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“2nd International Conference on Mathematical Modelling in Mechanics and Engineering”

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Belgrade, 12.-14. September 2024.

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PREFACE

It's my pleasure to introduce the "2nd International Conference on Mathematical Modelling in Mechanics and Engineering", organized by the Mathematical Institute of the Serbian Academy of Sciences and Arts and co-organized by the Faculty of Mechanical Engineering, University of Belgrade; the Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac; and the Scientific Society for Engineering Design, Simulations and Innovations. The conference will be held in the hybrid form at the Mathematical Institute of the Serbian Academy of Sciences and Arts, Belgrade, Serbia, from the 12th to the 14th of September 2024.

This conference is planned as the second event in the series of conferences, which is planned to be held every two years and bring together leading academic scientists, researchers, and research scholars to exchange and share experience and research results on various aspects of mathematical modelling in mechanics and engineering. It will keep an interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, theories, and algorithms, as well as practical challenges encountered and solutions adopted in the fields of Classical Mechanics, Solid and Fluid Mechanics, Computational Mechanics, Biomechanics, Applied Mathematics and Physics, Structural Mechanics and Engineering. A considerable number of prominent scientists and professors submitted their abstracts and confirmed their attendance at the conference. The scientists and researchers from different countries in Europe and the world (Netherlands, Greece, Spain, Russia, USA, China, Kazakhstan, Italy, India, Malaysia, Slovenia, Bulgaria, Algeria etc.) also have confirmed participation at the conference. The conference presentations will cover development of analytical and numerical methods for effective simulations of different complex problems in mechanical engineering based on multiscale problems, from nano to macro-scales, analytical/numerical and data driven solutions to study complex media, composite aerospace and periodic structures and metamaterials, and capture essential features of linear and nonlinear dynamics that can lead to new designs of such systems. Some presentations will include new experimental setups to study engineering materials and novel control strategies based on classical or fractional derivative models used to control the dynamics of multibody, flexible and/or electromechanical systems. Finally, I believe that the sessions' discussions will have high potential to give significant contributions to the development of new and advanced mathematical models of real-world engineering mechanical systems.

On behalf of the Organizing Committee, I am very proud to announce that the number of accepted contributions to be presented at this Conference is 127, with 7 plenary and 7 invited lecture presentations. We would like to express our gratitude to the institutions that support the conference financially: The Ministry of Science, Technological Development and Innovation, Republic of Serbia; METALFER STEEL MILL, Serbia; SHIMADZU, Serbia; eCon Engineering Kft, Hungary; SVECOM, Beograd, Serbia; "PROJEKTINŽENJERING TIM", Niš, Serbia; AMING PROJEKT, Knjaževac, Serbia; BREGAVA, Beograd, Serbia. We are especially grateful to the members of the International Scientific Committee who contributed to this international scientific meeting with their advices and abstracts' reviews. We also thank the support of the co-organizers of this Conference.

I would also like to express special gratitude to the Department of Technical Sciences SANU, the Scientific Board of the Mathematical Institute of the Serbian Academy of Sciences and Arts, and the family of Academician Prof. Dr. Vladan Djordjevic for their support in organizing the Special session within this conference dedicated to the memory of Academician Prof. Dr. Vladan Djordjevic and establish the "Prof. Vladan Djordjevic" award for young scientists aged up to 35 contributing in the field of fluid mechanics.

I hope that this conference will be successful, at least as the first in this series of international conferences. I wish all participants a successful presentation of their scientific results.

Cordially,

Ivana Atanasovska, Conference Chair

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PLENARY LECTURES

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GENERAL SESSIONS

SPECIAL SESSION 1 - Fluid Mechanics

PHASE-FIELD FATIGUE MODELING IN SHAPE MEMORY ALLOYS

Vladimir Lj. Dunić[1] and Miroslav M. Živković[1]

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ABSTRACT

Shape Memory Alloys (SMA) are smart materials that can exhibit superelasticity and shape memory effects. The same alloy can show both responses depending on the environment's temperature. The superelasticity occurs at a temperature above the austenitic finish. In practical applications like actuators and sensors, superelasticity is mainly exploited where many cycles can be expected. The investigation of SMA device failure is essential for the application, especially for responsible parts such as coronary stents or actuators in airplanes.

