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Engineering Power

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EDITOR-IN-CHIEF'S WORD

In its 26 years of existence the Croatian Academy of Engineering has always striven to publish the results of its distinguished members in professional and scientific research fields, which also gives an insight into the relevant achievements of engineering sciences in Croatia.

In order that this insight is more widely visible, in its Bulletin Engineering Power the Academy periodically presents some of these results that seem to be interesting, which is also confirmed by this issue.

Therefore, I believe that the articles prepared by our regular member Zdenko Tonković with his associates present good information and benefit to everyone who closely pursues the field of mechanical engineering.

Editor-in-Chief
Vladimir Andročec, President of the Croatian Academy of Engineering

EDITOR'S WORD

Dear readers,

Production and application of new advanced materials are, beyond any doubt, one of the most important fields in modern science and technology.

In this edition of Academy's Bulletin Engineering Power we are focusing on the related research area: structural analysis of such materials based on numerical modelling and development of the pertinent computational simulation tools.

The Guest-Editor of this issue is Zdenko Tonković, Member of the Academy and Professor at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, who is presenting part of the activities of the Faculty's Laboratory for Numerical Mechanics.

Editor
Zdravko Terze, Vice-President of the Croatian Academy of Engineering

FOREWORD

New demands on safety, reliability, maintainability, efficiency and optimal control, together with the applications of new materials and new production technologies, can only be realized by using methods of advanced structural analysis and more realistic description of material behaviour. Therein, material heterogeneity plays a major role, because almost all materials are heterogeneous and anisotropic due to their natural structure, particularly on the microscopic scale, or as the result of manufacturing procedure. The crack initiation and propagation in heterogeneous material are under the great influence of the microstructure and properties of its constituents and defects as well as the residual stresses due to the various manufacturing processes, such as welding. Therefore, in order to predict the failure of engineering materials and structures for the purpose of structural integrity assessment, an accurate and efficient analysis on the microlevel is unavoidable. As in many other cases, numerical simulations are widely used to complement or substitute much more expensive experiments.

The papers listed below represent a part of the scientific research in the above-mentioned fields of the members of the Laboratory for Numerical Mechanics at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb and their associates from the Faculty and industry. The studies have been carried out within the frame of the projects approved by the Croatian Science Foundation and the European Union through the Science and Innovation Investment Fund Grant Scheme, as well as the project funded by the Alexander von Humboldt foundation from Germany. The first paper deals with the numerical modelling of fracture phenomena occurring in real microstructures of heterogeneous materials. The arbitrary heterogenous geometry based on a microstructure of nodular cast iron is analysed with the phase-field method which, in the past few years, has emerged as a very *powerful* simulation *tool to* predict complex crack patterns even in three-dimensional settings. The second paper presents the multiscale modelling of heterogeneous materials, where the macroscopic properties are being determined by the homogenization process acting on an effective, homogenized sample of material microstructure called representative volume element. Multiscale modelling has attracted increasing interest in past years not only in the scientific community but also in the industrial sector due to the recent dramatic increase in computational power, the experimental capabilities to provide material properties down to the atomic level, and the development of advanced methods, such as computational homogenization, that admit multiple length scales. The last paper presents an efficient finite element procedure for the prediction of welding-induced residual stresses and distortions in engineering structures. The numerical simulation of thick steel plates welding using new high-productive buried arc technology is performed and experimentally validated using a fully automated welding process.

Guest-Editor
Zdenko Tonković, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture