodies (solid, liquid, and gas) under the action forces and heat input. Thermomechanical phenomena commonly occur in the human environment, from the action of solar radiation to the technological processes. The analysis of these phenomena often requires extensive interdisciplinary knowledge, e.g., thermodynamics, continuum mechanics (solid and fluid), soil mechanics, biomechanics, metallurgy, hydraulics, civil engineering, and materials science and even anatomy, chemistry, meteorology, or hydrology. The wide range of thermomechanics applications depends on the field of science and the areas of knowledge in which phenomena are considered. The description of these phenomena requires not only knowledge of the laws of physics but the use of advanced mathematical apparatus, tensor algebra, and methods for solving differential and integral equations. Thermomechanical phenomena are analyzed using analytical and numerical methods. The analytical solution offers a quicker assessment of the searched values and its dependence on the various parameters, but for more complex problems, they are difficult or even impossible to apply. Some problems can be solved only with numerical methods, of which the finite element method is commonly used, but also methods of boundary elements, finite differences and elementary balances. In addition to the mentioned above methods, one needs to know how to solve complex equation systems (in case of the author's original software) or to possess the ability to handle professional engineer's packages.

Thermomechanics therefore describes a broad category of phenomena. It is a generalization of classical mechanical theory and thermodynamic theory. Currently, thermomechanical coupling is a fully formed issue. Basic dependences and differential equations have been formulated based on mechanical and thermodynamic laws. Numerous methods and algorithms for solving differential equations of thermomechanical coupling have been developed, including the finite element method.

Looking at the development of thermomechanics, we cannot omit scientists who laid the foundation for this area of science. First and foremost, Isaak Newton, the author of the three principles of dynamics [1], an outstanding physicist and mathematician, parallels with G.W. Leibniz who developed the theory of differential and integral calculus. In turn, the development of thermomechanics (and not only) was contributed by Fourier, the creator of the Fourier transform and Fourier series theories, which he used in his fundamental work on the theory of heat conduction [2]. One should also mention eminent scientists, the creator of the law of thermal radiation, Kirchhoff [3] and Maxwell [4, 5]. Over the past half-century, a number of books have been published that take into account the mutual coupling of thermal and mechanical phenomena, among which one can mention, for example, books written by Gibbings [6], Wilmański [7], Mićunović [8], Ziegler [9], Hsu [10], Maugin [11], Bermudes [12], Nicholson [13], Jou et al. [14], Consiglieri [15], or Kleiber and Kowalczyk [16].

Modern solutions of thermomechanics concern mainly the solid body [7–9, 11–13, 16] and fluids [6, 9, 14, 15], as inanimate nature objects. Increasingly, however, the interests of scientists turn to the analysis of the human body [17, 18]. The scale of the considered phenomena is also widening from the macro scale, through micro, to nano [19, 20].

Because the whole world around us is subject to the laws of mechanics (everything that moves under the laws of kinematics or dynamics), and at the same time constantly real objects are subject to the influence of heat, thermomechanics becomes ubiquitous in human life.

Despite extensive literature, the number of practical examples of using thermomechanics to solve engineering problems is still insufficient.

This book intends to present current trends and methods in solving thermomechanical problems.

Author details

Jerzy Winczek
Faculty of Mechanical Engineering and Computer Science, Czestochowa University of Technology, Czestochowa, Poland

*Address all correspondence to: winczek@imipkm.pcz.pl

IntechOpen

© 2018 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

[1] Newton I. Philosophiae Naturalis Principia Mathematica. London: Juffu Societatis Regre ac Typis Josephi Streater Proftant Venales apud Sam. Smith ad infignia Principis Walia in Coemiterio D. Pauli; 1687. 511 p

[2] Fourier JB. Théorie Analytique de la Chaleur. Paris: Firmin Didot; 1822. 639 p

[3] Kirchhoff RG. Vorlesungen über Mathematische Physik: Mechanik. Leipzig: Druck und Verlag von G.G. Teubner; 1876. 466 p

[4] Maxwell JC. Matter and Motion. London: Society for Promoting Christian Knowledge; 1876. 163 p

[5] Maxwell JC. Theory of Heat. London: Longmans; 1871. 348 p

[6] Gibbings JC. An Introduction to the Governing Equations of Thermodynamics and of the Mechanics of Fluids. Oxford, London: Pergamon Press; 1970. 302 p

[7] Wilmański K. Thermomechanics of Continua. Berlin: Springer; 1998. 273 p

[8] Mićunović MV. Thermomechanics of Viscoplasticity. Fundamentals and Applications. New York: Springer; 2009. 249 p

[9] Ziegler H. An Introduction to Thermomechanics. Amsterdam, New York: North-Holland; 1983. 370 p

[10] Hsu T-R. The Finite Element Method in Thermomechanics. Boston: Allen & Unwin; 1986. 391 p

[11] Maugin GA. The Thermomechanics of Plasticity and Fracture. Cambridge University Press; 1992. 350 p

[12] Bermudes AB. Continuum Thermomechanics. Basel: Birkhäuser Verlag; 2000. 209 p

[13] Nicholson DW. Finite Element Analysis: Thermomechanics of Solids. 2nd ed. Boca Raton: CRC Press Taylor & Francis Group; 2008. 457 p

[14] Jou D, Casas-Vázquez J, Criado-Sancho M. Thermodynamics of Fluids Under Flow. Dordrecht, Heidelberg, London, New York: Springer; 2011. 255 p

[15] Consiglieri L. Mathematical Analysis of Selected Problems from Fluid Thermomechanics. Colne: Lambert Academic Publishing; 2011. 188 p

[16] Kleiber M, Kowalczyk P. Introduction to Nonlinear Thermomechanics of Solids. Basel: Springer International Publishing Switzerland; 2016. 345 p

[17] Ciesielski M, Mochnacki B. Numerical simulation of the heating process in the domain of tissue insulated by protective clothing. Journal of Applied Mathematics and Computational Mechanics. 2014;**13**(4): 91-96

[18] Massoudi M, Kim J, Antaki JF. Modeling and numerical simulation of blood flow using the theory of interacting continua. International Journal of Non-Linear Mechanics. 2012; **47**(5):506-520

[19] Hill TL. Extension of nanothermodynamics to include a one-dimensional surface excess. Nano Letters. 2001;**1**(3):159

[20] Qian H. Hill's small systems nanothermodynamics: A simple macromolecular partition problem with a statistical perspective. Journal of Biological Physics. 2012;**38**(2):201-207