Fatigue is the primary mechanism behind fracture occurrence in structures exposed to cyclic loading. This is particularly true for SMA devices operating in the superelasticity regime, which are subjected to several thousands of cycles. Cracks are initiated from micro-voids and micro-cracks in the material, and due to the repeated loading-unloading, the fracture occurs. This underscores the urgent need to address fatigue in SMA devices. Phase-field damage modeling (PFDM) can be a powerful tool in this regard, as it allows for the simulation of crack initiation, evolution, and propagation in various materials. SMA modeling, widely known in literature [1], offers promising solutions, with the Lagoudas model being one of the most popular constitutive models, modified and extended for application to large strain theory and thermo-mechanical coupling conditions by Dunić [2].

One of the recent papers [3] covers the subloop loading condition of SMA and damage, which increases mainly during elastic loading. In contrast, martensitic transformation does not increase it and can be neglected. As it is presented in that paper, the evolution law of the damage phase-field needs to be modified as follows [3]:

$$f\left(\bar{\alpha}\right)G_V\left[d-l_c^2\nabla^2 d\right]+g'\left(d\right)\psi=0, \tag{1}$$

where l_c is the characteristic length, d is the damage variable, $g'(d)$ is the derivative of the damage function, ψ is the strain energy density, and $f\left(\bar{\alpha}\right)$ is the fatigue function [3,4]:

$$f\left(\bar{\alpha}\right)=\begin{cases} 1 & \text{if} \quad \bar{\alpha}\le\alpha_T \\ \left(\dfrac{2\alpha_T}{\bar{\alpha}+\alpha_T}\right)^2 & \text{if} \quad \bar{\alpha}>\alpha_T \end{cases}. \tag{2}$$

In previous equation, α_T represents a value of fatigue history variable $\bar{\alpha}$, below which the fracture energy G_V remains unaffected [5]:

$$\alpha_T=\frac{G_V}{12}. \tag{3}$$

The fatigue history variable increases only during the loading and it can be computed as [3-5]:

$$ {}^{t+\Delta t}\bar{\alpha} = {}^{t}\bar{\alpha} + \int_{t}^{t+\Delta t} H\left(\alpha\dot{\alpha}\right)\left|\dot{\alpha}\right| d\tau \qquad (4) $$

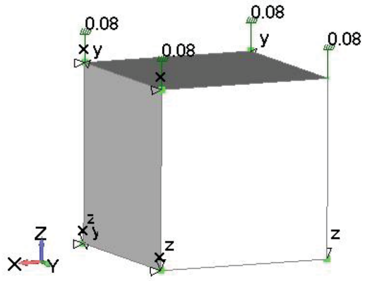

Fig. 1 Boundary and loading conditions – Unit cube

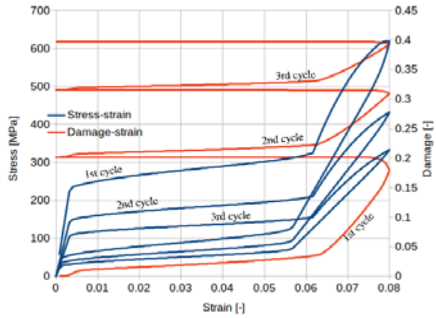

Fig. 2 Stress vs. Strain and Damage vs. Strain for three loading – unloading cycles

As shown in Fig. 2, the strong influence of damage increase can be noticed. The stress-strain curve decreases after each cycle, while the damage value increases in the loading branch and is kept constant during unloading. The presented example is simulated using general material constants from the literature [1] to show the possibility of simulating phenomena.

The research was supported by the Science Fund of the Republic of Serbia, #GRANT No 7475, Prediction of damage evolution in engineering structures - PROMINENT and by the University of Kragujevac project for young scientist Developing the procedure for damage simulation in metallic structures due to cyclic loading - DEEDS.

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