
**Journal of Thermal Stresses**

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uths20

# Generalized Thermoelastic Vibration of an Axially Moving Clamped Microbeam Subjected to Ramp-Type Thermal Loading

Ashraf M. Zenkour [a] [b] , Ahmed E. Abouelregal [c] [d] & Ibrahim A. Abbas [e] [f]

[a] Department of Mathematics, Faculty of Science , King Abdulaziz University , Jeddah , Saudi Arabia

[b] Department of Mathematics, Faculty of Science , Kafrelsheikh University , Kafr El-Sheikh , Egypt

[c] Department of Mathematics, Faculty of Science , Mansoura University , Mansoura , Egypt

[d] Department of Mathematics, College of Science and Arts , University of Aljouf , El-Qurayat , Saudi Arabia

[e] Department of Mathematics, Faculty of Science and Arts-Khulais , King Abdulaziz University , Jeddah , Saudi Arabia

[f] Department of Mathematics, Faculty of Science , Sohag University , Sohag , Egypt

Published online: 13 Aug 2014.

**To cite this article:** Ashraf M. Zenkour , Ahmed E. Abouelregal & Ibrahim A. Abbas (2014) Generalized Thermoelastic Vibration of an Axially Moving Clamped Microbeam Subjected to Ramp-Type Thermal Loading, Journal of Thermal Stresses, 37:11, 1302-1323, DOI: 10.1080/01495739.2014.937209

**To link to this article:** http://dx.doi.org/10.1080/01495739.2014.937209

Journal of Thermal Stresses, 37: 1302–1323, 2014

ISSN: 0149-5739 print/1521-074X online
DOI: 10.1080/01495739.2014.937209

Taylor & Francis
Taylor & Francis Group

# GENERALIZED THERMOELASTIC VIBRATION OF AN AXIALLY MOVING CLAMPED MICROBEAM SUBJECTED TO RAMP-TYPE THERMAL LOADING

**Ashraf M. Zenkour[1,2], Ahmed E. Abouelregal[3,4], and Ibrahim A. Abbas[5,6]**
[1]*Department of Mathematics, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia*
[2]*Department of Mathematics, Faculty of Science, Kafrelsheikh University, Kafr El-Sheikh, Egypt*
[3]*Department of Mathematics, Faculty of Science, Mansoura University, Mansoura, Egypt*
[4]*Department of Mathematics, College of Science and Arts, University of Aljouf, El-Qurayat, Saudi Arabia*
[5]*Department of Mathematics, Faculty of Science and Arts-Khulais, King Abdulaziz University, Jeddah, Saudi Arabia*
[6]*Department of Mathematics, Faculty of Science, Sohag University, Sohag, Egypt*



***In this article, the generalized thermoelastic problem of an axially moving microbeam subjected to ramp-type heating is studied. Based on the heat conduction equation containing the thermoelastic coupling term and the classical Euler–Bernoulli thin beam theory, the thermoelastic coupling differential equation of motion of the microbeam is established. The generalized thermoelasticity theory with dual-phase-lags (DPLs) model is used to solve this problem. An analytical technique is used to calculate the vibration of deflections and temperature. The effects of the PLs, the transport speed and the ramp-time parameters on the lateral vibration, temperature, displacement, stress, bending moment, and strain energy density of the microbeam are discussed. Some comparisons have been shown graphically to estimate the effects of the dimensionless speed as well as the time on all the studied fields. The through-the-thickness distributions of all fields are also investigated.***

***Keywords***: Euler–Bernoulli theory; Moving microbeams; Ramp-type heating; Thermoelasticity

## INTRODUCTION

Axially moving beams can represent many engineering devices, such as band saws, crane hoist cables, flexible robotic manipulators, power transmission belts,

Received 24 December 2013; accepted 6 January 2014.
Address correspondence to Ashraf M. Zenkour, Department of Mathematics, Faculty of Science, King Abdulaziz University, P.O. Box 80203, Jeddah 21589, Saudi Arabia. E-mail: zenkour@gmail.com
Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/uths.

aerial cable tramways, and spacecraft deploying appendages. Despite usefulness and advantages of these devices, vibrations associated with the devices have limited their applications. Therefore, understanding transverse vibrations of axially moving beams is important for the design of the devices. The investigations on vibrations of axially moving beams have theoretical importance as well, because an axially moving beam is a typical representative of distributed gyroscopic systems. Because of the practical and theoretical significance, the investigation on vibrations of axially moving beams is a challenging subject that has been studied for many years and is still of interest today.

The lateral vibrations of the axially moving beams are of considerable interest in many applications. Some examples of the engineering fields include, such as transmission belt, aerial lifter, band saw, magnetic tape and weave fiber. Most of the investigations are concerned with the transverse vibration characteristics and dynamical behaviors of an axially moving beam. The investigations on transverse vibrations of axially moving strings have theoretical significance as well, because an axially moving string is the simplest representative of distributed gyroscopic systems.

Historically, one-dimensional string theory and beam theory were used in modeling the axially moving continua. The research of axially moving materials started early, and various methods were applied to study characteristics of vibration with different models of axially moving materials under different boundary conditions. Wickert and Mote [1, 2] have given a review of the literature with detailed introduction in this field from 1949 up to 1988. The relevant researches on transverse vibrations of axially moving strings can be dated back to more than 100 years ago. Analysis of such vibrations are challenging subjects that have been investigated for many years and are still of interest today. Chen and Zu [3] summarized the related progress up through 2000, but did not cover new results afterwards. Chen [4] presented a comprehensive survey with a complete, detailed representation of current researches. Chen and Zu [3] and Chen [4] have stated that a major problem is the occurrence of large transverse vibrations due to stress or axial speed variation known as “parametric vibrations.”

The research of the coupled thermoelastic vibration characteristics for the engineering system components has become a new research field. Because the coupled temperature and displacement fields exist, the thermal conduction equation involving the deformation term and the equation of motion must be couple-solved. Chakraborty and Mallik [5] have investigated the relation between the wave propagation and the free vibration in a traveling beam with simple supports. Kong and Parker [6] researched the free vibration of the axially moving beam with small flexural stiffness. The asymptotic solutions of natural frequencies were obtained by the perturbation method of algebraic equations.

Yang [7] studied the natural frequencies of axially moving beams by using the method of multiple scales. The impacts of temperature changes are ignored in the above-mentioned researches, i.e., they are in the stable temperature field. It should be noted that in the actual engineering systems, the impacts of temperature changes must be considered. The temperature changes in the elastic vibration have significant effects on the bending of the beam. So, the vibration characteristics and dynamics of the beam will be changed due to temperature variation [8, 9]. Chang and Wan [10] studied the nonlinear coupled thermoelastic vibration of an isotropic rectangular thin plate under different boundary conditions.